DEPARTMENT OF DEFENSE

AUDIT REPORT

SELECTED ACQUISITION ACTIONS ON THE
C-17 AIRCRAFT

No. 91-007

November 2, 1990

Office of the
Inspector General

INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
400 ARMY NAVY DRIVE
ARLINGTON, VIRGINIA 22202-2884

November 2, 1990

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION
ASSISTANT SECRETARY OF THE AIR FORCE
(FINANCIAL MANAGEMENT AND COMPTROLLER)

SUBJECT: Audit Report on Selected Acquisition Actions on the C-17 Aircraft (Report No. 91-007)

This is our final report on the Audit of Selected Acquisition Actions on the C-17 Aircraft. We made the audit from October 24, 1989, through February 2, 1990, in response to a DoD Hotline allegation that the Air Force inappropriately exercised a contract option in July 1989 to buy four C-17 aircraft for $691 million and that the status of C-17 software development was worsening.

The complainant alleged that not all software was reviewed during the mission computer software critical design review (CDR) conducted in April 1989 and that not all deficiencies identified during the CDR were corrected before the contract option was exercised. The complainant also alleged that changes made in July 1989 regarding software development responsibilities of two subcontractors indicated that the status of software development was worsening and that the prime contractor, Douglas Aircraft Company (Douglas), McDonnell Douglas Corporation, planned to replace a third subcontractor late in the program.

The objectives of the audit were to review the circumstances and documentation relating to the C-17 aircraft that were procured in July 1989 and to assess the status of software development for selected C-17 subsystems. We also evaluated whether the program development schedule was realistic. In addition, we evaluated compliance with internal controls applicable to the C-17 program.

The C-17 is being developed to provide additional capability to the Air Force to airlift all classes of military cargo and to operate into short, austere airfields. At the time of our audit, the Air Force planned to buy 210 C-17 aircraft at a total cost of about $41.8 billion. In April 1990, due to reductions in the DoD budget and the expectations of greater warning of a possible attack, the Secretary of Defense planned to reduce the procurement quantity to 120 aircraft at a total cost of about $29.9 billion. The Air Force expects the first flight of the C-17 to occur in June 1991.

The audit showed that Douglas did not review the detail design of all software for the mission computer during the CDR in April 1989. The full-scale development (FSD) contract made the exercise of the contract option for FY 1989 contingent on the determination by the procuring contracting officer at the C-17 System Program Office that the mission computer CDR was completed. The FSD contract allowed the C-17 Program Director to exercise the contract option for FY 1989 at any time, notwithstanding CDR results. However, we believe that the April 1989 CDR did not provide a sufficient basis to determine that the mission computer CDR was completed since not all of the mission computer detail design for software was reviewed. We determined, nonetheless, that plans prepared by Douglas were adequate to correct the critical deficiencies identified during the CDR.

The audit showed that serious problems had been experienced in developing software for the C-17 program, but that Douglas had taken actions to keep the software development program from worsening. Douglas planned to obtain a new subcontractor for a hardware panel for an avionics subsystem, but we believe that the change will not adversely affect the program development schedule. The Air Force's event-based contract award strategy is an excellent method to ensure that procurement decisions are justified and not predetermined. However, the Air Force needed to clarify the provisions of the FY 1990 milestone event to ensure that adequate development progress is demonstrated before aircraft are procured in FY 1990.

The audit also showed that delays in the development and integration of software were major risks to the program development schedule, and further schedule delays could yet occur. Douglas has initiated actions to improve the management of the C-17 program; however, because the actions were taken late in the program and have not yet proved to be successful, further delays in the program schedule may occur.

The results of the audit are summarized in the following paragraphs, and the details, audit recommendations, and management comments are in Part II of this report. The audit did not identify any material internal control weaknesses or potential monetary benefits; however, other benefits are summarized in Appendix E.

Before the mission computer software CDR was completed, as required by a November 1988 modification of the FSD contract with Douglas, the C-17 System Program Office (SPO) exercised a contract option to buy four C-17 aircraft. The C-17 Program Director considered the CDR to be completed because the top-level software design of the mission computer was reviewed during the

CDR, and Douglas had taken management actions to ensure completion of the detail design of the mission computer software. Military Standard 1521A, "Technical Reviews and Audits for Systems, Equipments, and Computer Software," states that a software CDR shall be conducted when the detail design is essentially complete. When the CDR was conducted in April 1989, detail design was completed for only the software needed for the aircraft's first 100 hours of flight testing, or about 60 percent of all software in the mission computer. In our opinion, the April 1989 CDR only when taken together with a software design review to be done in late 1990 constitutes a completed CDR of the mission computer software. We believe that if experts in software developments had attended meetings of the Conventional Systems Committee (the Committee) of the Defense Acquisition Board regarding the C-17 aircraft, the Committee would have questioned more rigorously Douglas's ability to complete the CDR in April 1989. The C-17 program will be delayed if the software is not fully developed when required for operational testing. We recommended that individuals with technical expertise attend Committee meetings when their oversight of software development matters is needed. We also recommended that the FSD contract be amended to require completion of the software design review before procuring four C-17 aircraft for FY 1990 and to specify the minimum assembly required for the test aircraft for the milestone event for the Lot III production contract (page 7).

Douglas had not met contractual milestones for developing the aircraft and had not prepared an adequate plan for testing and integrating C-17 avionics software. The Air Force had to postpone major program milestones, and further delays in development may occur. We recommended that OSD establish procurement policy that requires contractors to submit a systems engineering management plan as part of the FSD proposal for contracts that assign total performance responsibility to contractors. In addition, we recommended that the Air Force set a deadline for Douglas to prepare an avionics integration test plan and require Douglas to prepare a revised schedule showing new program milestone dates. We also recommended that the Air Force obtain compensation from Douglas for missed contractual milestones. We are not claiming potential monetary benefits for any compensation received from Douglas. The intent of the recommendation was to add impetus to the Air Force's efforts in obtaining compensation, which began before the audit was initiated. During the audit, we were informed that Douglas had not responded to a request from the SPO dated August 18, 1989, to provide compensation for missed contractual milestones (page 17).

A draft of this report was provided to the Under Secretary of Defense for Acquisition and the Assistant Secretary of the Air

Force (Financial Management and Comptroller) on June 14, 1990. Comments were received from the Office of the Under Secretary on August 20, 1990, and from the Air Force on August 17, 1990.

The Office of the Under Secretary of Defense for Acquisition nonconcurred in Recommendation A.1., which would have required the Committee to have two permanent members with expertise in software matters. The management comments stated that the Committee's policy has been to allow attendance by supporting staff members with relevant expertise. We accepted the premise that principals will bring individuals with software expertise to future Committee meetings when their expertise is required, and we revised our recommendation in the final report accordingly. We request management comments on the revised recommendation. Management nonconcurred in Recommendation B.1., which recommended that procurement policy be established for contracts for major acquisition programs that assign total performance responsibility to contractors, because broad guidance on systems engineering currently exists in the draft DoD Instruction 5000.2, and because it was not clear that problems with developing and integrating C-17 avionics systems would have been prevented by a policy requiring formal documentation of systems engineering. We believe the recommendation is still warranted for the reasons discussed in Part II of this report.

The Air Force nonconcurred in all recommendations (A.2.a., A.2.b., B.2.a., B.2.b., and B.2.c.) addressed to it. Although the Air Force nonconcurred, the actions taken in response to Recommendation A.2.b., which recommended a definition be made of the minimum assembly required to consider the test aircraft assembled, and actions taken in response to Recommendation B.2.b., which recommended a revised program schedule, meet the intent of the audit recommendations. Accordingly, additional management comments on Recommendations A.2.b. and B.2.b. in the final report are not required.

The Air Force nonconcurred in Recommendation A.2.a., which would have required the mission computer software CDR to be completed before awarding the Lot III production contract. The Air Force and Douglas consider the mission computer CDR to be completed, as evidenced by the exercise of the FY 1989 contract option. Accordingly, we revised our recommendation in the final report to require that the software design review of the mission computer software be completed before awarding the FY 1990 production contract. We request management comments on the revised recommendation. The Air Force also nonconcurred in Recommendation B.2.a., which recommended setting a completion date for Douglas to finalize and issue an avionics integration test plan, because avionics planning is an evolutionary process, and updated versions of an Avionics Integration Test Plan were

submitted by Douglas in April 1990 and in July 1990. In addition, the Air Force nonconcurred in Recommendation B.2.c., to obtain compensation to the Government from Douglas for missed contractual milestones, because the process to obtain the compensation had begun before the audit was initiated. We believe Recommendations B.2.a. and B.2.c. are still warranted for the reasons discussed in Part II of the report.

DoD Directive 7650.3 requires that all audit recommendations be resolved within 6 months of the date of the final report. Accordingly, the Under Secretary of Defense for Acquisition and the Air Force should provide final comments on the unresolved issues in this report within 60 days of the date of this memorandum.

The courtesies extended to the audit staff are appreciated. A list of audit team members is in Appendix G. Copies of this report are being provided to the activities listed in Appendix H. If you have any questions on this audit, please contact Mr. Ronald Porter on (703) 693-0163 (AUTOVON 223-0163) or Mr. John Mundell on (703) 693-0168 (AUTOVON 223-0168).

Robert J. Lieberman
Assistant Inspector General
for Auditing

Enclosure

cc:
Secretary of the Air Force

SELECTED ACQUISITION ACTIONS ON THE C-17 AIRCRAFT

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Prepared By:
Readiness and Operational
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Project No. 0RA-8001

SELECTED ACQUISITION ACTIONS ON THE C-17 AIRCRAFT

PART I - INTRODUCTION

Background

The C-17 aircraft is being developed to provide additional capability to the Air Force to airlift the full range of DoD cargo and to provide military capabilities currently not available in any one cargo aircraft. The C-17 aircraft would help to attain a fiscally constrained goal established in 1981 for an intercontinental airlift of 66 million ton-miles[1/] per day. The C-17 is being designed to land on austere airfields as short as 3,000 feet to deliver cargo directly to user forces.

