United States General Accounting Office

GAO

Report to the Chairman, Subcommittee on Strategic Forces and Nuclear Deterrence, Committee on Armed Services, U.S. Senate

December 1991

MILITARY SPACE OPERATIONS

Satellite Control System Improved, But Serious Problems Remain

GAO/IMTEC-92-3

GAO

United States
General Accounting Office
Washington, D.C. 20548

Information Management and
Technology Division

B-243181

December 27, 1991

The Honorable J. James Exon
Chairman, Subcommittee on Strategic
Forces and Nuclear Deterrence
Committee on Armed Services
United States Senate

Dear Mr. Chairman:

This report responds to your request that we review the Air Force's actions to complete its satellite command and control system upgrade, called the Command and Control Segment (CCS), and turn it over to the Air Force Space Command in April 1993. We found that the Air Force may not be able to complete CCS on schedule, and made recommendations to help ensure that CCS provides the needed capacity and performance when completed.

We are sending copies of this report to the Chairmen, Senate Committees on Appropriations and Governmental Affairs; House Committees on Appropriations, Armed Services, and Government Operations; the Director, Office of Management and Budget; and the Secretaries of Defense and the Air Force. We are also making copies available to others upon request.

This report was prepared under the direction of Samuel W. Bowlin, Director, Defense and Security Information Systems, who can be reached at (202) 336-6240. Other major contributors are listed in appendix III.

Sincerely yours,

Ralph V. Carlone
Assistant Comptroller General

Executive Summary

Purpose

The Department of Defense's (DOD) satellites perform a wide variety of missions to support national security interests and pursue advances in research and development. The missions include communications, navigation, strategic defense, tactical warning and attack assessment, and other classified missions. The Air Force's Satellite Control Network controls satellite launches, maintains satellites, and keeps them in orbit. Since 1980, Air Force Systems Command has been upgrading its satellite command and control system, called the Command and Control Segment (CCS). The Chairman, Subcommittee on Strategic Forces and Nuclear Deterrence, Senate Committee on Armed Services, concerned about the program's shifting requirements, continuing schedule delays, technical problems, and increasing costs, asked GAO to review the Air Force's actions to complete the command and control system upgrade and turn it over to Air Force Space Command in 1993.

Background

Since the late 1960s, the Air Force has used the Current Data System (CDS) to command and control its satellites. However, CDS uses obsolete computers and is expensive to maintain, with maintenance costs of $30 million annually. CCS was planned as a modern system that could replace CDS, as well as cut costs, improve performance, and enhance functionality. Until CCS is completed, the Air Force is using both the partially completed CCS and the old CDS. CCS is not scheduled to be completed, and CDS deactivated, until July 1993.

The Air Force runs CCS in 11 computer centers called mission control complexes (MCCS). An MCC supports satellite launches and orbiting satellites, including tracking and determining how well each is working. Each MCC controls a specific type and number of satellites. Collectively, the MCCS control about 72 satellites.

Systems Command and Space Command share responsibility for commanding and controlling the network's satellites through their respective MCCS. Currently, Systems Command uses both CDS and the current version of CCS to command and control its satellites. Space Command is gradually assuming responsibility for operational military satellites and uses only the current version of CCS to command and control these satellites. Once Systems Command completes the CCS upgrade and the system is fully operational, responsibility for commanding and controlling those operational satellites will transfer to Space Command and CDS will be deactivated.

Results in Brief

The Air Force's ability to meet the July 1993 deadline is questionable and depends largely on whether it can fix CCS' critical operational deficiencies. However, slow progress in correcting some of these problems, combined with the growing number of satellites CCS is expected to control and the new problems that continue to be found, increases the risk that CCS will not be completed on time.

Further, CCS may not be able to provide the needed capacity and performance because the Air Force has not: adequately defined work-load requirements for CCS, adequately tested CCS, set up an effective capacity and performance management program, or obtained adequate software documentation. Without up-to-date work-load requirements, the Air Force cannot (1) assure that the system is properly sized for current and future needs, (2) develop tests to adequately stress the system, and (3) reliably assess the impact of CCS changes on mission effectiveness. Without adequate testing, the Air Force cannot determine if CCS will effectively support all satellites. Without an effective capacity and performance management program, the Air Force does not know how well CCS is working, nor can it effectively plan for future computer resource requirements. And finally, unless the Air Force corrects deficiencies in CCS' software documentation, it will be increasingly difficult to maintain and enhance CCS as requirements continue to change and evolve.

If these problems are not resolved quickly, the Air Force will be forced to continue using CDS to perform some command and control functions, and spending $30 million annually to maintain CDS, which is recognized as being outdated.

Principal Findings

CCS Cannot Perform Key Command and Control Operations

CCS is required to be able to contact[1] and communicate with multiple satellites simultaneously under expected peak work-load conditions. At most MCCS, however, CCS cannot make the required number of simultaneous contacts. Making simultaneous contacts is a key requirement used to judge whether CCS is ready to handle all satellite control functions at an MCC, and to permit CDS to be deactivated. In addition, CCS has other

[1]A contact is the reception and/or transmission of information between a space vehicle and an MCC. There are three primary functions of a contact: telemetry, tracking, and commanding.

serious operational problems (e.g., long recovery time from system failures). Some problems affect all satellites and MCCs, others affect only a specific satellite or MCC. While the Air Force has fixed several hundred problems, other critical problems have not been fixed and new problems continue to be found. Meanwhile, the costs to make CCS fully operational continue to increase. GAO estimates that the cost to develop CCS and provide sustaining engineering is at least $906 million through September 1991.

Work-Load Requirements Not Adequately Defined

Well-defined work-load requirements are needed to help size the system for current and future needs, to develop tests to stress the system, and to ensure that the system functions effectively under expected peak work loads. However, the work-load requirements for the MCCs are outdated and do not accurately describe expected peak work loads. The work-load requirements were last updated in 1987. Since that time, the number of satellites has increased by 36 percent and, according to Systems Command's Program Office officials, the MCCs now handle different types and numbers of satellites. Because the work-load requirements have not been updated, they do not reflect actual operational conditions and cannot be used effectively to size, stress, and test the system.

CCS Testing Inadequate

Without accurately defined work-load requirements, the Air Force cannot adequately test and evaluate CCS to determine if it meets the MCCs' requirements before being turned over to Space Command. Further, new CCS software releases are not being adequately tested in the Air Force's Software Development Testing Laboratory before being used. Therefore, critical deficiencies are not detected until the software is actually used to control satellites. Between March 1989 and March 1990, three major software releases were tested in the laboratory; no critical deficiencies were found. However, after these releases were approved for use in the MCCs, approximately 175 critical deficiencies were discovered. At this late stage, these problems are more difficult and expensive to correct. Moreover, finding a critical problem while CCS is helping launch or track a satellite could jeopardize that satellite.

These software deficiencies are due, at least in part, to the fact that the laboratory does not have the hardware needed to simulate the MCCs' high-stress work loads. The laboratory can only test whether new releases can make three simultaneous contacts. However, because the

MCCs use the systems under tougher conditions, e.g., five simultaneous contacts, critical deficiencies are discovered.

Capacity and Performance Management Program Inadequate

In order to measure computer use and performance and to help predict future needs, agencies should routinely collect and analyze detailed capacity and performance data. However, the Air Force is not doing this and, as a result, does not know how well CCS is working and how much capacity is being used. Without this information, the Air Force cannot effectively determine whether and when changes are needed to meet mission requirements.

Instead, the Air Force relies on three sources of information to manage CCS computer resources: (1) data on satellite contact success rates using CCS and CDS, (2) computer operators' perceptions of CCS' limitations, and (3) infrequent ad hoc analyses of computer capacity and performance. While these provide some useful information, they do not give a complete picture of computer performance, mostly because they do not measure actual use or continuously assess performance. Furthermore, they do not offer the careful, comprehensive analysis needed to manage a system this large and complex.

Software Poorly Documented

Computer system software documentation must be well-organized, complete, and up-to-date, so that systems analysts can understand the system, identify problems, and make needed changes. CCS' software documentation, however, is incomplete, out-of-date, and difficult to use. Poor documentation delays fixing problems and increases maintenance costs, which make up the largest percentage of a system's life cycle costs.

Recommendations

GAO recommends that the Secretary of Defense direct the Secretary of the Air Force to ensure that (1) CCS work-load requirements (specifically, the peak work-load requirements for each MCC's computer system) are immediately updated and kept current; (2) the updated work-load requirements are used to operationally test CCS at the MCCs, and stress test each CCS software release before it is used in the MCCs; (3) a comprehensive CCS capacity and performance management program is immediately established; and (4) CCS' software documentation is adequately prepared.

