Accounting and Information
Management Division

B-248294

October 7, 1994

The Honorable William J. Perry
The Secretary of Defense

Dear Mr. Secretary:

As part of our continuing examination of the Department of
Defense's development and acquisition of embedded computers
for major weapons systems, we have reviewed the Air Force's
C-17 aircraft program for the Chairman, Subcommittee on
Legislation and National Security, House Committee on
Government Operations. Specifically, the Chairman asked us
to (1) assess the status of software development, (2)
identify future hardware and software changes and upgrades,
and (3) evaluate the Air Force's life-cycle software support
strategy.

As envisioned, the C-17 will be the most computerized,
software-intensive military transport aircraft ever built.
It contains 57 computerized avionics subsystems and nearly 1
million lines of code to control basic functions, such as
flight control, navigation, and cargo airdrop. In May 1992,
we reported that the Air Force was encountering significant
problems in developing software for the C-17.[1]
Specifically, the Air Force made a number of mistakes early
in the program that affected its ability to manage and
oversee software development. In addition, it allowed
McDonnell Douglas, its prime contractor, to take shortcuts
that increased the risk of continued software development,
testing, and support problems.

Our recently completed review showed that, while steady
progress has been made since our 1992 report, many of the
same software development problems still persist. As you
know, however, the C-17 program is currently undergoing
significant changes and it is difficult to determine how
these problems will affect the program. It is our
understanding that these changes will continue through 1994,
and that Defense plans to decide in November 1995 (Milestone

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[1] Embedded Computer Systems: Significant Software Problems
on C-17 Must be Addressed (GAO/IMTEC-92-48, May 7, 1992).

GAO/AIMD-95-12R Air Force C-17 Embedded Computers

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IIIB) whether to continue the program beyond the 40 aircraft currently authorized.

The purpose of this letter is to bring to your attention embedded computer and software issues that should be considered as future decisions are made concerning the C-17 program. Specifically, (1) continuing software development problems are delaying the flight test program, (2) a hardware upgrade to the mission computer will be necessary, and (3) problems with software development, documentation, and data rights are likely to increase dependence on the prime contractor and software support costs.

Software Development Problems
Delaying Flight Test Program

As originally planned, the first C-17 aircraft, delivered to the Air Force in September 1991, was to include all the subsystems and software necessary to perform its missions. However, software development and testing is continuing to take much longer than expected. As a result, while the Air Force has accepted 14 C-17 aircraft, it still has not received an aircraft with fully operational software.

Currently, avionics hardware components are in place to perform critical tasks, such as air refueling, steep approach landings, and low-altitude, low-velocity airdrops. However, almost 3 years after the start of the flight test program, testing and integration of the software required to perform these tasks are not yet complete. This is delaying the overall flight test program because many of the C-17's envisioned unique performance features, such as low-altitude, low-velocity airdrops, cannot be tested until the software is completed and installed in the test aircraft. In addition, because software is not complete for the mission computer and the aerial delivery system, 5 crew members, rather than the planned 3 person crew, are needed on many test missions to manually perform functions that were intended to be automated.

McDonnell Douglas officially plans to release additional software versions in October/November 1994 to provide the missing capability. However, Air Force documents indicate that these release dates are slipping and may not be achieved until at least February 1995. Such a slip would further delay testing which could delay the full-rate production decision scheduled for November 1995.

Another indication of software completeness or maturity is the number of unresolved software deficiencies. As of May

1994, there were nearly 500 software deficiencies that were unresolved. While there are no specific criteria for the number of deficiencies, both Air Force program and test officials believe this number is too high. McDonnell Douglas is resolving these deficiencies, but new problems continue to be identified. As a result, the number of unresolved deficiencies has remained fairly constant over the last 2 years, instead of declining as would be expected in this late stage of development.

Major Upgrade to Mission Computer Is Likely

The Air Force is currently considering several hardware and software upgrades and changes for the C-17. Although some of these envision additional capabilities, such as adding a defensive system to counter missile threats, most of the changes are intended to correct performance problems. Most important of these is the need to upgrade the aircraft's mission computer.