A DoD Hotline complaint alleged that the Air Force inappropriately exercised a contract option in July 1989 to buy four C-17 aircraft for $691 million and that the status of C-17 software development was worsening. The full-scale development (FSD) contract with Douglas Aircraft Company (Douglas), McDonnell Douglas Corporation, required the procuring contracting officer for the C-17 System Program Office to determine that the critical design review (CDR) of the mission computer was complete before exercising the production option for FY 1989. The complainant, who was granted anonymity, alleged that not all of the software for the mission computer was reviewed during the CDR conducted April 10 to 14, 1989. It was further alleged that certain deficiencies identified during the CDR were not corrected before the FY 1989 procurement option was exercised. In addition, the complainant alleged that Douglas's replacement of the subcontractor for the electronic flight control system and assumption of responsibility for the software for the mission computer from another subcontractor indicated that the status of software development was worsening. The complainant also alleged that at a late point in the program, Douglas planned to replace another subcontractor that was developing an avionics subsystem. The complainant's overriding concern was that the management of the software development process by the Air Force and Douglas appeared to increase the risk that the C-17 aircraft would not be developed on time and in an economical manner, and that expensive retrofits of the aircraft might be required after aircraft delivery.

At the time of our audit, the Air Force planned to buy 210 C-17 aircraft at a total cost of about $41.8 billion. In April 1990, due to reductions in the DoD budget and expectations of greater warning of a possible attack, the Secretary of Defense planned to reduce the procurement quantity to 120 C-17 aircraft at a total

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1/ A ton-mile is one ton of cargo flown one mile.

cost of $29.9 billion. The FSD contract with Douglas provides for the design, development, and testing of the aircraft and the production of two ground test aircraft and one flight test aircraft. The fixed-price incentive, firm-target contract has a target price of $4.2 billion. In addition, the FSD contract includes two production options. The first option for two aircraft (Lot I) was exercised on January 20, 1988, for $604 million. The second option for four aircraft (Lot II) was exercised on July 28, 1989, for $691 million. As of the time our audit concluded, the Air Force was preparing to negotiate a production contract to acquire additional C-17 aircraft. The last C-17 will be procured in FY 1997.

Objectives and Scope

The objectives of our audit were to review the circumstances and documentation relating to the contract option exercised in July 1989 to buy four C-17 aircraft for $691 million from Douglas and to assess the status of software development for selected C-17 subsystems. We also evaluated whether the program development schedule was realistic. During our audit, we obtained information on the CDR done in April 1989 for the C-17 mission computer software and on the development of software for selected C-17 subsystems. We examined records of C-17 program reviews dated from August 1988 through February 1990 and documentation dated from December 1985 through February 1990, which included program plans, development schedules, and the C-17 FSD contract. We interviewed officials at OSD, the Air Force, Douglas, and Douglas's subcontractors involved in the C-17 acquisition program. Our technical assessment staff assisted the auditors in evaluating systems engineering and software development efforts and results, C-17 program contracting practices, and software quality assurance procedures. Although we focused the scope of our audit primarily on software development and on whether the mission computer software CDR was completed, we noted some hardware development problems that are discussed in Part II of the report.

This economy and efficiency audit was conducted from October 24, 1989, through February 2, 1990, 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. The activities we visited during the audit are listed in Appendix F.

Internal Controls

We reviewed internal controls relating to our audit objectives. In assessing internal controls, we evaluated control techniques such as management plans, written policies, design reviews,

contractual provisions, and independent software reviews. No material internal control weaknesses were identified during the audit.

Prior Audit Coverage

Since October 1984, four audit reports were issued that discussed C-17 aircraft issues falling within the scope of this audit.

- Inspector General, DoD, Audit Report No. 89-059, "Acquisition of the C-17A Aircraft," March 20, 1989. This audit reviewed nine elements of the C-17 program management critical to the full-scale development phase of the program. It identified the on-time development of properly operating software as the biggest risk to the program. The report recommended that the Air Force require Douglas to establish an acceptable quality assurance program for software development. To establish an adequate software quality assurance program, the Air Force and Douglas agreed to a tailored version of Military Specification 52779A (MIL-S-52779A) and made it part of the FSD contract. The tailored MIL-S-52779A deleted the requirement for the quality assurance plan to provide for detecting, reporting, analyzing, and correcting software problems and deficiencies. At the same time, the tailored version of MIL-S-52779A retained paragraph 3.2.9, which requires the quality assurance plan to reference or document procedures assuring the prompt detection, documentation, and correction of software problems and deficiencies. Based on the results of the current audit, we believe that procedures referenced or documented in the quality assurance plan should be the procedures actually used by Douglas.

Report No. 89-059 also recommended that the Air Force improve guidance on the performance of either internal independent verification and validation (IIV&V) or independent verification and validation (IV&V) of software. The Air Force nonconcurred with improving guidance for IIV&V and IV&V stating that Air Force Regulation 800-14, "Life-cycle Management of Computer Resources in Systems," September 29, 1986, gives program directors the latitude to tailor program requirements based on the program risk. Changes made to the Aeronautical Systems Division (ASD), Air Force Systems Command, policy after the issuance of the report have lessened the concerns, because the new policy recognizes that using IIV&V for all contracts would be inappropriate. The principal concern was that ASD's former policy required the application of IIV&V as the sole means to accomplish IV&V. In deciding how to accomplish IV&V, program directors and their computer resource working groups should review the contractor's prior experience and the Air Force's capability to monitor software development progress. ASD's revised policy, to allow, but not to mandate IIV&V, provides the flexibility needed by the program directors to select the most appropriate method of IV&V.

The report further recommended that the Air Force fund and start an IV&V effort for the C-17 program. The Air Force nonconcurred with starting an IV&V effort stating that it was too late in the program's development to be beneficial. However, in 1987, the Air Force had requested Douglas to do IIV&V of flight critical software at no additional cost to the Government. In 1989, Douglas tasked the Space Systems Company of the McDonnell Douglas Corporation to conduct an IIV&V effort for the flight critical software for the C-17. The Space Systems Company, a corporate component independent of Douglas, can provide an independent and effective evaluation of the flight critical software for the C-17 through the use of IIV&V. Accordingly, the intent of the recommendation in Report No. 89-059 is considered met.

- Inspector General, DoD, Audit Report No. 89-067, "Review of the C-17 Cargo Aircraft Program as a Part of the Audit of the Effectiveness of the Defense Acquisition Board Process," April 6, 1989. This audit evaluated the C-17 program compliance with applicable DoD acquisition directives and instructions. It concluded that the planned Defense Acquisition Board (DAB) review in October 1990 of an Air Force request to procure 10 C-17 aircraft in FY 1991 and 20 C-17 aircraft in FY 1992 would represent a de facto full-rate production decision normally made at a Milestone IIIB review. The scope of the planned October 1990 DAB review was challenged because the results of the operational readiness evaluation and initial operational test and evaluation would not be known. The report recommended that the scope of the DAB review be reduced to the low-rate initial production quantity of 10 aircraft per year established at the Milestone IIIA (low-rate initial production) review held on December 5, 1988. OSD nonconcurred stating that the recommendation was judgmental and did not allow for improvements in production capability obtained from increasing production quantities. In response, the auditors maintained that the DAB should exercise caution in approving large procurement quantities of C-17 aircraft before operational test results are known.

In the FY 1990 Appropriations Act for DoD, Congress defined low-rate initial production for all programs, except naval vessels and satellites, as the minimum quantity necessary:

> (1) to provide production-configured or representative articles for operational tests pursuant to section 2399 of this title;
>
> (2) to establish an initial production base for the system;
>
> (3) to permit an orderly increase in the production rate for the system sufficient to lead to full-rate production upon the successful completion of operational testing.

Budget reductions made by the Congress because of development difficulties reduced C-17 procurement quantities for FY's 1990, 1991, 1992, and 1993 from 6, 10, 20, and 29 aircraft, respectively, to 4, 6, 12, and 24 aircraft, respectively. OSD officials stated that the revised procurement quantities represented a more gradual production increase and were consistent with the new congressional definition of low-rate initial production. The Secretary of Defense's decision on April 26, 1990, to reduce the total procurement quantity from 210 C-17 aircraft to 120 C-17 aircraft will further reduce the number of C-17's to be purchased each year. Accordingly, the intent of the recommendation in Report No. 89-067 is considered met.

- General Accounting Office (GAO) Report No. NSIAD-88-160 (OSD Case No. 7590), "DoD Acquisition Programs - Status of Selected Systems," June 30, 1988. GAO reported information on requirements, schedule, performance, cost, and funding for the C-17 aircraft and 22 other DoD acquisition programs. GAO reported that Air Force and contractor officials believed that the C-17 program faced technical performance-related challenges relating to hardware and software. These challenges included maintaining the aircraft's operating weight at 268,000 pounds and integrating the avionics into the aircraft in a timely manner. The GAO report did not contain any recommendations. We discuss problems in developing and integrating avionics software in Finding B of this report.

- GAO Report No. NSIAD-89-195 (OSD Case No. 7992), "C-17 Faces Schedule, Cost, and Performance Challenges," August 18, 1989. GAO reported that the C-17 Program Director considered it unlikely that the aircraft's first flight date, planned at that time for August 1990, would be met. The program's capability to meet a revised first flight date of December 1990[2/] was dependent on Douglas's ability to resolve assembly and avionics development difficulties. GAO's report discussed delays incurred in the development of the mission computer system and the electronic flight control system. GAO did not make any recommendations. We discuss similar problems in meeting development milestones and in developing avionics software in Finding B of this report.

2/ In December 1989, the Air Force revised the first flight date to June 1991.

PART II - FINDINGS AND RECOMMENDATIONS

A. Mission Computer Software Critical Design Review

FINDING

The C-17 System Program Office (SPO) exercised the FY 1989 contract option to buy four C-17 aircraft before Douglas Aircraft Company (Douglas) completed the required critical design review (CDR) of all mission computer software. Completion of the CDR, a prerequisite to exercising the option, was required by a November 1988 modification of the full-scale development (FSD) contract. The C-17 Program Director considered the CDR, made in April 1989, to be adequate and complete, even though Douglas had completed the detail design for only about 60 percent of all software in the mission computer. The C-17 program development has already experienced major delays, and unless all required mission computer software is developed before the C-17 passes from the developmental test and evaluation phase to the operational test and evaluation phase, the C-17 program schedule will be further delayed.

DISCUSSION OF DETAILS

Background. The FSD contract required the Air Force to exercise the FY 1989 production option (Lot II) for up to six aircraft on or before January 31, 1989, regardless of the program's development status, or the Air Force would have to renegotiate the option price. Before convening the Defense Acquisition Board (DAB) in 1988, OSD officials expressed concern about the appropriateness of exercising the FY 1989 production option when major delays were being experienced in the program's development. In response to this concern, the C-17 Program Director initiated an event-based contract award strategy for FY's 1989 through 1992. The Program Director stated that the purpose of this strategy was to encourage Douglas to demonstrate confidence in its capability to develop the C-17 aircraft on schedule and to give the Program Director added flexibility to influence Douglas. The event-based strategy was similar to a strategy outlined in the Air Force Systems Command Supplement to the Federal Acquisition Regulation, subparagraph 17.270, "Demonstration Milestones." The subparagraph provides that for FSD contracts with production options, the option exercise period shall be tied to and be contingent on the contractor's satisfactory demonstration of its ability to deliver the items in the option.