Agency Comments

DOD stated it partially concurred with most of the findings and all of the recommendations, and has taken steps to address each recommendation. DOD stated that the Air Force has defined CCS work-load requirements and plans to use them to operationally test CCS at the MCCS. Further, DOD stated the Air Force (1) has identified requirements to upgrade CCS testing capabilities, (2) will assess its capacity and performance management efforts, and (3) is upgrading some of CCS' software documentation. However, DOD did not require the Air Force to establish a formal capacity and performance management plan, or ensure that CCS is stress tested before it is used in the MCCS. These actions are essential to assure CCS effectively and efficiently meets its mission requirements.

DOD disagreed with GAO's finding that CCS costs are continuing to increase. DOD believes that GAO incorrectly combined acquisition costs (associated with the completed development of CCS) with subsequent life cycle costs. Since the purpose of CCS was to replace the old, out-of-date CDS, GAO believes it is appropriate to report all costs until all original requirements for CCS are completed and CDS is deactivated. An evaluation of DOD's comments is included in chapter 4 and appendix II.

Contents

'able

Abbreviations

AFOTEC	Air Force Operational Test and Evaluation Center
AFSCN	Air Force Satellite Control Network
CCS	Command and Control Segment
CDS	Current Data System
DOD	Department of Defense
GAO	General Accounting Office
IMTEC	Information Management and Technology Division
MCC	Mission Control Complex

ıtroduction

The Department of Defense's (DOD) satellites perform a wide variety of missions to support national security interests and pursue advances in research and development. The missions include communications, navigation, strategic defense, tactical warning and attack assessment, and other classified missions. By the year 2015, the Air Force Satellite Control Network (AFSCN) is expected to handle 122 Defense satellites, compared to the 72 Defense satellites it currently controls. Therefore, the Air Force must ensure that adequate computer capability is available to command and control these added satellites.

The Air Force has been replacing the Current Data System (CDS), an outdated satellite command and control system, with a system called the Command and Control Segment (CCS).[1] CCS was expected to increase performance and cut costs by replacing obsolete computers, centralizing real-time data processing, simplifying operations, and providing redesigned software so that mission controllers could use the system on a real-time basis.[2]

ission: Satellite ıpport

CCS is part of AFSCN, which supports Defense spacecraft during prelaunch, launch, and while the craft is in orbit.[3] This support includes determining and tracking a satellite's orbit, acquiring and processing telemetry data to determine spacecraft health and status,[4] receiving and relaying mission data to users, generating and transmitting commands, and fixing operational anomalies.[5] The network consists primarily of worldwide, ground-based tracking stations; a test center and an operations center; dedicated control stations; and communications links connecting these components. Appendix I illustrates the major elements of AFSCN.

[1]The Command and Control Segment was initially developed by the Data System Modernization program and was referred to by that name in our previous report, Military Space Operations: Operational Problems Continue With the Satellite Control Computer System (GAO/IMTEC-89-56, Aug. 8, 1989).

[2]Real-time refers to a system's capability to obtain data from an activity or process, perform computations, and return a response quickly enough to affect the outcome of that activity or process.

[3]AFSCN also supports National Aeronautics and Space Administration, North Atlantic Treaty Organization, and other space missions.

[4]A satellite contains telemetry equipment that is used to transmit information to the ground about a satellite's position and status.

[5]An anomaly is an unexpected event caused by a system malfunction or by space environmental effects. If the anomaly is not corrected quickly, the satellite or its capabilities may be lost.

CCS is being installed in the network's two satellite command and control centers: the Consolidated Space Test Center at Onizuka Air Force Base, in Sunnyvale, California, and the Consolidated Space Operations Center at Falcon Air Force Base, near Colorado Springs, Colorado. These centers are operated by Air Force Systems Command and Air Force Space Command, respectively. There are eight mission control complexes (MCCs) at the test center and three MCCs at the operations center.[6] Each MCC commands and controls specific types and numbers of satellites; each supports satellite launches, checks satellite operations, corrects problems, and keeps satellites in proper orbit.

While CCS' upgrade is underway, the completed portions are being used to control some satellites. Other satellites are still controlled by the old system, CDS.[7] Once CCS becomes fully operational at both centers, CDS will be deactivated. At that time, the operations center will mostly support working military satellites, and the test center will mostly support research and development programs, as well as selected Defense and other agency satellite programs.

etwork esponsibilities

Systems Command and Space Command share responsibility for AFSCN and CCS. Initially, Systems Command was fully responsible for establishing user requirements, designing and developing CCS, and operating AFSCN. However, the responsibility for determining user requirements shifted to Space Command in October 1987. Within Systems Command, the Satellite Control and Data Handling System Program Office (hereafter referred to as the Program Office) is the network system engineer, responsible for developing and acquiring network components, including CCS. Within Space Command, the Second Space Wing is the network manager and is responsible for commanding and controlling its operational satellites.

Systems Command and Space Command share responsibility for commanding and controlling the network's satellites through their respective MCCs. Currently, Systems Command uses both CDS and the current version of CCS to command and control its satellites. Space Command has been assuming responsibility for operational military satellites and uses only the current version of CCS to command and control these satellites.

[6]A fourth MCC is being set up at Falcon Air Force Base.

[7]For example, one satellite program requires the processing of a large amount of information at an extremely high speed. Currently, only CDS can meet this requirement, although CCS is being modified in order to provide this capability in the future.

Systems Command plans to transfer full responsibility for its seven operational satellite programs to Space Command by July 1993. The transfer is being done gradually as CCS is capable of supporting satellite programs at Space Command's MCCs. As of July 1991, six satellite programs had been transferred to Space Command.

Objectives, Scope, and Methodology

At the request of the Chairman, Subcommittee on Strategic Forces and Nuclear Deterrence, Senate Committee on Armed Services, and in subsequent discussions with subcommittee staff, we reviewed the Air Force's actions to complete CCS' upgrade and turn it over to Space Command in 1993.

We interviewed Air Force officials responsible for developing and operating CCS and reviewed Air Force management, technical, and contractual documents to obtain information on CCS requirements, testing, capacity management, and software documentation. We analyzed CCS performance reports, problem reports, cost and schedule data, and discussed our findings with Systems Command, Space Command, and Air Force Operational Test and Evaluation Center (AFOTEC) officials. (AFOTEC is responsible for testing the operational capabilities of Space Command's MCCs, including CCS software.) We also interviewed Air Force headquarters officials about capacity and computer performance.

To identify criteria for effective system requirements and capacity management programs, we reviewed the Military Standard for Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs (MIL-STD-483A), and the Military Standard for Specification Practices (MIL-STD-490A). We also used the Federal Information Resources Management Regulation, the National Bureau of Standards work-load analysis and forecasting guidelines in Federal Information Processing Standards Publication 49, and the General Service Administration's Federal Systems Integration and Management Center guidelines on capacity management. We compared these criteria to CCS' requirements and the Air Force's capacity management program.

We reviewed the Air Force's plans to test CCS at Falcon Air Force Base before turning over responsibility at that site to Space Command. We gathered information on the number and type of software and hardware problems that were identified after CCS software releases were used operationally and interviewed Space Command, Systems Command, and AFOTEC officials to discuss the testing and the significance of the problems we found.

We reviewed AFOTEC's software documentation evaluations to determine the extent and significance of CCS' software documentation problems. We obtained the views of AFOTEC, Space Command, and Systems Command officials on the problems AFOTEC identified, and determined what actions were taken to correct these problems.

Our work was conducted at Air Force headquarters, in Washington, D.C.; Space Systems Division at Los Angeles Air Force Base, California; Air Force Space Command headquarters, Peterson Air Force Base, Colorado; Space Command's Second Space Wing, Falcon Air Force Base, Colorado; and Space Systems Division's Consolidated Space Test Center, Onizuka Air Force Base, California.

We performed our review from November 1989 through November 1991, in accordance with generally accepted auditing standards. DOD provided written comments on a draft of this report. These comments and our evaluation are summarized in chapter 4. Appendix II contains complete agency comments, as well as our detailed evaluation of those comments.