In our May 1992 report, we identified several subsystems, in particular the mission computer, that did not meet memory and/or processing capacity requirements. The C-17's mission computer currently does not and, according to program officials, will not meet its contractually required 29 percent reserve processing capacity.[2] As a result, the mission computer will not have the reserve capacity needed to support software changes and new capabilities the Air Force may wish to add in the future.

In addition, the mission computer cannot meet the Air Mobility Command's (the C-17 user) requirement for processing speed for certain mission planning changes. According to C-17 pilots, the mission computer takes too much time--over 5 minutes as compared to the required 90 seconds--to compute worst-case mission planning changes during flight. Program office analysis indicates that a computer at least 3 times faster would be needed to reach the 90 second requirement.

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[2] Defense standards require that embedded computer systems be designed and developed with sufficient spare memory and processing capacity to allow for future software growth. Typically, software growth occurs throughout the life cycle of the embedded system, due to correction of software problems detected in testing, routine software maintenance, and the addition of new capabilities.

McDonnell Douglas is currently analyzing several alternatives to address these inadequacies, including several possible mission computer upgrade options. These options range from minor computer hardware upgrades at no cost to the government to a complete redesign using more recent technology that could add significant development cost to the program. The Air Force plans to make a final decision by late Fall 1994.

C-17 Software Support Change
Could Increase Dependence
on Contractor and Cost

The Air Force originally planned to develop an in-house software support capability at its San Antonio Air Logistics Center. However, as a result of ongoing software development problems, inadequate software documentation (such as lack of maintenance manuals), disagreements over giving the Air Force access to software data that McDonnell Douglas and its subcontractors have developed, and the lack of trained software maintenance personnel, the Air Force is making little effort to establish an in-house software support capability at San Antonio. Unless these problems are resolved, the Air Force may not be able to develop an in-house capability.

In addition, even if the Air Force were able to contract for C-17 software support, McDonnell Douglas may have a substantial advantage over other potential vendors. The knowledge and integration experience McDonnell Douglas has gained in developing the C-17 software would be difficult for other vendors to overcome. Finally, the Air Force has modified its 1985 development contract with McDonnell Douglas to provide $82.7 million to build an Avionics Integration Support Facility at the contractor's plant. Thus, without an in-house support capability, the Air Force could become dependent upon McDonnell Douglas for C-17 software support.

The Air Force recently estimated that software support would cost about $1 billion. It further estimated that locating the support facility at McDonnell Douglas could increase the cost about $100 million. The Air Force plans to make a final decision on how to provide C-17 life-cycle software support at its planned full-rate production decision in November 1995.

In summary, we found that delays in completing software development and testing are delaying the flight test program, and thus, could delay subsequent milestones, such

as the start of operational testing planned in December 1994 or the full-rate production decision planned in November 1995. Meanwhile, the Air Force continues to accept the delivery of aircraft without having fully operational software to perform its missions. In addition, the Air Force is still evaluating mission computer upgrade and software support alternatives, which could affect program costs, schedule, and performance.

As requested, we did not provide a draft of this letter to the Department of Defense for its review and comment. Instead, we discussed the letter's contents with Defense and Air Force officials involved in the issues presented and have incorporated their views as appropriate. We conducted our review between September 1993 and August 1994, in accordance with generally accepted government auditing standards.

We are sending a copy of this letter to the Chairman and Ranking Minority Member, Subcommittee on Legislation and National Security, House Committee on Government Affairs. We will also send copies to the Chairmen and Ranking Minority Members of the House and Senate Committees on Appropriations and the House and Senate Committees on Armed Services, to the Secretary of the Air Force, and to other interested parties upon request. If you have questions or wish to discuss the issues in this letter further, please contact me at (202) 512-6240 or John B. Stephenson, Assistant Director, at (202) 512-6225.

Sincerely yours,
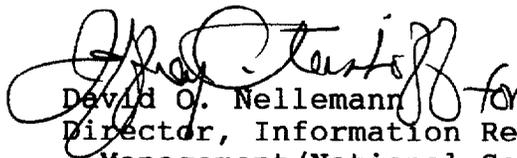
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