FSD Contract Modification. In November 1988, the Air Force modified the FSD contract to specify certain program events that had to take place annually before aircraft would be procured in FY's 1989 through 1992 (see Appendix A). However, to give the Government flexibility, the contract modification also provided that the Government could buy the aircraft even if annual program events were not completed. In addition to establishing program milestone events, the FSD contract modification stated that a production contract could not be awarded until the milestone event for FY 1990 was accomplished. Furthermore, the production contract, when awarded, would make FY 1991 and 1992 procurements contingent on the successful completion of milestone events described in the FSD contract modification.

The Mission Computer CDR. The exercise of the procurement option for FY 1989 was made contingent on the procuring contracting officer's determination that the mission computer CDR was complete, because the C-17 Program Director believed that the CDR would be the most significant measurable event to occur in FY 1989. In addition, development of the mission computer is crucial to complete the overall avionics integration and to keep the program on schedule. Douglas and the Air Force did a CDR of the C-17 aircraft in 1988, for which Douglas provided the mission computer's hardware design, but not its software design. During the CDR, the Air Force determined that a lack of progress in the mission computer development was a serious problem. As a result, the SPO withheld $5.4 million in payment to Douglas pending successful completion of the CDR of mission computer software.

The FSD contract required CDR's of the subsystems being developed by Douglas's subcontractors to be done in accordance with the intent of Military Standard 1521A (MIL-STD-1521A), "Technical Reviews and Audits for Systems, Equipments, and Computer Software." The Military Standard states that a CDR of software shall be conducted when the detail design is essentially complete. According to the Military Standard, the purpose of a CDR of software is to determine if the detail design of software satisfies performance and engineering requirements. The primary product of the CDR is the identification of specific computer programming documentation that may be released for coding and subsequent testing. CDR's may be tailored to the level of review appropriate to the weapon system and its subsystems. Accordingly, a simple off-the-shelf system may not need a CDR, whereas a complex system comprised of an aggregate of subsystems may require that the CDR be done in increments as the subsystems are developed.

Because the mission computer for the C-17 aircraft is complex, its CDR was being done in increments. The mission computer acts as the heart of the automated avionics system and performs

functions normally done by the flight engineer. It receives data from other systems, analyzes data, performs calculations, and displays information to the pilot and copilot. Douglas and its subcontractor for the mission computer, Delco Systems Operations (Delco), General Motors Corporation, made incremental reviews of the mission computer hardware and the software (three reviews of hardware, one review of software) during May through August 1988. Douglas and Delco intended for the review of the mission computer software in April 1989 to be the final increment of the mission computer CDR.

Before August 1988, Delco planned to complete all mission computer software before the C-17's first flight, then scheduled for August 1990. In August 1988, an independent review team that included personnel from McDonnell Douglas, Douglas, Hughes Electronics, and the Air Force concluded that mission computer software requirements were not well defined, but that not all software was required before the C-17's first flight. Based on the results of the independent review team, the mission computer software development was divided into two new segments. The first segment, FT1, consisted of software needed for the first 100 hours of flight testing. The second segment, FT2, consisted of all FT1 and residual software needed for the aircraft and would be used for testing and evaluating the avionics system. FT1 and FT2 were interdependent; any change to FT1 would affect the design and coding of FT2. Changes to FT2 need not affect FT1, because FT2 included some independent functions. Despite the change in the software development strategy, Douglas continued to plan for a single CDR of all mission computer software. The auditors were told that the SPO engineers were concerned that the FT2 software would not be ready for the 1989 CDR, and that the SPO engineers wanted Douglas to perform a review of all the software after the CDR was performed. However, we found no evidence before the FSD contract was modified in November 1988 to incorporate the event-based strategy that Douglas agreed to do a software review after the CDR, or that the time and scope of that software review was decided.

Scope of the Mission Computer CDR. In our opinion, the CDR of the mission computer software was a significant event; however, it demonstrated that a well-defined transition point was not attained between detail design and coding and testing of all mission computer software. The CDR was important to SPO officials, because it was the first time that the Air Force could see how Douglas planned to implement the mission computer functions. According to the CDR plan prepared by Douglas in February 1989, the objective of the CDR was to review Delco's detail design solutions to show that Delco's design would satisfy contractual requirements. According to the plan, CDR tasks included discussion of performance and design requirements, a thorough review of the software design concept and detail design and an evaluation of overall development status. To perform the

CDR, the plan required that 95 percent of the software requirements be defined, 80 percent of the overall top-level software design be completed, and 90 percent of the detail design of the software needed for FT1 be completed. Only 60 percent of the detail design for software for the mission computer was needed for FT1. Although the CDR plan also called for the completion of 50 percent of all detail design for software before the CDR, this criterion could be met without any FT2 detail design. Before performing the CDR, the SPO chief avionics engineer determined that although mission computer software requirements and design were done in accordance with provisions in the CDR plan, they were not sufficiently complete. Because only the detail design of the FT1 software was to be essentially completed for the CDR, the chief avionics engineer concluded that the mission computer represented a high risk (likely to affect performance, schedule, or cost even with contractor emphasis and close Government monitoring).

Performance of the Mission Computer CDR. Although prerequisites to performing the CDR were technically met, the CDR did not include a review of the detail design of software for FT1 or FT2 as required by the CDR plan. From April 10 to April 14, 1989, Douglas performed the CDR of the mission computer software being developed by Delco. The Air Force's participation was limited to asking questions, because the FSD contract makes Douglas totally responsible for developing the aircraft. Two Air Force participants in the CDR told the auditors that overall software requirements and FT1 and FT2 top-level designs for the mission computer were discussed during the CDR, but no detail designs for software were discussed in-depth. According to the two participants, Delco officials turned aside questions about the FT1 detail design saying the design was available for review in a library of software. During the audit, Delco officials told the auditors that the FT2 detail design, which was only 8 percent complete at the time of the CDR, was not presented. The auditors were told by a SPO official that because of time limitations, the principal objective of the CDR was to determine if Delco understood system requirements and not to determine if Delco had completed the detail design of FT1. The SPO official stated that the top-level design and the detail design of a few FT1 software modules were reviewed to check Delco's understanding.

We audited Air Force, Douglas, and Delco actions taken to correct nine review items written by the Air Force and Douglas during the mission computer software CDR. Review items are critical deficiencies. The C-17 Program Director required that the review items be corrected or that corrective action plans be developed before the FY 1989 production option would be exercised. We determined that the corrective action plans as briefed by Douglas to the Air Force on June 5, 1989, were adequate. We believe that the corrective action plans provided a sufficient basis to consider the review items corrected, because the corrective work

required several months to complete and posed no obstacle to development of the mission computer if not corrected immediately. The review items and the status of the corrective actions as of February 2, 1990, are summarized in Appendix B.

Completion of Mission Computer Software. The performance of the mission computer software CDR in April 1989 was instrumental in Douglas and Delco developing a plan to complete the mission computer and in resolving management difficulties between Douglas and Delco. During the CDR, the Air Force requested a plan for completing the mission computer software, but Delco did not provide a plan. The last review item (Air Force-065) was written by the Air Force to force Delco to prepare a plan for completing the mission computer software. Ultimately, Douglas presented a plan to the SPO on June 5, 1989. The plan proposed a software design review in October 1990 [3/] to review the detail design of FT2. Although scheduled as a software design review, SPO officials stressed that the software design review would not be reduced in importance from the CDR. The SPO officials added that the software design review was not called a CDR because the CDR occurred in April 1989, and the October 1990 review required less preparation by the participants. The SPO officials stated that, except in name, the software design review will constitute a CDR of FT2 software.

Before exercising the 1989 option, the C-17 Program Director wanted Douglas and Delco to agree on their respective responsibilities in completing the mission computer work and to commit to meeting the program schedule. Douglas and Delco officials told us that during the CDR, Delco was unwilling to commit to a plan for completing the mission computer software due to a poor working relationship with Douglas. The changes clause in the contract between Delco and Douglas provided that Douglas could make changes within the general scope of the contract without compensating Delco. Delco believed that Douglas was initiating software requirements changes that were unreasonable and that were outside the contract scope. Moreover, Delco officials told us that the expense of making the changes was becoming onerous.

On July 18, 1989, Douglas and Delco signed a memorandum of agreement that curtailed Delco's role in developing the mission computer software. Douglas terminated Delco's responsibility for mission computer software system engineering, development, and integration and testing, but retained Delco personnel to continue working on the C-17 project. Delco remained responsible for developing mission computer hardware and software test equipment. On July 24, 1989, Douglas's vice president-general manager for

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[3/] We were informed on October 22, 1990, that the software design review had been rescheduled to December 1990.

the C-17 wrote to the C-17 Program Director stating that the mission computer CDR could be considered completed based on the development of a plan for completing the mission computer software and on Douglas's assumption of management responsibility from Delco for the mission computer software. Delco's general director advised Douglas in a letter dated July 27, 1989, that Delco's corporate parent, Delco Electronics Corporation, considered the memorandum of agreement with Douglas to be acceptable. The C-17 Program Director believed that this commitment from Delco and Delco Electronics Corporation provided adequate assurance that measures were in place to complete development of the C-17 mission computer software.

The C-17 Program Director considered the CDR to be completed based on the review of the top-level software design in April 1989 and on management actions taken by Douglas. He did not consider the "software design review" then scheduled for October 1990 to be part of the CDR or to have any bearing on the event-based contract award strategy. The SPO exercised the contract option to buy four C-17 aircraft on July 28, 1989. Additional problems in developing mission computer software are discussed in Finding B of this report.