CCS Implementation—Progress Being Made But Costs Continue To Increase and Some Major Problems Still Need to Be Fixed

Since our 1989 report,[1] the Air Force has made considerable progress in upgrading CCS. The system is now handling a larger portion of satellite contacts and several hundred critical design deficiencies have been fixed. At the same time, however, the old CDS system is still needed and the cost to complete CCS continues to increase, requirements continue to expand, and new system deficiencies are being found. CCS still cannot perform the required number of simultaneous contacts during peak work-loads and the scheduled fix dates for some critical design deficiencies have slipped over a year. Until resolved, CCS will not be able to function as intended and the Air Force will have to use CDS to augment it.

CCS Costs Continue to Increase

The cost to make CCS fully operational is increasing. On the basis of the Air Force's figures as of March 1989 and an anticipated June 1991 completion date, we estimated in 1989 that the cost to develop CCS and provide sustaining engineering would be at least $762 million through September 1989. As of March 1991, we estimated that costs have increased to at least $906 million through September 1991.[2] However, the Program Office was not able to determine how much of this increase was due to providing additional system capabilities and how much to correcting system deficiencies. Further, costs will continue to increase because CCS will not be completed until July 1993. An Air Force official said a follow-on contract was awarded in September 1991 to continue efforts to maintain and complete CCS (DOD did not provide the details in time to include in our report).

Further, because CCS is not completely operational and some satellite operations still depend on the old CDS system, the Air Force must continue to maintain CDS. In 1988 the Air Force estimated that the cost to operate and maintain CDS was $30 million annually. Although Air Force officials did not provide a revised estimate for these costs during our current review, they noted that because parts of CDS are planned to be deactivated by the end of 1991, CDS maintenance costs should fall.

[1]GAO/IMTEC-89-56, Aug. 8, 1989.

[2]Both estimated costs are based on Air Force figures that include $458 million for the original development contract, as well as the costs for the sustaining engineering contract. The estimates include operations and maintenance costs and do not include costs for fixing some critical deficiencies for which no estimate was available.

CCS Cannot Perform Key Command and Control Operations

Air Force measurements of CCS performance include the percent of satellite contacts that are deemed successful. The Air Force requires a 95 percent contact success rate for CCS. According to the Program Office, CCS has achieved over a 95 percent average contact success rate—up from the 93 percent we reported in 1989. Further, CCS now supports 120 percent of the total work-load that existed about 3 years ago and it has supported every satellite launch in the past year. In addition, the percentage of contacts CCS makes has increased since we reported in 1989. CCS made between 90 and 98 percent of the attempted AFSCN contacts during the 5 months ending April 1991.[3] The Air Force relies on CDS to make the rest of the contacts.

Using this measure, the number of successful contacts made, CCS' performance has improved. However, the Air Force also requires that most MCCs be able to support at least five simultaneous satellite contacts.[4] Using this measurement, CCS still comes up short. CCS cannot make the required number of simultaneous contacts under all expected work-load scenarios.[5] On the basis of Air Force officials' comments and documentation they provided, we found that only two of the eight MCCs we reviewed can make the required simultaneous contacts under expected peak work loads.[6] In fact, the operators sometimes cut down on the number and length of satellite contacts to make sure they do not exceed the system's capacity. For example, during some satellite launches operators delay other contacts until they feel comfortable that the work load can be processed.

In addition to the problem of making five simultaneous contacts, CCS has other serious problems—some affecting all satellites and others affecting only a specific MCC or satellite. The Air Force calls these problems critical deficiencies because they must be fixed before CDS can be deactivated and CCS turned over to Space Command. Examples of systemwide critical deficiencies include data base and file contention,[7] an

[3]Based on weekly satellite contact performance data from December 1990 through April 1991.

[4]All MCCs, except two, are required to support at least five simultaneous satellite contacts. The other MCCs are required to support less than five simultaneous contacts.

[5]These scenarios should include the conditions (e.g., the number and types of contacts, the number and frequency of display updates, and the number of commands per contact) that place the expected peak (worst case) demand on system resources.

[6]Data was available for only eight MCCs.

[7]Contention occurs when programs that share common resources (e.g., disk files, processor) need to use the same resource simultaneously. This creates delays since one program has to wait until the other is finished.

inability to effectively create and delete files in real time, and long recovery times from system failures. These kinds of problems could damage critical files or data bases needed to contact satellites, or delay contact with or lose satellites. Critical deficiencies that affect a specific MCC or satellite, such as an inability to send satellite commands or contact several satellites simultaneously, can cause missed satellite contacts, delays in maneuvering and monitoring satellites, delays in correcting anomalies, or even the loss of a satellite.

According to Air Force officials, there are two reasons for CCS' problems: CCS software is incomplete and inefficient, with some functions missing and others not working correctly; and CCS hardware capacity is insufficient to perform some functions. Air Force officials attributed CCS' incomplete software and insufficient capacity, at least in part, to new requirements. Program Office officials said that new requirements are urgent and have to be implemented; they cannot be delayed until CCS is turned over to Space Command.

The Program Office is taking positive steps to correct CCS' critical deficiencies. First, it is trying to fix software problems that are critical to command and control and mission planning. Second, it is adding new functions in software releases. The fixes and changes are being made in software modifications that are released approximately every 6 months. Third, it is adding equipment to three MCCS to meet capacity and performance requirements.

Critical Deficiencies Are Being Resolved But Hundreds Remain

The Air Force has corrected several hundred critical deficiencies since our last report. However, delays have occurred and the current schedule could slip again because some deficiencies have taken more time to correct than expected, correction of others has been deferred as higher priority problems arose, and new ones continue to be identified.

Eight hundred and ninety-four critical deficiencies existed in April 1989, when we last reported on this program.[8] By December 1990, this number had been reduced to 321, including some that existed in April 1989 as well as some new ones that developed. A Program Office official stated that the Program Office plans to fix all problems, as well as any new ones that may arise, by completion of the CCS upgrade in 1993.

[8]GAO/IMTEC-89-56, Aug. 8, 1989.

However, correcting CCS' deficiencies has taken more time than the Air Force expected. For example, in February 1990, Program Office officials said they planned to correct all known critical deficiencies (569 at that time) by September 1991. Subsequently, that date was pushed back twice, first to March 1992 and then to September 1992. Given that the Air Force did not meet its earlier two schedules, this latest estimate may still not be realistic.

The former Program Manager for CCS said that, in general, deficiencies miss their original correction date because past attempts to fix the deficiencies failed, or the deficiencies' correction dates were delayed because other, more critical problems arose that had to be resolved first.

The Air Force also continues to find new critical deficiencies in each new software release. For example, 175 new critical deficiencies were identified between March 1989 and October 1990. According to the Air Force, each new deficiency is evaluated and scheduled to be corrected as it arises. These deficiencies must be corrected before CCS can be fully operational. However, as of December 1990, some of these had not even been scheduled to be fixed.

These deficiencies must be corrected before CCS can function as intended. Furthermore, we believe that the Air Force has four additional problems that jeopardize the likelihood of CCS' success: inadequately defined work-load scenarios; inadequate testing; an inadequate capacity and performance management program; and poor software documentation. These problems are addressed in chapter 3.

Inadequate Requirements Definition, Testing, Capacity Management, and Software Documentation Puts CCS at Risk

We are concerned that the Air Force has not: adequately defined expected peak work-load requirements for CCS; adequately tested CCS; set up an adequate capacity and performance management program; and obtained adequate software documentation. These problems raise serious doubts, not only about the Air Force's ability to complete CCS by July 1993, but also about CCS' capability to meet its mission requirements.

CCS Requirements Are Not Adequately Defined

The CCS contract requires compliance with Military Standard 483A, "Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs," and Military Standard 490A, "Specification Practices." These military standards call for detailed requirements to be prepared when acquiring or modifying computer systems, including peak processing work loads. The expected peak work loads are critical to assuring that the system will function effectively under maximum expected stress. These work loads are used to help size the system for current and future needs, to develop tests to stress the system, and as input for capacity and performance management activities.

In the case of CCS, these requirements are defined by work-load scenarios that describe such factors as: the mix of satellites and the types of contacts that must be controlled simultaneously during a certain time period, the number of terminals the system must support, and the amount of data that must be processed. These scenarios should include those that place the greatest expected demand on system resources (i.e., the expected peak work load or worst-case scenario). For example, the worst-case scenario for one MCC involves simultaneously performing: command and telemetry contacts for three satellites, a mission data contact for a fourth satellite, and a state of health contact for a fifth satellite.