We believe that the April 1989 CDR represented an excellent opportunity for the SPO and Douglas to assess the mission computer software development status and to assess Delco's understanding of the mission computer requirements. However, in our opinion, the CDR was not complete because it did not include a review of the detail design of the mission computer software. Although MIL-STD-1521A allows the criteria for conducting CDR's to be tailored to meet specific program needs, the criteria should be rigorous when the software development task is complex and the software developers lack experience, as was the case with the C-17 mission computer. We believe that to perform the CDR in April 1989 was premature because of the interdependency of FT1 and FT2 software, because the SPO and Douglas knew that significant mission computer software development problems existed, and because only 60 percent of the overall detail design for software was complete. In our opinion, the April 1989 CDR only when taken together with the software design review to be done in late 1990 constitutes a completed CDR of the mission computer software. Although the C-17 Program Director had the prerogative to exercise the contract option at any time, notwithstanding CDR results, we believe that he should not have considered the CDR to be completed.

Future Milestone Event. The milestone event for FY 1990 in the FSD contract needs to be better defined by the C-17 Program Director to eliminate possible future misunderstandings. The milestone event makes procurement of up to six aircraft in 1990 contingent on final assembly of the T-1 (test aircraft), scheduled to be completed in December 1990. At the end of our

audit, Douglas and the Air Force were attempting to agree on the meaning of "T-1 final assembly," and on which components could be missing and still have the test aircraft be considered assembled.

OSD Oversight. Members of the DAB Conventional Systems Committee (the Committee) were unaware that the CDR of C-17 mission computer software done in April 1989 was not a comprehensive review of the detail design of mission computer software. In preparation for the Milestone IIIA (low-rate initial production) review in December 1988, the C-17 Program Director had informed the Committee that the software was being developed in increments, and that the first increment included software required for the first 100 hours of flight testing. The C-17 Program Director's program status briefing to the Committee in November 1988 indicated that the CDR would be completed in March 1989 and provided the status of the software development. A briefing chart showed that as of November 10, 1988, 55 percent of the top-level design and 36 percent of the overall detail design was completed. OSD officials informed the auditors that no Committee members had expertise in computer software developments. If experts in software developments had been present during the program status briefing, we believe the Committee would have questioned more rigorously whether Douglas would be able to complete all detail design by the scheduled CDR, or would have advised against doing the CDR with so much of the total detail design yet undone. An OSD official indicated that although the Committee still might have recommended approval of the FY 1989 procurement, if members of the Committee had expertise in software developments, it might have recommended that completion of a CDR of all mission computer software be a prerequisite to the FY 1990 buy. At the Milestone IIIA review, the DAB approved C-17 procurements for FY's 1989 and 1990 and an advance procurement in FY 1990 for FY 1991 production contingent on only the attainment of each program milestone event stated in the FSD contract.

The Office of the Deputy Director of Defense Research and Engineering (Research and Advanced Technology), Office of the Under Secretary of Defense for Acquisition, is responsible for many functions, one of which is software development policy for mission critical computer systems. With only one seat on the Committee, this office is unable to send individuals with expertise in software and in all other system development areas to the Committee meetings. Furthermore, software development experts in Research and Advanced Technology perform other functions that detract from the time needed for weapon system reviews. We believe that sufficient personnel having expertise in software development matters should be present at Committee meetings to provide effective oversight of software developments.

Following our audit, we learned that, as part of the reorganization of the acquisition management structure, OSD had

proposed steps to improve the oversight of software development. On February 9, 1990, the Deputy Director of Defense Research and Engineering (Research and Advanced Technology) published for review and comment a preliminary draft of a DoD Software Master Plan. The draft master plan identifies 27 actions to meet challenges facing DoD that relate to software development, utilization, and cost. Included is a proposal to establish single offices at OSD and the Military Department levels for managing and implementing software acquisition and life-cycle management policies. The plan also includes a proposal to revise policy directives and instructions to ensure that software development matters are addressed by the DAB. We believe that establishing these offices and revising the policy directives and instructions will help ensure that software developments are properly addressed by the DAB and its subordinate committees.

Conclusion. We support the Air Force's use of the event-based contract award strategy for the C-17 aircraft. However, we believe that milestone events used in the strategy should contain definitive criteria to exercise contract options to ensure that the Government and the contractor fully understand contractual requirements. Personnel with technical expertise providing oversight in software developments would help ensure that acquisition programs heavily reliant on software receive the appropriate scrutiny before procurement decisions are made.

RECOMMENDATIONS FOR CORRECTIVE ACTION

1. We recommend that the Under Secretary of Defense for Acquisition require that individuals with appropriate technical expertise attend meetings of the Conventional Systems Committee of the Defense Acquisition Board when their oversight of software development matters is needed.

2. We recommend that the C-17 Program Director, Air Force Systems Command, amend the C-17 full-scale development contract with Douglas Aircraft Company to:

a. Require completion of the software design review of the mission computer software as a precondition to awarding the Lot III production contract to procure four aircraft for FY 1990.

b. Specify the minimum assembly required to consider the test aircraft (T-1) assembled for the milestone event for Lot III.

MANAGEMENT COMMENTS

The Director of Defense Research and Engineering nonconcurred with Recommendation A.1., because principals of the Committee are allowed to bring supporting staff members with relevant expertise to meetings. The Director agreed with the intent of the

recommendation to strengthen oversight of software development, and agreed that actions proposed in the preliminary draft of the DoD Software Master Plan would strengthen software oversight. A complete text of the comments is in Appendix C.

The Air Force's Deputy Assistant Secretary (Acquisition) nonconcurred with the finding and the recommendations. He stated that Douglas met all requirements of the CDR and that the Air Force and Douglas considered the CDR to be completed. He indicated that the auditors used an academic definition of a CDR rather than what had been agreed to by the Air Force and Douglas. Although he nonconcurred with Recommendation A.2.a., he stated that the "SPO and DAC [Douglas Aircraft Company] have reached an agreement on a more precise definition of the T-1 assembly complete milestone." Complete comments are provided in Appendix D.

AUDIT RESPONSE TO MANAGEMENT COMMENTS

Regarding Recommendation A.1., the Committee's policy of allowing principal staff members to bring individuals with the relevant technical expertise to Committee meetings could provide proper oversight, provided the experts do attend the meetings. However, individuals with technical expertise in software matters did not attend Committee meetings on the C-17 prior to the DAB review in December 1988, despite the fact that the C-17 Program Director had identified software as one of his primary concerns with the program. We believe that proper OSD oversight of software developments on major weapon systems in general and the C-17 avionics system in particular demands that software experts regularly participate in DAB milestone decisions. We agree with the Director that principal members can bring staff with relevant expertise to Committee meetings when their oversight is needed and we have revised the recommendation accordingly. Therefore, we ask that management provide comments on revised Recommendation A.1. in response to the final report.

Regarding Recommendation A.2.a., the auditors evaluated the CDR in accordance with the definition contained in MIL-STD-1521A. We could find no evidence that the Air Force and Douglas had agreed to anything less than a complete CDR before the contract's modification in November 1988. The contractual language of Special Provision H-111 (see Appendix A) does not indicate that less than a complete CDR was contemplated or agreed on. The CDR plan, developed in February 1989, provided criteria for holding the CDR. As discussed on page 9, the criteria allowed the CDR to occur before the detail software design of the total mission computer was essentially completed. We maintain that the Program Director should not have considered the CDR to be completed, because only about 60 percent of the detail design was completed. However, we accept that both the Air Force and Douglas consider the CDR to be completed. Because the mission

computer is critical for full operational performance of the C-17 aircraft, we believe it is important that the Air Force not commit to procuring more C-17 aircraft until the software design review of FT2 is completed. We ask that management reconsider its position on Recommendation A.2.a. in response to the final report.

Although the Deputy Assistant Secretary (Acquisition) nonconcurred in Recommendation A.2.b., the actions taken by the Air Force to obtain a definition of T-1 assembly meet the intent of the recommendation. Accordingly, additional management comments on Recommendation A.2.b. are not required.

B. Engineering Planning and Subcontractor Management

FINDING

Douglas had not fully accomplished technical requirements to meet contractual milestones for the development of the C-17 aircraft and had not prepared an adequate integration test plan for the development and integration of software for the avionics system. The total performance responsibility contract that the Air Force has with Douglas does not specify all management plans necessary for the successful development of the C-17 program and restricts the actions of the SPO to ensure that milestones are accomplished. Delays in the development of the aircraft have caused the Air Force to postpone major program milestones, and further delays may occur.

DISCUSSION OF DETAILS

Background. The C-17 full-scale development (FSD) contract, F33657-81-C-2108, places total system development responsibility on Douglas. Special Provision H-21 states:

> The Contractor hereby accepts Total System Responsibility for the C-X Transport Aircraft whether or not such systems (or subsystem, components thereof, or CFP [contractor-furnished property]) are fabricated, manufactured, or assembled by the prime contractor, subcontractor . . . or furnished as GFP [Government-furnished property].

The C-17 contract Special Provision H-9, "Subcontractor Management," holds Douglas responsible to effectively manage subcontractors and to ". . . apply special management emphasis in surveillance of major/critical subcontractor's performance to provide reasonable assurance that contractual requirements will be met." The C-17 contract lists critical program milestones in Special Provision H-11, "Demonstration Milestones," and Special Provision H-111, "Prerequisite to Outyear Production Award." Special Provision H-11 establishes contractual milestones for developing the aircraft. Special Provision H-111 stipulates events that must be accomplished before procuring aircraft during FY's 1989 through 1992 and is discussed further in Finding A.

The Government has no legal basis to direct the actions of a subcontractor except through the prime contractor. This prohibition is referred to as the no privity rule. Privity of contract means that relationships exist only between the Government and the prime contractor, between the prime contractor and the first tier subcontractor, and so on.

Performance Specifications. A specification is a description of the technical requirements for a material, product, or service, including the procedure by which it will be determined that the requirements have been met. A detail design specification tells the contractor exactly what to build and how to build it. For developmental programs such as the C-17, the detail design specification is not established until the functional and physical configuration audits are completed. A performance specification tells the contractor the performance characteristics that the system must have in order to be accepted by the Government. With the exception of certain military design standards that must be observed, the prime contractor is free to devise any design that will meet these performance specifications. Performance specifications allow contractors to use existing commercial products instead of developing new items.

Performance specifications are good for the Government because they place responsibility for designing and developing the system on the contractor who has the necessary expertise, resources, and profit-oriented motivation. However, the prime contractor must fully understand the system requirements, be technically capable of developing the system, and have management controls in place to ensure that performance requirements can be met. To help ensure that the contractor is competent and properly organized, Air Force Systems Command (AFSC) Regulation 800-21, "Subcontracting Management," July 16, 1987, requires the SPO to communicate with the prime contractor and to evaluate the prime contractor's subcontracting and program management to ensure that management "operates in a preventive rather than reactive mode."

Program Technical Requirements. Contractor and SPO officials told the auditors that Douglas and the Air Force initially underestimated the difficulty of developing the C-17 aircraft because they assumed that the program had low technical risk and low schedule risk. Douglas and the Air Force believed that the C-17 development program had low technical risk because the design of the C-17 relied heavily on demonstrated technologies. Although no new technologies have been developed for the C-17, the aircraft is a new cargo airlifter that is dependent on a complex integrated avionics system to reduce the aircrew size to two pilots and one cargo loadmaster. In our opinion, Douglas did not recognize the schedule risk because the C-17 was Douglas's first attempt at developing a modern military cargo aircraft, and because Douglas lacked experience in integrating complex avionics systems. Military cargo aircraft must be capable of airdropping cargo and personnel, operating into and out of austere airfields, and performing other missions not required of commercial aircraft.

Douglas selected subcontractors with the specialized skills to develop 64 subsystems for the avionics system and gave its subcontractors general system requirements for developing the

subsystems. Subcontracting the complete development of subsystems is Douglas's normal business practice, and it is an effective strategy when requirements are straightforward. However, the lack of detailed requirements and timely guidance caused subcontractors to experience problems in developing the subsystems.

Electronic Flight Control System. On June 12, 1986, Douglas awarded a firm-fixed-price contract to Sperry Corporation, which was later purchased by Honeywell, Inc., to develop a flight control system for the C-17. The proposed design was for a dual-channel, hybrid fly-by-wire and hydromechanical flight control system. In a fly-by-wire system, hydraulic actuation of aircraft control surfaces (e.g., slats, flaps, rudders, and stabilizers) is controlled electronically rather than mechanically. In May 1987, Douglas directed Honeywell to change the flight control system to a quadruple-redundant, digital, fly-by-wire system, with mechanical backup. Douglas directed this change after confirming that in wind tunnel tests, the aircraft configuration and original flight control system could allow the pilot to put the aircraft into an uncontrollable stall during certain tactical maneuvers. The potential for a stall was initially identified in 1985 during a preliminary design review for the overall aircraft design. The change in flight control systems forced Honeywell to redefine the subsystem requirements; however, the program development schedule was not changed. In order to fully define the subsystem requirements and to be able to design the flight control hardware and software, Honeywell first had to determine how the electronic flight control system (EFCS) interacted with subsystems being developed by other subcontractors and to prepare an interface control document (ICD) defining the software interactions between subsystems. Honeywell did not complete the ICD until July 1989.

During 1988 and 1989, Douglas grew increasingly concerned about Honeywell missing schedule milestones. In November 1988, Honeywell identified a 7-month schedule delay for the first software engineering development units. In March 1989, Honeywell and Douglas signed a memorandum of agreement (MOA) that identified a further delay of 4 months in the development schedule. In April 1989, an Air Force review team determined that stronger communications were a must between Douglas and Honeywell on system and interface issues. On June 6, 1989, Honeywell identified an additional 7-month delay from the delivery date in the March 1989 MOA, and established April 25, 1991, as the new date for delivering flight qualified software. On June 16, 1989, Douglas and Aircraft Electronics Division,

General Electric (GE), signed an MOA for GE to develop an EFCS concurrently with Honeywell. On July 21, 1989, Douglas ended Honeywell's contract for the EFCS.

To develop the EFCS, GE was using its previously developed hardware and software and the ICD developed by Honeywell. GE had developed similar systems for the B-2, F-15E, and F-18 aircraft. GE was developing the EFCS in two increments and was working ahead of its schedule to deliver the first increment by October 31, 1990, when it is needed for avionics integration. Although GE had committed resources to the program and was developing the system for the C-17, at the end of our audit, Douglas still had not finalized the terms and conditions of GE's contract. We were told by Douglas and GE officials that contract negotiations were in process.

Mission Computer. Douglas awarded a firm-fixed-price contract to Delco on July 10, 1986, to develop the mission computer. In August 1988, an independent review team that included personnel from McDonnell Douglas, Douglas, Hughes Electronics, and the Air Force concluded that system engineering had been inadequately accomplished and that the mission computer system requirements were not adequately defined. During late 1988 and early 1989, Douglas and Delco tried to establish the baseline requirements. Although development of the baseline requirements served as a means to force Douglas and Delco to discuss requirements, Delco officials stated that documented baseline requirements were not formalized and included in the contract. Delco sufficiently developed the mission computer software to hold a CDR of the detail design in April 1989 for the first of two increments of software. Delco, however, would not commit to a plan for completing the mission computer, because the mission computer requirements and Delco's responsibilities had not been adequately defined. On July 18, 1989, Douglas and Delco signed an MOA that partially terminated Delco's contract for the mission computer subsystem. Douglas assumed the responsibility to manage the overall software development effort for the mission computer. Delco remained responsible for the hardware development portion of the contract. For software development, Delco is providing personnel and equipment on a time and materials basis. On November 30, 1989, Douglas gave Delco a letter contract formalizing the changes in responsibilities.

Douglas's actions kept the software development program from worsening, but the actions clearly indicated that software development for the C-17 program was in serious trouble late in the program. Douglas's management actions may speed up the development of the software for the EFCS and mission computer, but Douglas still faces integrating all the subsystems into a functional avionics system.

Management Plans and Organization. Douglas has not prepared the engineering plans necessary to ensure that the C-17 will be developed on time. In addition, Douglas did not effectively staff the C-17 development with qualified people to manage the program. Two key planning tools that can be used to ensure that contractors have properly defined requirements and set procedures in place to manage major acquisition programs are the systems engineering management plan (SEMP), and the avionics integration test plan. The SPO did not require Douglas to develop a SEMP or its equivalent. We discussed the importance of a SEMP with officials at another Air Force SPO that was responsible for developing a fighter aircraft. That SPO told us that the SEMP was important to ensure that the contractor has adequately planned the development effort. In fact, the SPO for that fighter aircraft had developed a SEMP for its prime contractor.

At the end of our audit, Douglas still had not prepared an adequate avionics integration test plan and had not adequately staffed its management of the C-17 program to perform the test and integration of the avionics system. For reasons discussed in the following paragraphs, we believe that the lack of an effective avionics integration test plan and inadequate staffing for integration testing pose twin risks to the program schedule, especially because the C-17 program is Douglas's first significant effort at integrating a complex avionics system.

Systems Engineering Management Plan. When Military Standard 499A (MIL-STD-499A), "Engineering Management," is included in the contract, a SEMP is required to be submitted within the contractor's proposal. A SEMP is a summary management plan covering the nature, timing, and integration of all technical development activities. The SEMP provides program management organization, systems engineering direction, control mechanisms, and personnel to be used throughout development to satisfy cost, performance, and schedule objectives. MIL-STD-499A was not included in the FSD contract because the C-17 program was considered too dynamic to make comprehensive management plans. As a result, Douglas was not required to prepare a SEMP or its equivalent. Instead, Douglas prepared schedules to depict the program's planned development. We recognize that programs often change as they are developed, but we believe the changes must be effectively managed. A SEMP would have provided Douglas a more disciplined approach to identifying potential program risks, subsystem interfaces, and possible solutions to technical problems in the system development.

Avionics Integration Test Plan and Organization. Douglas had not completed the planning needed to ensure that all necessary subsystems will be tested and integrated in time for the aircraft's first flight in June 1991. Douglas did prepare an avionics integration test plan, dated December 1, 1989, but it was incomplete. The plan did not specify all required tests for

integration of two or more subsystems. The plan also omitted system level tests (tests of the whole avionics system) to be made in the flight hardware simulator of all equipment functions. According to SPO officials, the test plan contained too many concurrent tests and overlapping tests, and allowed too little time for corrections and retesting. Douglas did not establish a date for completing the avionics integration test plan. In 1988, the SPO withheld $1.0 million from Douglas because a CDR of the aircraft determined that the avionics design was not complete and that an avionics integration test plan had not been prepared. The SPO has rejected Douglas's December 1989 test plan as a basis to consider the avionics design and integration plan as complete and to pay the $1.0 million. After completing the integration plan, Douglas must still write the procedures for the individual tests.

SPO and Douglas officials stated that Douglas had not developed the test plan or written test procedures because of personnel shortages. Attempts to hire additional people with the proper skills had failed. Douglas planned to use the same employees to develop and perform integration tests and to develop system level tests of all functions. Because Douglas lacked experience in system integration, SPO officials were concerned that the people writing and performing integration test procedures might not be fully qualified to write the detailed tests needed for system integration. Douglas officials told us that they were getting more experienced staff from corporate headquarters, McDonnell Douglas Corporation, to assist in the effort.

We believe that integration of a functional avionics system remains a major challenge to the successful and timely development of the C-17 program. Although not all integration plans and test procedures demand immediate implementation, reasonable estimates of the amount of time required to complete integration cannot be made until detailed planning is finished. In our opinion, the development schedule does not allow much time to do system level integration if the first flight date of June 1991 is to be met. Subcontractors must complete development of the subsystems and deliver them to Douglas for integration. Although the subsystems may work properly alone, Douglas must ensure that they work together as an avionics system. An analysis made by the Aeronautical Systems Division, AFSC, determined that 48 percent of software design errors are corrected during the system integration phase. Another potential barrier to completing system level testing on schedule was the completion of the flight hardware simulator, originally scheduled for September 1990.

Contractor Management Organization. Douglas did not establish an adequate management structure at the outset of the C-17 program. A more effective organizational structure to better manage the C-17 program was being formed late in the

program. McDonnell Douglas Corporation had begun transferring personnel to Douglas from other corporate components to provide the experience and expertise previously not available at Douglas. In October 1989, Douglas established a general manager's office to provide full-time oversight of the EFCS development. We were told that personnel selected to staff that office were being transferred to Douglas from McDonnell Douglas, St. Louis, Missouri, where they had helped to develop the EFCS for the F-18 aircraft. In another change, Douglas recognized that the complexity of the avionics system demanded that a separate organization be made responsible for avionics development. As a result, Douglas established the position of general manager for the C-17 avionics system. A position of business unit manager for avionics system integration and testing was also established, but as of February 2, 1990, this critical position had not been filled officially. As of the same date, the heads of 2 of 7 business units and 16 of 29 group leaders had not yet been officially appointed to manage the C-17 avionics system development.

In February 1989, in a move affecting all of the programs that Douglas manages, McDonnell Douglas directed Douglas to make a significant change to its management structure. The change affected both military and commercial programs and was intended to put more focus on individual products and customers. The reorganization eliminated four levels of management and gave the vice president-general manager for the C-17 direct control of the resources working on the program. Although the reorganization may have long-term beneficial effects, its implementation disrupted the C-17 program, because supervisors were distracted during the reorganization, and not all supervisors were appointed immediately.