Because MCCs are set up to support specific types and numbers of satellites, each MCC has its own set of work-load scenarios. The Air Force last updated its expected peak work loads for the MCCs in 1987. However, since then, the number of satellites has increased by 36 percent and, according to Program Office officials, the MCCs are handling different types and numbers of satellites. Therefore, the 1987 expected peak work loads are obsolete. For example, the MCC that handles the Space Shuttle and another space vehicle program now also supports a third program. However, its work-load requirement is still based only on the first two programs; it has not been updated to include the work load

generated by the third program. Without updated requirements, the Air Force cannot assure that the system is properly sized for current and future needs, it cannot develop tests to adequately stress the system, and it cannot reliably assess the impact of continual CCS changes on mission effectiveness.

Space Command officials said that because of other priorities—they are concentrating on trying to identify CCS problems and working with the Program Office and MCCs to correct them—they have not updated the worst-case work loads. They said that they are working to define the criteria for the MCCs' operational tests and evaluations (see next section), which will include testing worst-case scenarios.

Testing Inadequate

Expected peak work loads are not only critical to developing a system, but they are essential for testing a system and its modifications to determine if the system can do its job. If testing is inadequate, design flaws and errors may not be found until the system is put in operation. At this late stage, problems are more difficult and expensive to correct than if they had been discovered and fixed earlier. Moreover, finding a critical problem while CCS is helping launch or track a satellite could jeopardize that satellite.

Until the MCCs have updated work-load requirements, the Air Force cannot (1) operationally test the current CCS configuration to ensure that the more taxing satellite contact scenarios can be met before the MCCs are turned over to Space Command, and (2) stress test each software release in a laboratory setting before it is used in the MCCs. Further, the testing that is being done on new software releases is not thorough enough to uncover critical problems before CCS is used in an operational environment in the MCCs.

Air Force Operational Testing and Stress Testing of CCS Not Based on Updated Work-Load Requirements

The Air Force Operational Test and Evaluation Center (AFOTEC) is required to test all the MCCs at Falcon Air Force Base before they are turned over to Space Command. This operational testing and evaluation is to determine the MCCs' operational effectiveness and suitability, and is a critical milestone for CCS' turnover. It involves (1) testing the computer's software and hardware, (2) checking procedures, and (3) certifying personnel. AFOTEC and Space Command officials said one key test is determining if the system can perform the required number of simultaneous contacts under expected peak work-load conditions. However, because the Air Force has not updated the MCCs' expected peak work-

load requirements, AFOTEC cannot conduct effective tests and evaluations.

Further, major CCS software releases are currently being issued approximately twice a year. These new releases are intended to correct existing software problems and add new functions. However, without a current worst-case work-load scenario, the software cannot be stress tested to see how it performs under maximum work-load conditions.

Software Testing Not Identifying All Critical Problems

CCS software is not being adequately tested before it is put into an operational environment in the MCCs. Critical deficiencies continue to be found after new and revised software is released for use. This is due, at least in part, to the fact that the test center's Software Development Testing Laboratory, which is responsible for testing CCS software releases, is not equipped to simulate the high stress work loads that MCCs must support.

All but two MCCs are required to perform at least five simultaneous contacts. However, according to Program Office officials, the lab can only simulate the work load generated by three simultaneous satellite contacts. As a result, testing at the lab does not provide information on whether the system can perform more than three simultaneous contacts. The Air Force has no way of reliably assessing how the system will perform under more stringent conditions until it installs the new software in the MCCs and uses CCS to command and control the satellites.

Because the software is not fully tested, most critical deficiencies are not found until the MCCs use the software. Between March 1989 and March 1990, three major software releases were tested at the lab; no new critical deficiencies were found. However, after these releases were used in the MCCs, operators found about 175 new critical deficiencies. For example, one CCS function does not always accurately predict satellite positioning, which could result in an incorrect satellite maneuver. Program Office officials said they believe the majority of critical deficiencies were not identified because of the inability to test the software in scenarios involving more than three simultaneous contacts.

Both Program Office and sustaining engineering contractor officials believe the limited test capabilities (i.e., no more than three simultaneous contacts) hurts their ability to adequately test new software

releases.[1] Program Office officials believe testing is important and have requested, but not received, funds to improve the test facilities.

Computer Capacity and Performance Management Not Adequate

Capacity and performance management is the process by which the components of the computerized system are configured, used, and maintained to assure that the current and projected work loads are processed effectively, efficiently, and economically. Federal regulations and guidance recognize the importance of conducting capacity management activities to plan, acquire, and use computer resources.[2] In addition, the General Services Administration's Federal Systems Integration and Management Center considers capacity management (including performance management) to be an important tool in effectively using information processing systems. Such activities are important because they provide agencies with information about current system utilization and additional capacity that may be required to meet future needs.

Failure to monitor capacity use and anticipate capacity limitations can have potentially damaging consequences. For example, the Federal Aviation Administration uses computers to handle air traffic control, but due to capacity limitations, data describing air traffic began disappearing from controllers' computer terminals. This occurred, in part, because the agency did not know how much computer capacity was being used during normal operations.[3]

To manage capacity effectively, managers must regularly monitor system performance and capacity utilization. They must make reasoned predictions about future work loads; determine how proposed and actual changes to the system will affect system performance; and make recommendations concerning system configuration and operation to assure good service to users now and in the future. Performance data, gathered by system facilities, hardware monitors, and software monitors, and the use of effective analytic modeling tools and techniques are essential in managing capacity effectively.

The Air Force has not set up an effective capacity and performance management program, even though it acknowledges that CCS has

[1]CCS' sustaining engineering contractor analyzes the system and its interfaces; designs and implements hardware, firmware, and software modifications; and maintains the software.

[2]E.g., the Federal Information Resources Management Regulation.

[3]Air Traffic Control: Computer Capacity Shortfalls May Impair Flight Safety (GAO/IMTEC-89-63, July 6, 1989).

capacity problems in three MCCs. The Program Office relies on CCS satellite contact success data, the computer operators' perceptions of the system's limitations, and infrequent ad hoc analyses of computer capacity and performance to manage computer resources. However, these only provide indications of system performance—they do not measure actual use or reliably assess performance on a continuous basis.

First, the analysis that was done using the information collected is limited. For instance, the Program Office collects data on the number of successful and failed contacts using CCS, but does not perform detailed analyses to pinpoint the causes of failed contacts. Failed contacts are only attributed to affected areas, such as CCS computer hardware, CCS software, or other network resources. The data do not provide enough information to determine what actually caused the problem.

Second, relying on the system operators' perceptions to manage capacity is also not an effective management tool. Program Office officials said that operators manage satellite command, control, and mission data processing work loads to stay within what they believe are the system's capacity and performance parameters. Operators come up with ways to work around system problems that are known to occur. Basically, the operators cut down on the number or length of satellite contacts they make at certain times to make sure that computer use stays within the perceived capacity and performance limits. However, working this way does not tell management how well CCS is performing its mission, what capacity and performance limitations actually are, or identify what type and when improvements in computer resources are needed to increase capacity.

Third, conducting infrequent ad hoc computer capacity and performance analyses is inadequate. According to Program Office officials, these analyses are narrowly focused—they only address specific questions regarding the MCCs' ability to perform selected work-load scenarios at isolated points in time. The analytical results are not detailed enough to assess system performance and capacity, and they cannot trace problems to particular processing events. Further, these analyses do not always adequately describe the methods used or the specific work-load scenarios, and they are not done on a regular basis. Therefore, they cannot be used to show trends in capacity use and performance.

Officials from Space Command's Second Space Wing agreed that the indicators currently being used were inadequate to manage CCS capacity. The former CCS Program Manager agreed that two of the indicators—the

contact success data and ad hoc analyses—were inadequate to assess capacity, but he stated that the operators' knowledge of how the system is working is a sufficient tool to manage capacity. Program Office officials added that despite the problems with ad hoc analyses, they will continue to use them because they believe conducting comprehensive computer capacity and performance analyses are too expensive. Regardless of the cost, Program Office officials also claimed that the MCCs' computers do not have the capacity to do capacity and performance analyses on a regular basis since such analyses would overload the system. However, the Program Office did not provide any documentation supporting their claims that their ad hoc analyses were sufficient, or that systematic capacity utilization and performance measurement would be too expensive and resource-intensive.

The Program Office is not planning to improve capacity and performance analyses in the future. CCS' sustaining engineering contractor asked the Program Office in February 1990 to allow it to measure CCS' performance, including computer capacity and use, within the MCCs. The contractor believed this would help in understanding the MCCs' capabilities, fixing existing problems, and preventing future ones. The Program Office, however, did not approve this request, citing limited funds and the need for the contractor to first solve CCS' software and hardware problems.