Management Approach by the C-17 System Program Office. Because Douglas has total responsibility for the contract, the SPO Program Director was limited in directing corrective actions to early indicators that subcontractors were having management problems. The C-17 Program Director informed the auditors that he did not seek to direct the actions of Douglas's subcontractors so that the SPO would not relieve Douglas of total performance responsibility and shift schedule risks from Douglas to the Government. To prompt Douglas to make the appropriate decisions and to take the necessary actions, SPO personnel worked closely with Douglas personnel to provide oversight of program management. For example, to check the progress of the program, the Program Director required Douglas to submit reports on "inchstones." In addition, SPO personnel actively participated in technical interchange meetings with Douglas and with the subcontractors to ensure requirements were being communicated and understood. To influence Douglas to adhere to the program schedule, the Program Director implemented an event-based contract strategy. In November 1988, the SPO modified the FSD

contract to make procurements of C-17 aircraft during FY's 1989 through 1992 contingent on Douglas accomplishing specified milestones. Although the event-based strategy is an excellent method to ensure that procurements are made only when appropriate, the Program Director needed to redefine the event for FY 1990 to specify the minimum assembly work to be completed on the T-1 (test aircraft) to consider the T-1 to be assembled.

Award Fee Evaluations. We believe the SPO's formal evaluations of Douglas's management highlighted many of the problems being experienced in the C-17 program development. The SPO provided formal evaluations to Douglas when fixing the amount of award fees earned by Douglas. The FSD contract included a pool of $10 million in award fees to provide an added incentive to effectively develop the C-17. The planned length of the FSD contract was divided into seven award periods, and evaluation criteria were established for each period depending on the management area or principle the Air Force wanted to emphasize. The amount of the award fee earned for each period depended on how well Douglas performed in each evaluation category. Starting with the second award fee period (October 2, 1986, to July 1, 1987), the SPO's evaluation has included comments on weaknesses in Douglas's subcontractor management. For the third award fee evaluation period (July 2, 1987, to April 1, 1988), the SPO criticized Douglas's subcontractor management more specifically. Commenting on Douglas's performance during the fourth award period (April 2, 1988, to April 1, 1989), the SPO stated:

> Tendency to award subcontracts and assume subcontractor will work the problems and deliver on time. This management approach was ill-advised in a number of major subcontracts ([with] Delco, Lockheed, LTV). Definition of subcontractor requirements and formal changes (SCP's [software change proposals]) are not implemented in a timely manner.
>
> Sudden and sometimes inadequately explained schedule slips at major suppliers indicate a lack of depth in understanding of progress and status at the major/critical subcontractors. The capability to anticipate or avoid future problems has been lacking.

The overall rating for the fourth award period for subcontractor management was 30 percent and for program management, 25 percent, down from 71 percent and 85 percent, respectively, for the third award period.

Progress Payments. Federal Acquisition Regulation, subpart 32.503-6, authorizes the contracting officer to withhold progress payments when the contractor has not complied with all material requirements of the contract. Before withholding payments, the contracting officer must notify the contractor of the intended action and evaluate the effect of the withheld payments on the contractor's financial condition. The SPO withheld one progress payment of $15 million based on the results of a CDR of the C-17 aircraft in 1988. At the end of our audit, the SPO had released $6.7 million of the withheld payment based on corrective actions taken by Douglas. On November 14, 1989, the SPO's Administrative Contracting Officer (ACO) issued a letter to Douglas stating that future payments may be withheld because Douglas had not met program schedule inchstones and milestones. On December 6, 1989, Douglas responded that corrective actions had been taken on the development problems and that withheld progress payments would have an adverse financial impact. On January 12, 1990, the ACO informed Douglas that additional withheld payments would be deferred pending further evaluation of Douglas's progress in developing the aircraft and of Douglas's financial condition.

Development of Hardware. Although we concentrated primarily on problems being experienced with software development, during the audit, we noted some difficulties in hardware development. Most significantly, Douglas did not accomplish milestones listed in Special Provision H-11 of the FSD contract to join the wing to the fuselage for the test aircraft (T-1) by July 31, 1989, and to begin assembly of the fourth production aircraft by January 31, 1990. Douglas accomplished the wing-to-fuselage join in March 1990 and rescheduled the assembly start of the fourth production aircraft to July 1990. An August 18, 1989, letter from the SPO to Douglas stated that the delay in joining the wing adversely affected the whole training program for the C-17. The SPO requested Douglas to identify all schedule dates that would be affected by rescheduling the wing join and to submit a revised schedule showing when Douglas would accomplish all contractual milestones. In addition, the SPO asked Douglas to propose compensation to the Government for having missed the milestone for the wing join and to provide rationale for the proposed compensation. At the end of our audit, Douglas had not responded to the SPO's letter. In addition, Douglas had not provided any compensation to the Government for missing the contractual milestones.

The November 1989 Cost Performance Report prepared by Douglas stated that problems had been encountered by two of its subcontractors: Lockheed in the development of wing components, and LTV on the development of horizontal and vertical stabilizers and refueling panels. After the completion of our audit, Douglas decided to replace Lockheed after Lockheed completes the wing components through the sixth C-17 production aircraft. Douglas

decided to obtain other subcontractors for the wing components because Lockheed's costs were increasing. Lockheed officials had stated that additional expenses were incurred after Douglas began changing requirements for the wing components.

The Hotline complainant had expressed concern that, at a very late point in the development program, Douglas was considering replacing its subcontractor, Teledyne, Inc., because of problems in developing hardware. Douglas officials informed us that the panel being designed by Teledyne for the warning and caution system was incompatible with night-vision goggles and exceeded touch-temperature limitations. Douglas had solicited bids from other vendors to develop a suitable panel that could be successfully incorporated into Teledyne's warning and caution system. Douglas officials stated that a new panel could not be developed and installed before the aircraft's planned first flight in June 1991. However, Douglas did not expect that use of Teledyne's panel would adversely affect the first flight. After discussions with the SPO and Douglas, the auditors concluded that changing subcontractors for the panel would not adversely affect the program schedule. Douglas plans to install the panel by the sixth production aircraft and to retrofit the initial production aircraft with the panel at no additional increase to the target cost.

Schedule Realism. Delays in the development of software and hardware have caused the date of the first flight to be postponed. First flight was originally scheduled to occur in August 1990, but in August 1989, the SPO Program Director concluded that first flight would not occur until December 1990. Following a DAB review in October 1989, the first flight was changed officially to June 1991. In our opinion, the June 1991 date will provide additional needed time, but the schedule is still success-oriented with little time available for unforeseen delays. Douglas has identified the software required for first flight and is placing emphasis on developing that software to enable the first flight to be made on time. However, SPO and Douglas officials told us that problems being experienced with hardware development made it impossible to predict whether the hardware or the software would be completed first. SPO officials told us that the EFCS and the mission computer were still considered to be high risk developments. Early lapses by Douglas in systems engineering adversely affected subcontractors Honeywell and Delco and may yet affect subsystems being developed by other subcontractors. Because Douglas lacks personnel experienced in integrating complex avionics systems and because Douglas has not prepared integration test planning in sufficient detail, the needed integration may not be accomplished in time for the June 1991 first flight. Douglas has made and is continuing to make changes to the management of the program intending to correct development difficulties. These changes improve the chances that the program will be developed on time,

but because the changes are being made late in the program and because they have not yet proved to be successful, further delays in the program schedule may yet occur.

RECOMMENDATIONS FOR CORRECTIVE ACTION

1. We recommend that the Under Secretary of Defense for Acquisition establish procurement policy applicable to contracts for major acquisition programs that assign total performance responsibility to contractors. At a minimum, this policy should require that a systems engineering management plan (SEMP), or its equivalent, be required in full-scale development contracts and that the SEMP be updated when determined necessary by the Program Director.

2. We recommend that the Program Director for the C-17 aircraft System Program Office, Air Force Systems Command:

a. Set a completion date for Douglas Aircraft Company to finalize and issue an avionics integration test plan addressing integration testing of multiple subsystems and system-level testing of all equipment functions to be performed before the first flight of the C-17 aircraft.

b. Require Douglas Aircraft Company to prepare a revised schedule showing new program milestone dates.

c. Obtain compensation to the Government from Douglas Aircraft Company for the missed contract milestones relating to the wing-to-fuselage join and the assembly start of the fourth production aircraft.

MANAGEMENT COMMENTS

The Director of Defense Research and Engineering nonconcurred with Recommendation B.1., because broad guidance on systems engineering is already available in the draft DoD Instruction 5000.2, "Defense Acquisition Management Policies and Procedures," and because it was not clear that avionics development and integration difficulties would have been avoided even if additional guidance had been provided. He also stated that requiring a SEMP in every full-scale development contract may not be prudent policy. Management's complete comments are provided in Appendix C.

The Air Force nonconcurred in Recommendation B.2.a. through B.2.c. Regarding Recommendation B.2.a., the Air Force stated that C-17 avionics planning is an evolutionary process. Douglas submitted a revised C-17 Avionics Integration Test Plan in April 1990 and again in July 1990. Although the Air Force nonconcurred with Recommendation B.2.b., the Air Force stated that Douglas has "rebaselined their schedules to the new program

milestones." Concerning Recommendation B.2.c., the Air Force stated that consideration for the overall schedule slip was expected to be obtained from Douglas by August 30, 1990, and the process to obtain compensation was begun before the audit was initiated. A complete text of management comments is provided in Appendix D.

AUDIT RESPONSE TO MANAGEMENT COMMENTS

Regarding Recommendation B.1., we agree with management that draft DoD Instruction 5000.2 provides guidance for systems engineering for acquisition programs. Because draft Instruction 5000.2 requires the program office to obtain a SEMP from the contractor, we believe that management agrees that policy should be established to require contractors to submit a SEMP. However, the proposed policy in the Instruction does not require that the SEMP be part of the FSD contract or that it be updated when required. Effective development of complex weapon systems demands that sound planning be initiated at the beginning of the program and be updated as the program develops. Although we acknowledge that the avionics and integration difficulties encountered in the C-17 program might not have been avoided with a SEMP, we believe a well-conceived plan would have caused the problems to be identified earlier in the program. Accordingly, we request that management reevaluate its position on the recommendation in response to the final report.