On the other hand, the Second Space Wing recognizes that it will need better sources of information when it assumes responsibility for its portions of CCS software in 1993. In March 1990, the Wing reorganized its computer performance branch to place more emphasis on performance and capacity planning and analysis. This reorganization is a constructive step towards assessing performance and capacity.

CCS Software Documentation Is Not Adequate

A fourth problem that also affects the Air Force's ability to upgrade, test, modify, and maintain CCS is poor software documentation. Federal Information Processing Standards (Publication 38) recognize that good computer system software documentation is needed for effectively managing computer resources and expediting software changes.

Software documentation should be complete, up-to-date, and well organized. It should describe: 1) requirements; 2) design specifications; 3) users, operations, and program maintenance procedures; 4) test plans; and 5) test results and findings. Without adequate documentation,

software maintenance takes more time and effort and there is less assurance that software modifications will function as required.

CCS system software documentation is incomplete, out-of-date, and difficult to use. According to AFOTEC officials, inadequate documentation represents a significant risk to satellite control operations. Specifically, it impairs the Air Force's ability to identify and correct problems in a timely and cost-effective way.

In preparation for Space Command assuming responsibility for CCS software, AFOTEC is evaluating CCS' software documentation. As of April 1991, it had evaluated 12 of CCS' 28 software configuration items.[4] It found that most of the documentation were less than acceptable—some were missing, some were incomplete, and some were out-of-date. AFOTEC concluded that the existing documentation will make the system difficult to maintain and that improvements are needed. Table 3.1 shows AFOTEC's evaluation results.

Table 3.1: AFOTEC's Evaluation of Software Documentation for 12 CCS Software Configuration Items at the Consolidated Space Operations Center

	Level of Documentation Quality			
Type of Software Items	Unacceptable	Unacceptable to Marginal	Marginal	Acceptable
Common User[a]	4	1	•	•
Mission Unique[b]	1	2	2	2
Total	**5**	**3**	**2**	**2**

[a]Common user software items are used in every MCC. There are 19 common user software configuration items in use at the Operations Center.

[b]Mission unique software items are unique to particular MCCs and support a specific satellite program. There are nine mission unique software configuration items in use at the Operations Center.

Based on AFOTEC's evaluations, software documentation that is unacceptable or unacceptable-to-marginal means that the software will be difficult to maintain because of either poor or missing documentation. AFOTEC reported that this type of documentation will generally need many changes before it can be used as an effective maintenance tool. A marginal assessment by AFOTEC means that while the documentation is useful as a maintenance tool, the documentation was incomplete. As a result, it will take more time, effort, and resources to maintain the software (for example, to find problems and fix them).

[4]For the purpose of this report, a software configuration item can be either a single software module or an aggregation of software modules that perform a specific function or process.

Poor documentation also makes it more difficult for programmers to understand the code and its logic. Therefore, they may make modifications that cause errors or that run inefficiently, i.e., that unnecessarily consume capacity and potentially degrade system performance. The former CCS Program Manager stated that Program Office officials believe the combination of inadequate software documentation and CCS' inefficiently written software modifications has resulted in inefficient use of computer resources. The former CCS Program Manager also stated that inefficient software was one reason why most MCCs cannot perform the required maximum number of simultaneous satellite contacts during expected peak work loads. However, according to this official, no evidence is available to support this point.

Program Office and AFOTEC officials attributed inadequate software documentation to: (1) poor management control over the initial CCS development, and (2) an overriding interest in getting an operational system within budget and on schedule. While the Program Office believes the documentation is adequate to maintain the software, AFOTEC's findings show otherwise. We believe that adequate software documentation is essential for maintaining and modifying a system in a cost-effective and efficient manner.

DOD audits, our reports, and other studies have shown repeatedly that poor software documentation increases maintenance costs, which comprise the largest percentage of a system's life cycle costs. According to Barry W. Boehm,[5] estimates of the magnitude of software maintenance range from slightly over 50 to 75 percent of overall software life cycle costs. DOD's Inspector General reported in 1988 that the computer industry estimates that about 60 percent of programming resources are dedicated to the modification and maintenance of existing software.[6] It is widely recognized that shortchanging documentation is a poor strategy both economically and operationally. We have reported that without good documentation, software is difficult to understand and maintain.[7] Organizations have, in fact, chosen to redesign and rebuild systems because understanding and modifying the poorly documented existing system was so difficult.

[5]Barry W. Boehm, Software Engineering Economics, (Prentice-Hall, Inc., 1981).

[6]Summary Report on the Defense-wide Audit of Support for Tactical Software, (Department of Defense, Office of the Inspector General, April 1988).

[7]Federal Agencies' Maintenance Of Computer Programs: Expensive and Undermanaged (GAO-AFMD-81-25, Feb. 26, 1981).

Conclusions and Recommendations

Conclusions

The Air Force is working to complete CCS' upgrade by fixing software problems, adding new functions to CCS, and adding equipment to specific MCCS. These efforts have fixed many of CCS' problems and CCS is now used to make most satellite contacts. However, CCS costs continue to increase, and new software problems continue to be identified. The Air Force may not be able to correct these problems and CCS may not have all of the functions, capacity, and performance needed by 1993 because the Air Force has not: adequately defined work-load requirements for CCS; adequately tested CCS; set up an effective capacity and performance management program; and obtained adequate software documentation.

Without up-to-date work-load requirements, the Air Force cannot assure that the system is properly sized for current and future needs, it cannot develop tests to adequately stress the system, and it cannot reliably assess the impact of CCS changes on mission effectiveness. Further, until the work loads are updated, the Air Force cannot determine if CCS can meet the MCCS' operational requirements, nor can it adequately stress test CCS software releases. In addition, since the Air Force does not have an effective capacity and performance management program, it does not know how well CCS is performing and it cannot determine how much more capacity, if any, is needed to meet the ever-changing future requirements. Finally, unless the Air Force corrects deficiencies in CCS' software documentation, it will be increasingly difficult to maintain and enhance CCS as requirements continue to change and evolve, and the costs to maintain CCS are likely to continue to increase.

Unless all of these problems are resolved soon, the Air Force is assuming a significant risk that CCS may not have the functions, capacity, and performance needed to command, control, and plan satellite missions. Further, if CCS' upgrade misses its deadline, turnover of the MCCS to Space Command may be delayed, and the Air Force would be forced to continue spending up to $30 million annually to maintain an outdated system.

Recommendations

To increase the Air Force's ability to plan, measure, and control the computer resources required to meet current and future satellite command and control and mission planning processing requirements, we recommend that the Secretary of Defense direct the Secretary of the Air Force to ensure that:

- CCS work-load requirements (specifically, the peak work-load requirements for each MCC's computer system) are immediately updated and kept current;
- the updated work-load requirements are used to (1) operationally test CCS at the MCCs before the MCCs are turned over to Space Command, and (2) stress test each CCS software release before it is used in the MCCs;
- a comprehensive CCS capacity and performance management program is immediately established; and
- CCS's software documentation deficiencies are corrected before the system is turned over to Space Command, and documentation is adequately prepared and maintained in the future.

Agency Comments and Our Evaluation

In commenting on a draft of this report, DOD partially concurred with all the findings but one. DOD believes that our updated estimates for total system costs incorrectly combined acquisition costs (associated with the completed development of CCS) and subsequent life cycle costs. We believe that DOD incorrectly characterizes the cost information in the report, which clearly states that the costs include those for developing CCS and those for the sustaining engineering needed to complete development and to satisfy new requirements. Since the purpose of CCS was to replace the old, out-of-date CDS, we believe it is appropriate to report all costs until all original requirements for CCS have been completed and CDS is deactivated. As noted in the report, the Air Force was not able to determine how much of the sustaining engineering costs were for meeting original requirements and how much were for new requirements.

DOD partially concurred with our finding that CCS cannot perform key operations. Its partial nonconcurrence appears to center on the Air Force's position that, today, CCS is supporting virtually all scheduled satellite contacts—a position that was clearly recognized in our draft report. However, DOD agreed that most MCCs cannot make five simultaneous contacts under all expected work-load scenarios. We, therefore, continue to believe that CCS may not meet the five simultaneous contact requirement at turnover in July 1993, particularly as work loads continue to change and grow.

DOD partially concurred with our finding that critical deficiencies still remain, and agreed with our finding that correcting some critical deficiencies has taken longer than originally expected. However, DOD objected to what it characterized as our combining deficiencies associated with the development phase and those associated with new

evolving requirements, and it asserts that the last six turnover critical deficiencies are scheduled to be corrected by June 1992.

The 321 critical deficiencies that we identified were based, as the report clearly states, on the Air Force's criteria for critical deficiencies—deficiencies that must be fixed before CDS can be deactivated and CCS turned over to Space Command. The additional information the Air Force supplied to support its position was inconsistent with the information previously provided and the Air Force did not provide explanations for these inconsistencies. Further, the Air Force did not provide an explanation of the disposition of the 321 critical deficiencies. Therefore, we have not revised the report to present this new information.

DOD partially concurred with our conclusions and recommendation on updating and keeping work-load requirements current. DOD stated that the Air Force has defined work-load requirements for turnover of the MCCs and that it will define and continue to evaluate evolving peak work-load requirements for all MCCs as new missions are added. We believe that the Air Force's actions respond to our concerns. We were unable to evaluate the adequacy of the updated requirements since this information was not supplied to us when DOD provided its comments.

DOD partially concurred with our conclusions and recommendations on CCS testing. DOD stated that the Air Force is identifying the tests necessary to validate CCS for operational turnover to Space Command consistent with satellite program requirements. DOD noted that while these requirements do not necessarily represent current peak work loads, the Air Force will ensure that modifications to CCS are made as necessary to meet evolving work-load requirements. DOD's response recognizes the need to ensure that the updated work-load requirements are used to operationally test CCS at MCCs before they are turned over to Space Command.

DOD agreed that the Air Force's current software test tools are not adequate to stress test CCS at peak work loads before it is used in the MCCs. However, DOD was silent on requiring the Air Force to conduct these tests. DOD stated the Air Force has plans to upgrade the test environment, but noted that these requirements will compete for funding in the budget cycle. While we recognize that DOD and the Air Force are under funding constraints, we believe that DOD should take a stronger position on requiring testing and ensuring funds are spent on upgrading the test facilities. Testing is extremely important to assuring that CCS can meet

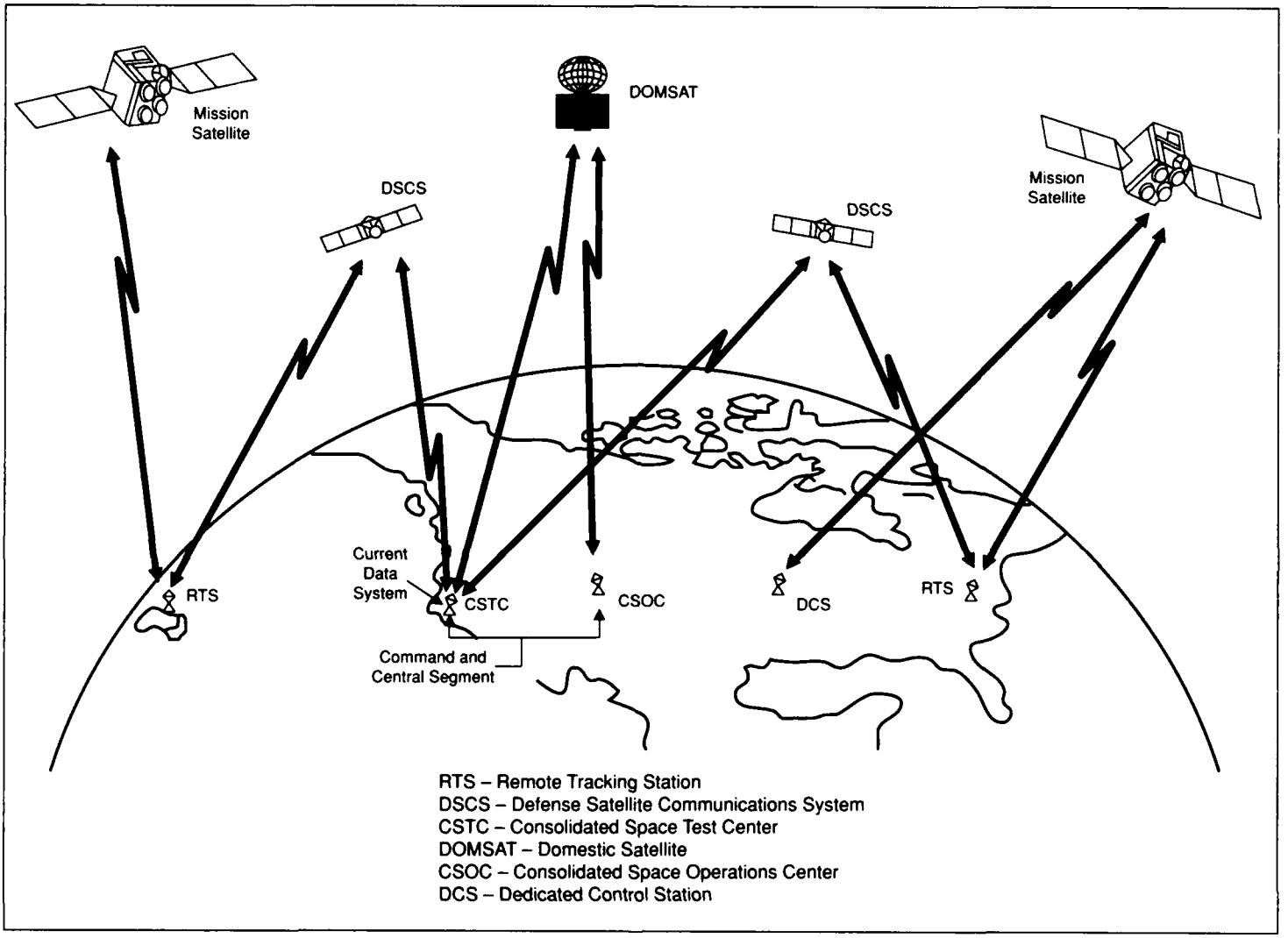
its mission, and correcting problems before, instead of after, implementation should save funds over the long run.

DOD partially concurred with our conclusions and recommendation on CCS capacity and performance management. DOD stated that the current methods are sufficient and it did not require the Air Force to establish a formal capacity and performance management program. However, DOD directed the Air Force to assess its current methods and determine how to improve capacity and performance management. The Air Force's current efforts to manage CCS do not provide the information necessary to adequately manage system capacity and performance. We believe that getting the Air Force to assess its current efforts is a step in the right direction and should demonstrate that it needs a capacity and performance management program that regularly monitors system performance and capacity utilization.

DOD partially concurred with our conclusions and recommendation on software documentation. DOD stated that AFOTEC found that some documentation is less than acceptable and the Program Office has undertaken action to upgrade some of the documentation. However, DOD asserts that AFOTEC's findings should not be interpreted as indicating that the documentation is unacceptable for turnover. We disagree. AFOTEC concluded that the unacceptable documentation will make it difficult to maintain the software and that some portions will need changes before the documentation can be used as an effective maintenance tool. AFOTEC's conclusion makes it clear that portions of the documentation are unacceptable for turnover.

Further, DOD cited the Air Force's Competition Advocate General's evaluation of the competition for the new sustaining engineering contract as support for CCS' software documentation being adequate for maintaining the system. To evaluate the documentation, the Competition Advocate General discussed its adequacy with one potential bidder. He did not evaluate CCS software documentation nor did he review AFOTEC's findings. His conclusion that there were no documentation deficiencies that precluded fair competition is unrelated to the question of whether the documentation is an effective tool for maintaining the software.

Air Force Satellite Control Network



Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, DC 20301-3010

1 NOV 1991

Mr. Ralph V. Carlone
Assistant Comptroller General
Information Management and
Technology Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Carlone:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) Draft Report, "MILITARY SPACE OPERATIONS: Satellite Control System Improved, But Serious Problems Remain," dated September 20, 1991 (GAO Code 510474, OSD Case 8745).

Although the Department partially concurs with most of the findings and all of the recommendations, the DoD non-concurs with the finding entitled "Command and Control Segment Costs Continue To Increase." The fundamental disagreement concerns combining initial acquisition costs associated with the development of the Command and Control Segment and normal life-cycle costs associated with its operation.

Additional DoD comments to the draft report findings are enclosed. Thank you for the opportunity to comment on the draft report.