Recommendation B.2.a. would require Douglas to determine the feasibility of accomplishing all required C-17 avionics integration testing within the program schedule. Until the test plans and procedures are completed, the Air Force cannot be assured that all necessary testing can be accomplished to meet program milestones. Establishing a deadline to complete the avionics integration test plan would also force Douglas to finalize the definition of all requirements and to complete the detail design of all subsystems needed for first flight. Although Douglas submitted an incomplete plan and two revisions, the Air Force still had not paid the $1.0 million withheld in 1988. Consequently, we ask that management reevaluate its position on the recommendation in response to the final report.

Although the Air Force nonconcurred in Recommendation B.2.b., the action taken by the Air Force to obtain a revised program schedule meets the intent of the recommendation. Accordingly, additional management comments on the recommendation are not required.

Recommendation B.2.c. would require Douglas to provide compensation for the missed contractual milestones. The recommendation was made to add impetus to the Air Force's efforts to obtain compensation from Douglas. During the audit, we were informed that Douglas had not responded to an August 18, 1989,

letter from the SPO requesting compensation for missed milestones. We were informed on October 18, 1990, that a contract modification providing compensation to the Government was signed on September 24, 1990. Therefore, we ask that the Air Force provide in its comments on the final report the type and amount, if monetary, of the compensation obtained.

SECTION H (Continued)

111. PREREQUISITE TO OUTYEAR PRODUCTION AWARD

1. Annual long lead for each production buy will be awarded on or before 31 Jan of each year.

2. Douglas Aircraft Company will commit to an aircraft delivery schedule as part of each long lead award.

3. Notwithstanding any other provision of this contractor or any successor contract hereto, the contractor agrees that the expiration date of the FY89 production option under this contract (CLINs 0013 thru 0018); the effective date of the successor production contract for FY90 (Lot III); and, the expiration dates of the production options for FY91 (Lot IV) and FY92 (Lot V) under the said successor contract, are conditioned on the completion of the following respective milestones by the following respective dates:

FY BUY	MILESTONES	APPROXIMATE COMPLETION DATE
89	PCO Determination of Mission Computer CDR Complete	Mar 89
90	This milestone will be accomplished when T-1 moves out of assembly position 1 and the PCO determines that any remaining assembly work can be completed without significant disruption to planned ground and flight test efforts.	Jan 90
91	PCO determination of the First Flight of of T-1 and P-1, whichever shall last occur	Oct 90
92	P-5 Completion of FCA/PCA & Delivery (signed DD 250)	Sep 91

Should the contractor not complete the above milestones in accordance with this schedule, the contractor hereby agrees to grant to the Air Force an extension of the expiration date of the FY89 production option under this contract (CLINs 0013 thru 0018) until the date 30 days after the Mission Computer CDR is acknowledged by the Air Force to be completed; an extension of one day for each day completion of any above milestone is delayed in the effective date of the successor production contract for FY90 production (Lot III); and, an extension of one day for each day completion of any above milestone is delayed is the expiration dates of the production options for FY91 (Lot IV) and FY92 (Lot V) under the successor production contract. Further, the contractor agrees that any such extension will not also extend the contract delivery schedule of the CLINs of this contract or any successor contract which are affected thereby and will not require the obligation by the Air Force of any additional long lead funds on this contract or any successor contract.

SECTION H (Continued)

4. Nothing in this clause precludes the Government from exercising any of the FY buys, as shown in paragraph 3 above, before the milestone is complete, if it so elects to. However, no option will be exercised under this contract, nor will award of any successor contract be made, nor will any production option under such a successor contract be exercised, until the availability of funds for obligation in the Fiscal Year in question has been certified.

5. Upon evidence of completion of a milestone, the Government has 30 days to exercise the corresponding FY production buy, if it so elects to.

6. The milestone for FY90 must be met before the next production contract (Lot III) is awarded.

7. Upon award of the next production contract (Lot III), this clause will be transferred to the new contract to extend coverage to the FY91 and FY92 production option.

STATUS OF CORRECTIVE ACTION PLANS FOR MISSION COMPUTER SOFTWARE CRITICAL DESIGN REVIEW ITEMS

Review Item	Corrective Action Plan as of June 5, 1989	Status as of February 2, 1990*
Douglas 2-6. Values for determining the reasonableness of data and making comparison tests of redundant data displayed to the pilot and copilot should be included in the Computer Program Development Specification (CPDS), which contains the design methodology for the mission computer.	Delco Systems Operations (Delco) to investigate and respond via an Engineering Coordination Memorandum with values to be inserted in Revision K of the CPDS.	The Air Force reviewed the Engineering Coordination Memorandum and agreed with the values presented. Values for the initial increment (FT1) of the mission computer software have been included in Revision K of the CPDS. Values required for the next increment of software (FT2) will be included in Revision L of the CPDS.
Air Force-005. Some functionality was not scheduled to be incorporated until after the functional and configuration audits (FCA/PCA) were performed on the fifth production aircraft and, therefore, was not to be tested before declaration of Initial Operational Capability, which is scheduled for June 1993.	A new increment of software, FT3, was established to include all functionality not included in FT1 and FT2. FT3 will include changes made as a result of flight tests. Functions to be included in each increment of software were identified and provided to the Air Force. With the establishment of FT3, all software is scheduled to be tested before declaration of Initial Operational Capability.	No further action required.

* The Air Force considers the review items closed based on actions taken as of February 2, 1990. Information correcting the review items is included in Revision K of the CPDS and will be included in Revision L of the CPDS. The Air Force may decide to reopen some of these review items if the action taken as of February 2, 1990, is determined to be inadequate.

STATUS OF CORRECTIVE ACTION PLANS FOR MISSION COMPUTER SOFTWARE CRITICAL DESIGN REVIEW ITEMS (Continued)

Review Item	Corrective Action Plan as of June 5, 1990	Status as of February 2, 1990*
Air Force-023. The Air Force stated that there were no requirements in the contract between Douglas Aircraft Company (Douglas) and Delco to audit the production software. Delco stated that the contract requires FCA/PCA to be made of FT2 software.	Known open issues will be closed before designating the software as the production software.	The July 18, 1989, memorandum of agreement between Douglas and Delco makes Douglas responsible for all software development and tests for the mission computer. Douglas has agreed to perform FCA/PCA on FT3. After FCA/PCA is complete, the software will be designated as the production software.
Air Force-031. Critical and Catastrophic parameters must be identified, and specific verification requirements must be established.	Douglas provided a list of critical and catastrophic parameters. The list will be identified in Revision K of the CPDS.	The Air Force is reviewing Revision K of the CPDS for completeness of critical and catastrophic parameters and for adequacy of the verification requirements.
Air Force-041. The Lateral Guidance software cannot support cockpit information for both the pilot and copilot when only one of the three mission computers is operating. This shortfall in software capability precludes the pilot and copilot from being independent during in-flight operations.	Douglas and the Air Force to establish the proper definition of requirements for the pilot and copilot display information when only one of the three mission computers is operating.	The procurement specification for the mission computer was modified to read that the requirement for pilot and copilot independence applies only when two or three mission computers are operating.

STATUS OF CORRECTIVE ACTION PLANS FOR MISSION COMPUTER SOFTWARE CRITICAL DESIGN REVIEW ITEMS (Continued)

Review Item	Corrective Action Plan as of June 5, 1989	Status as of February 2, 1990*
Air Force-047. Delco stated that the mission computer station-keeping software was safety critical, but a safety analysis identified "airspeed target" and "bank angle target" as the only two parameters critical in station-keeping.	Safety studies were completed by Delco and submitted to Douglas. Douglas will review the safety studies and forward them to the Air Force with additional analyses.	Douglas is scheduled to submit an analysis of the station-keeping software to the Air Force by March 31, 1990. Revision K of the CPDS has already been revised to indicate "airspeed target" and "bank angle target" as the critical parameters in station-keeping software.
Air Force-051. Delco presented a development schedule that did not align with current Air Force flight test schedules. No production aircraft had been allocated for required flight testing of software.	Douglas committed to a review of the flight test program and to a schedule for revising the mission computer software based on flight test results.	No further action required. Based on the revised schedule, all mission computer software is scheduled to be tested before declaration of Initial Operational Capability.
Air Force-056. Delco could not provide the specific conditions necessary for the mission computer to give the green light for automatic cargo release during airdrop missions. Delco could not explain when and where the cargo is automatically released if the point determined by the Computer Automatic Release Plan is missed.	Delco will provide an Engineering Change Memorandum to Douglas that defines the specific conditions for the mission computer to generate a green light during airdrop missions. Reasonable checks and release limits will be included to ensure that the cargo does not drop in an unsafe area.	The Air Force is reviewing Revision K of the CPDS to ensure that the conditions for the mission computer to generate a green light at appropriate times during airdrop missions have been included.

STATUS OF CORRECTIVE ACTION PLANS FOR MISSION COMPUTER SOFTWARE CRITICAL DESIGN REVIEW ITEMS (Continued)

Review Item	Corrective Action Plan as of June 5, 1989	Status as of February 2, 1990*
Air Force-065. Delco did not present plans to complete the mission computer, and Delco should delete references to them in the agenda and minutes of the critical design review.	Delete references to the plans for completing the mission computer in the critical design review minutes and provide a preamble to the minutes stating that Delco did not present plans to correct the review items.	Douglas added a preamble to the critical design review minutes stating that Delco did not provide corrective action plans. On June 5, 1989, Douglas presented a plan to the Air Force for completing the mission computer software.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, DC 20301-3010

August 20, 1990

MEMORANDUM FOR THE INSPECTOR GENERAL

SUBJECT: Draft Audit Report on Selected Acquisition Actions on the C-17 Aircraft

This responds to your June 14, 1990, memorandum requesting comments on the subject draft report.

Section A - Recommendation 1.

I do not concur with the recommendation that the Conventional Systems Committee (CSC) of the Defense Acquisition Board (DAB) be staffed with "at least two members having expertise in computer software developments." The report implies that the Office of the Deputy Director of Defense Research and Engineering (Research and Advanced Technology), with only one seat on the CSC, is "unable to send individuals with expertise in software, plus all other system development areas, to the Committee meetings." This is simply not the case. The CSC has always maintained a liberal policy regarding attendance at meetings by supporting staff members. No principal staff member is denied the opportunity to bring staff members with relevant expertise to CSC meetings, particularly when that expertise is needed for a full understanding of a technical issue.

I recognize that the intent of this recommendation is to help strengthen oversight of software issues in major system reviews. I support that objective, and agree with your appraisal that "steps already initiated by the Department to improve the oversight of software development.... will help ensure that software developments are properly addressed by the DAB and its subordinate committees."