Sincerely,

Charles E. Adolph
By Direction of the Secretary of Defense

GAO DRAFT REPORT - DATED SEPTEMBER 20, 1991
(GAO CODE 510474) OSD CASE 8745

"MILITARY SPACE OPERATIONS: SATELLITE CONTROL SYSTEM IMPROVED, BUT SERIOUS PROBLEMS REMAIN"

DEPARTMENT OF DEFENSE COMMENTS

* * * * *

FINDINGS

- **Finding A: Command and Control Segment Costs Continue To Increase.** The GAO reported that, since 1980, the Air Force Systems Command has been upgrading its satellite command and control system, called the Command and Control Segment. The GAO found that, since it last reported on the effort in 1989 (GAO/IMTEC-89-56, OSD Case 8083), the Air Force has made considerable progress in upgrading the Segment. The GAO reported, for example, that the system is now handling a larger portion of satellite contacts and several hundred critical design deficiencies have been fixed. At the same time, however, the GAO reported that the cost to complete the Segment continues to increase, requirements continue to expand, and new system deficiencies are being found.

  With regard to costs, the GAO noted that, based on Air Force figures as of March 1989, and an anticipated June 1991 completion date, it previously estimated the cost to develop the Command and Control Segment and provide sustaining engineering would be at least $762 million through September 1989. As of March 1991, the GAO estimated the costs had increased to at least $906 million through September 1991. According to the GAO, the program office was not able to determine how much of the increase was attributable to providing additional system capabilities and how much was for correcting system deficiencies. The GAO observed that costs will continue to increase, since the Segment will not be completed until July 1993.

  The GAO also reported that, because the Command and Control Segment is not completely operational, the Air Force must continue to maintain the older Current Data System. The GAO reported that in 1988, the Air Force estimated the cost to operate and maintain that System was $30 million annually. The GAO noted that the Air Force did not provide a revised estimate for System costs during its current review, but said maintenance costs should fall, since parts of the System will be deactivated by the end of 1991. (pp. 1-4, pp. 19-20/GAO Draft Report)

See comment 1.

DoD Response: Non-Concur. While some of the basic information reported is correct, the GAO incorrectly combines acquisition costs associated with the completed development of the Command and Control Segment and subsequent life cycle costs which are a normal aspect of support to space operations. The Command and Control Segment development phase was completed in 1987. Since that time, the Command and Control Segment has

supported a continually evolving mix of satellite programs that have new or changing missions and requirements. Periodic deliveries of new and modified software have provided the capabilities needed to support these requirements, as well as the maintenance of existing software. The costs associated with this continual support should not be construed as cost to "complete" the Command and Control Segment development.

The Air Force has previously provided the GAO the development costs associated with the Command and Control Segment. The Congress, in the FY 1989 Appropriations Act report language, acknowledged that the Command and Control Segment development was complete, and found the on-going software support to be "more appropriately an operations and maintenance activity."

- **FINDING B: The Command And Control Segment Cannot Perform Key Command And Control Operations.** The GAO explained that the Command and Control Segment is required to be able to contact and communicate with multiple satellites simultaneously-under expected peak work load conditions. The GAO found that the contact success rate has increased since 1989. The GAO reported, however, that the Air Force also requires that each mission control complex be able to support at least five simultaneous satellite contacts. The GAO noted that this is a key requirement that is used to judge whether the Segment is ready to handle all satellite control functions at a mission control complex, and to permit the Current Data System to be deactivated. The GAO found, however, that at most of the control complexes, the Command and Control Segment cannot make the required number of simultaneous contacts. The GAO noted, in fact, that operators sometimes cut down on the number and length of satellite contacts to make sure they did not exceed system capacity.

  The GAO found that the Command and Control Segment also has other serious problems, such as long recovery time from system failures. According to the GAO, the problems are termed critical deficiencies by the Air Force, because they must be fixed before the Current Data System can be deactivated and the Segment turned over to Air Force Space Command. The GAO noted that some problems affect all satellites and control complexes, while others affect only a specific satellite or complex.

  The GAO acknowledged that the program office is taking positive steps to correct Command and Control Segment critical deficiencies. The GAO reported, for example, that the program office is (1) trying to fix software problems, (2) adding new functions in software releases, and (3) adding equipment to three mission control complexes to meet capacity and performance requirements. (pp. 3-4, p. 19, pp. 20-23/GAO Draft Report)

See comment 2.

DoD Response: Partially concur. To be accurate, a distinction must be made between those deficiencies related to the original requirements and those related to subsequently evolved requirements for the Command and Control Segment.

The DoD partially concurs with the GAO assessment of simultaneous contact loading. Evolving operational requirements have resulted in increases to individual contact workloads - which, in some cases, currently prevent a five simultaneous contact capability under present operational conditions. Contact loading requirements in the Air Force Satellite Control

Network Mission Control Complexes vary from three to six simultaneous contacts. Workloads involved in each satellite contact can vary significantly. Most Mission Control Complexes require five simultaneous contacts, but each has a unique set of loading conditions for the specified number of contacts. All centers meet their baseline requirements for Command and Control System transition at Onizuka Air Force Base and for the Consolidated Space Operations Center turnover at Falcon Air Force Base. Simultaneous contacts at the specified levels routinely are accomplished at all Mission Control Complexes. Additionally, even under current operational conditions, the Command and Control Segment supports 99 percent of Air Force Satellite Control Network satellite contacts with a contact success rate in excess of 99 percent. (The required contact success rate is 95 percent.) The system has supported every Air Force Satellite Control Network satellite launch over the last year and the Air Force Space Command currently operates all operational satellites using the system. In total capacity, during Operation Desert Storm, the system supported 130 percent of the total 1988 Air Force Satellite Control Network satellite contact workload it was delivered to meet. The computer systems, which were replaced by the Command and Control Segment, are almost entirely deactivated, and the few remaining are scheduled to be deactivated by June 1992. Where current validated requirements for capacity greater than now available exist, modifications to improve processing efficiencies and/or increase capacity have been designed and are being implemented as part of the normal sustaining engineering support process.

- **FINDING C: Critical Deficiencies Are Being Resolved, But Hundreds Remain**. The GAO acknowledged that, since its 1989 report, the Air Force corrected several hundred critical deficiencies. The GAO reported that, as of December 1990, the number of critical deficiencies had been reduced to 321, as compared to 894 in April 1989. According to the GAO, a program official said that the Air Force plans to fix all of the problems by the completion of the Segment upgrade in 1993.

  The GAO also pointed out, however, that correcting the deficiencies has taken more time than the Air Force expected. The GAO cited prior Air Force estimates for resolving problems that were not met. The GAO concluded, therefore, that the latest estimate for resolving all problems may not be realistic. In addition, the GAO pointed out that the Air Force continues to find new critical deficiencies in each new software release. According to the GAO, as of December 1990, some of those deficiencies had not even been scheduled to be fixed. Overall, the GAO observed that slow progress on some of these critical problems increases the risk that the Command and Control Segment will not be completed on time. (pp. 3-4, p. 19, pp. 23-25/GAO Draft Report)

See comment 3.

DoD Response: Partially concur. Again, the issue is one of differentiating between "deficiencies" associated with the development phase of the Command and Control Segment and those that are the result of subsequent normal operational requirement evolution. The term "critical deficiencies," as used by the Air Force Satellite Control Network operators and program office, refers to "unsatisfied operational requirements essential to support of a specified event" (e.g., a launch, elimination of a former mode of operating, turnover of a new capability, ability to support a specific mission). Because the Air Force Satellite Control

Network requirements are continually evolving to meet new operational needs, there will likely always exist a set of currently "critical deficiencies." The term cannot and should not be interpreted to be synonymous with "flaw in delivered product," as the GAO apparently assumes. Nor does it necessarily imply a condition that represents a risk to satellite operations. As an example, the term "turnover-critical deficiency" is associated with a capability or performance characteristic mutually agreed to be a condition for the formal transfer of ownership of a system from the Air Force Systems Command to the Air Force Space Command.

Many of the 214 requirements stipulated by the Air Force Space Command have been determined to be new requirements, outside the baseline objectives of the Consolidated Space Operations Center program. Those requirements will be prioritized and delivered when appropriate, as part of the ongoing Air Force Satellite Control Network improvement and modernization program.

With respect to formal transfer of operational Command and Control Segment systems within the Space Operations Complex to the Air Force Space Command, the last six software modifications termed "turnover-critical" are scheduled for delivery in June 1992.

Formal turnover of Mission Control Complexes to the Air Force Space Command in 1993 will complete a carefully planned set of modification and maintenance efforts needed to meet operational requirements and turnover agreements, as well as thorough operator testing and training.

All software modifications termed "transition-critical" (i.e., necessary to complete the transfer of operations at Consolidated Space Test Center off of the old data system) have been delivered. As previously stated, the computer systems which were replaced by the Command and Control Segment are almost entirely deactivated, and the few remaining are scheduled to be deactivated by June 1992.