In light of the fact that CSC administrative procedures allow for sufficient representation of subject matter experts, and actions to strengthen software oversight were identified during the course of the audit, this recommendation should be withdrawn.

SECTION B - Recommendation 1.

I do not concur with the recommendation that a system engineering management plan (SEMP), or equivalent document, be required in all full-scale development contracts for major acquisition programs. The draft DODD 5000.2 provides broad guidance on systems engineering and technical planning considerations. Within the Air Force, systems

engineering management is addressed in MIL-STD-499, which is currently being revised for adoption by the other Services as a Tri-Service MIL-STD. Thus, the acquisition policy guidance and implementation standards exist for use when it is determined to be in the government's best interest to employ that level of oversight in program management.

It is not clear that the schedule impact of avionics development and integration difficulties encountered in the early stages of C-17 development would have been prevented or significantly reduced had a SEMP been required. In that same light, there is insufficient evidence to support the conclusion that requiring a SEMP in every full-scale development contract is prudent policy. This should remain an option subject to decision on a case-by-case basis. Accordingly, this recommendation should be withdrawn.

Internal Controls

The discussion of "**non-material** weaknesses" in the context of internal controls on pages iii, 5 and 55 of the draft report has been the source of considerable confusion. I recognize there is a requirement to state whether or not "**material** internal control weaknesses" were identified during the course of the audit. Since no **material** internal control weaknesses were identified, I recommend that the discussions of "**non-material** weaknesses" be deleted or suitably modified, as per recent discussions between our staffs. This will prevent the merits of the findings being obscured by the question of their relevance to statutorily defined internal control guidelines. ii, 2

for George R Schmuter
Charles M. Herzfeld

DEPARTMENT OF THE AIR FORCE
WASHINGTON DC 20330-1000

OFFICE OF THE ASSISTANT SECRETARY

AUG 17 1990

MEMORANDUM FOR ASSISTANT INSPECTOR GENERAL FOR AUDITING
OFFICE OF THE INSPECTOR GENERAL
DEPARTMENT OF DEFENSE

SUBJECT: DoD(IG) Draft Audit Report on Selected Acquisition Actions on the C-17 Aircraft, June 14, 1990, DoD(IG) Project No. ORA-8001 - INFORMATION MEMORANDUM

This memorandum is in reply to the request for findings and recommendations made in the subject draft DoD(IG) report. Responses are included for Recommendations A.2.a. and b. and B.2.a.,b.,and c.. Responses are not included for Recommendations A.1. and B.1. since these recommendations are directed to the Under Secretary of Defense for Acquisition.

The Air Force will continue to employ the appropriate management emphasis to each area addressed in the final report as well as our commitment to the timely completion of the agreed-upon actions.

DANIEL S. RAK
Deputy Assistant Secretary
(Acquisition)

1 Attachment
Air Force Comments
Draft DoD(IG) Report
Project No. ORA-8001)

AIR FORCE COMMENTS
DoD(IG) Draft Report
(Project No. ORA-8001)

FINDING A. Mission Computer Software Critical Design Review:

The C-17 System Program Office (SPO) exercised the FY 1989 contract option to buy four C-17 aircraft before Douglas Aircraft Company (Douglas) completed the required critical design review (CDR) of all mission computer software. Completion of the CDR, a prerequisite to exercising the option, was required by November 1988 modification of the full-scale development (FSD) contract. The C-17 Program Director considered the CDR, made in April 1989, to be adequate and complete, even though Douglas had completed the detail design for only about 60 percent of all software in the mission computer. The C-17 program development has already experienced major delays, and unless all required mission computer software is developed before the C-17 passes from the developmental test and evaluation phase to the operational test and evaluation phase, the C-17 program schedule will be further delayed.

Response

Non-concur. This finding implies the FY 1989 contract option for four C-17 production aircraft was prematurely awarded. We disagree. The intent of the event of the Event Based Contract Award strategy, as incorporated into the C-17 FSED contract in November 1988, was to further incentivize DAC's schedule performance. The mission computer CDR was selected as the FY 1989 option milestone to emphasize Air Force concern over avionics development progress. The CDR was completed per the SPO-DAC November 1988 CDR Definition agreement, which included all requirements and top level design for the system. In fact, award of the contract was delayed for more than three months after the CDR itself to ensure closure of action items and to gain a written schedule commitment from both DAC and Delco on mission computer development. That schedule is being met. The IG team stated during their debriefing that their point of reference on the CDR was that of an "Academic CDR" not one that met the C-17 Program (SPO-DAC) agreement. Mission computer development is on track to meet program schedule and user needs. DAC and the SPO have always planned to complete mission computer development before the completion of development test and evaluation.

RECOMMENDATION A.2.a:

Require completion of the mission computer software critical design review, planned for October 1990, as a precondition to awarding the Lot III production contract to procure four aircraft for FY 1990.

Response

Non-concur. DAC and the SPO consider the mission computer CDR to be completed, per the bilateral Event Based Contract Award definition. DAC met all requirements. Since our agreement is bilateral, the government has no cause and the contractor has no reason to reopen the Event Based Contract.

RECOMMENDATION A.2.b.

Specify the minimum assembly required to consider the test aircraft (T-1) assembled for the milestone event for Lot III.

Response

Non-concur. The SPO and DAC have reached agreement on a more precise definition of the T-1 assembly complete milestone. This definition has been formalized in a memorandum of understanding, signed by DAC, and transmitted to the SPO by letter on 14 June 1990. This is a normal part of the Event Based Contract Award process and was in no way driven or influenced by the DoD IG report. No further action is required.

FINDING B: Engineering Planning and Subcontractor Management:

Douglas had not fully accomplished technical requirements to meet contractual milestones for the development of the C-17 aircraft and had not prepared an adequate integration test plan for the development and integration of software for the avionics system. The total performance responsibility contract that the Air Force has with Douglas does not specify all management plans necessary for the successful development of the C-17 program and restricts the action of the SPO to ensure that milestones are accomplished. Delays in the development of the aircraft have caused the Air Force to postpone major program milestones, and further delays may occur.

Response

Non-concur. See below.

RECOMMENDATION B.2.a.

Set a completion date for Douglas Aircraft Company to finalize and issue an avionics integration test plan addressing integration testing of multiple subsystems and system-level testing of all equipment functions to be performed before the first flight of the C-17 aircraft.

Response

Non-concur. The C-17 avionics planning is an evolutionary process. C-17 avionics development plans have been in existence since the first submittal by the contractor in 1984. The most recent version of the C-17 Avionics Integration Test Plan was submitted by DAC in April 1990. The SPO has worked closely with DAC to assure the document remains an effective management tool. An updated version was received in July 1990. This process is normal and not required as a result of the DOD IG inspection.

RECOMMENDATION B.2.b

Require Douglas Aircraft Company to prepare a revised schedule showing new program milestone dates.

Response

Non-concur. DAC has rebaselined their schedules to the new program milestones as part of the formal program rebaseline initiated by the SPO in the late summer of 1989. The next formal submittal of the Summary Program Master Schedule was submitted in July 1990 and reflects the rebaselined schedule.

RECOMMENDATION B.2.c.

Obtain compensation to the Government from Douglas Aircraft Company for the missed contract milestones relating to the wing-to-fuselage join and the assembly start of the fourth production aircraft.

Response:

Non-Concur. The missed contract milestones were part of an overall C-17 schedule slip affecting contract dates for FSED, the 1988 production option, and the 1989 production option. A revised schedule and consideration were negotiated in June 1990. The contract modification for this agreement is currently in process and expected to be issued by 30 August 1990. Consideration was negotiated for the overall slip and is not segregable by individual milestone. This process was begun before the DOD IG initiated its audit.

GENERAL COMMENTS:

In addition to the above comments, we recommend the following clarifications to subject draft report.

a. Page 7, Independent Verification & Validation (IV&V). Since the DOD IG is using the report to update the status of the previous reports, some clarification is necessary. The last paragraph in the section dealing with report 89-059 leads to the 3

impression that Douglas initiated internal IV&V in deference to the Air Force's nonconcurrence that an IV&V would be beneficial. This is inconsistent with the facts and that which the DOD IG stated on page 23 of the 89-059 report. In the report, they correctly state that the Air Force initiated the activities that resulted in Douglas implementing an internal IV&V program at no cost to the Air Force as the referenced report states.

b. Page 15, line 2. Insert "four" between "in" and "increments" to clarify which increments are being referred to. 8

c. Page 16, lines 10-14. This sentence should be rewritten for clarity. DAC did agree to a post-CDR software review, but not until after the November 1988 contract modification. 9

d. Page 17: 10

(1) Lines 13-16. This sentence implies requirements and design were not sufficiently complete for the CDR. Actually, they were not sufficient for completion of coding. During the CDR, insufficiencies were identified and corrective action plans developed and approved by DAC with the SPO's concurrence.

(2) Lines 16-21. The development of mission computer software was identified as a high-risk item long before the CDR. This sentence implies otherwise.

SUMMARY OF POTENTIAL MONETARY AND OTHER BENEFITS RESULTING FROM AUDIT

Recommendation Reference	Description of Benefit	Type of Benefit
A.1.	Economy and Efficiency. Improve the OSD oversight process by requiring individuals with software expertise to attend meetings of the Conventional Systems Committee of the Defense Acquisition Board.	Nonmonetary
A.2.a.	Economy and Efficiency. Ensure completion of the mission computer software design review by making the review a precondition to buying C-17 aircraft in FY 1990.	Nonmonetary
A.2.b.	Economy and Efficiency. Ensure the FY 1990 procurement is appropriately made by clarifying the preconditions to buying C-17 aircraft.	Nonmonetary
B.1.	Economy and Efficiency. Protect the Government's interest by establishing policy for total performance responsibility contracts.	Nonmonetary
B.2.a.	Economy and Efficiency. Establish integration test requirements and time frames by requiring a final integration test plan.	Nonmonetary
B.2.b.	Economy and Efficiency. Determine the program development schedule by requiring a revised milestone schedule.	Nonmonetary
B.2.c.	Economy and Efficiency. Obtain compensation for missed contractual milestones.	Nonmonetary *

* We are not claiming monetary benefits for any compensation because the Air Force began efforts to obtain compensation before the audit was initiated. The recommendation was made to add impetus to the Air Force's efforts to obtain compensation, because Douglas had not responded to a request by the Air Force for compensation for missed contractual milestones.

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