With 99 percent of all Air Force Satellite Control Network satellite contact activity requiring data analysis presently supported by the Command and Control Segment at over 99 percent mission success rate, and with a total workload presently exceeding 130 percent of that which the original system was delivered to meet, significant deficiencies associated with the development phase are small in number and are not deemed critical to continued operations or to turnover. The DoD concurs that delivery of system modifications to correct some "critical deficiencies" has taken more time than originally expected in 1987. The delivery of needed capability is scheduled based on priorities established by the operational users of the systems. Significant budget reductions in FY 1988, FY 1989, and again in FY 1991, caused severe disruption of program plans. The workload associated with higher priority requirements (e.g., to support launch of new satellites) also contributed to the delay. However, transition of operations from the old data system has proceeded on or ahead of the schedule established in FY 1989. Transfer of the satellite operations to the Air Force Space Command is on schedule, the system has always met the need dates for launch, and the turnover to the Air Force Space Command of operational Mission Control Complexes is scheduled consistent with current program direction. As previously stated, the term

"completion" is inappropriate for the continuing evolution of this system in response to operational needs.

- **FINDING D: Command And Control Segment Requirements Are Not Adequately Defined.** The GAO reported that the Command and Control Segment contract requires compliance with Military Standards 483A and 490A, which call for detailed requirements for computer systems, including peak processing work loads. The GAO explained that the work loads are critical in assuring that the system will function effectively under maximum expected stress, and to help size the system, develop stress tests, and serve as input for capacity and performance management.

  In the case of the Command and Control Segment, the GAO observed the requirements are defined by work load scenarios that describe various factors, such as (1) the mix of satellites and types of contacts that must be controlled simultaneously, (2) the number of terminals the system must support, and (3) the amount of data to be processed. The GAO further observed that these scenarios should include those that place the greatest expected demand on system resources.

  The GAO found, however, that the Air Force last updated the expected peak work loads for the control complexes in 1987. The GAO pointed out that since that time, the number of satellites has increased by 36 percent, and the complexes are handling different types and numbers of satellites. The GAO concluded, therefore, that the 1987 expected peak work loads are obsolete. The GAO further concluded that, without updated requirements, the Air Force cannot (1) assure that the system is properly sized, (2) develop tests to adequately stress the system, and (3) reliably assess the impact of continual Segment changes on mission effectiveness. The GAO concluded that this problem, together with the other three problems identified (see Findings E, F, and G), raise serious doubts not only about the ability of the Air Force to complete the Command and Control Segment, but also about the capability of the Segment to meet its mission requirements. (p. 5, pp. 26-28/GAO Draft Report)

See comment 4

DoD Response: Partially concur. The Command and Control Segment acquisition fully complied with Military Standards 483A and 490A. The requirements for the system were fully documented in a hierarchical set of baseline requirements documents which included an extensively detailed Appendix to the Baseline Requirements Specification that covered peak loading requirements.

The GAO correctly states that requirement changes, which have occurred subsequent to the completion of the development phase in 1987, have not been incorporated in the Baseline Requirements Specification. The Air Force Satellite Control Network requirements control process, used since 1987, has updated appendices to the baseline requirements specific tion, the allocated baseline, lower level design, and those product specifications considered adequate for support of the operational system.

The Command and Control Segment was shown to be contractually compliant with the Baseline Requirements Specification at the completion of the Data System Modernization

program. The subsequent increase in satellite programs and network loading may very well have changed peak loading requirements identified in the development contract. As indicated in the DoD response to Finding B, the Command and Control Segment presently supports a satellite mix and associated network workload far in excess of the levels present upon completion of the development phase of the program. Given the mission success rates associated with such support, the GAO conclusion that there are serious doubts the Command and Control Segment can meet its mission requirements is unwarranted. As previously indicated, the Air Force has the mechanisms in place to identify and meet those requirements necessary for turnover.

- **FINDING E: The Command And Control Segment Testing Is Inadequate.** The GAO observed that expected peak work loads are not only critical to developing a system, but are essential for testing a system and its modifications to determine if the system can do its job. The GAO further observed, however, that until the mission control complexes have updated work load requirements, the Air Force cannot (1) operationally test the current Command and Control Segment configuration to ensure the more taxing satellite scenarios can be met, and (2) stress test each software release in a laboratory setting before it is used in the complexes.

  The GAO observed that critical deficiencies continue to be found after new and revised software is released for use. According to the GAO, that is due, at least in part, to the fact the testing laboratory is not equipped to simulate the high stress work loads the control complexes must support. The GAO reported that, between March 1989 and March 1990, three major software releases were tested at the laboratory, but no new critical deficiencies were found. After the releases were used in the control complexes, however, the GAO reported that about 175 new critical deficiencies were identified. The GAO concluded that testing limitations, together with the other three problems identified (see Findings D, F, and G), raise serious doubts not only about the ability of the Air Force to complete the Command and Control Segment, but also about the capability of the Segment to meet its mission requirements. (pp. 5-6, p. 26, pp. 28-31/GAO Draft Report)

See comment 5.

DoD Response: Partially concur. In 1988, Headquarters, Air Force Systems Command performed an independent review of the Command and Control Segment and determined that additional testing capabilities would be beneficial for managing the sustaining engineering activities. An additional test facility was defined to meet validated test requirements. Within resources provided, additional test capabilities were activated in 1990.

The DoD agrees that the current test tools available do not allow testing at peak work load conditions. The Air Force obviously would prefer to have a higher fidelity test capability, but existing budgets have not allowed that level of upgrade. Requirements are currently identified to upgrade facilities and test capability improvements will compete for funding in the budget cycle.

- **FINDING F: The Command And Control Segment Capacity And Performance Management Program Is Inadequate.** The GAO reported that Federal regulations require agencies to manage computer capacity and performance. To do so, the GAO observed that managers must monitor system performance and capacity utilization regularly. The GAO further observed that agencies should routinely collect and analyze detailed capacity and performance data, which would also help predict future needs.

  The GAO found, however, that the Air Force has not set up an effective capacity and performance management program. Instead, the GAO found that the program office relies on three sources of data to manage Segment resources: (1) data on satellite success rates, using the Current Data System and the Command and Control Segment; (2) the perception of computer operators of Segment limitations; and (3) infrequent ad hoc analyses of computer capacity and performance. The GAO pointed out, however, that such sources provide only indications of system performance, but do not measure actual use or reliably assess performance on a continuing basis. In addition, the GAO observed that these sources do not offer the careful, comprehensive analysis needed to manage a system as large and complex as the Command and Control Segment. The GAO concluded that, since the Air Force does not have an effective capacity and performance management program, it does not know how well the Segment is performing and cannot determine how much more capacity, if any, is needed to meet ever changing future requirements.

  The GAO found that the program office is not planning to improve capacity and performance management in the near future. According to the GAO, the program office cited limited funds and the need for the contractor to first solve Segment software and hardware problems as reasons for not approving a sustaining engineering contractor request to measure Segment performance within the mission control complexes. On the other hand, the GAO found that in March 1990 the Second Space Wing reorganized its computer performance branch to place more emphasis on performance and capacity planning and analysis. The GAO termed it a constructive step towards assessing performance and capacity. The GAO concluded that inadequate Command and Control Segment capacity and performance management, together with the other three problems identified (see Findings D, E, and G), raise serious doubts not only about the ability of the Air Force to complete the Segment, but also about the capability of the Segment to meet its mission requirements. (p. 7, p. 26, pp. 31-36, pp. 41-42/GAO Draft Report)

See comment 6.

DoD Response: Partially concur. There currently exists no formal capacity and performance management program for the Command and Control Segment. To date, the Air Force has found its current method of assessing capacity and performance to be effective for operational and planning support. System performance in operation is constantly monitored by mission sustaining engineering support. Performance upgrades, like other requirements, are validated by operations organizations as mission workloads indicate they are needed. The Air Force Space Command continually evaluates data collected by Air Force Satellite Control Network program office engineers and by Air Force Space Command and other organizations' operators. An example of a mission change, which directed planning and execution of improvements to capacity and performance is the 1988 requirement to support two additional Defense Support Program satellites. That satellite has a very high telemetry

processing workload. Engineering analysis identified a solution using state-of-the-art workstation technology in conjunction with basic Command and Control Segment Capabilities would be the most effective. That new capability is now undergoing final testing for delivery to operations.

The Federal regulations cited by the GAO are general guidelines for acquiring and managing computer systems subject to the Brooks Act (40 USC 1059). The Command and Control Segment is exempted from the Brooks Act by the Nunn-Warner Amendment (10 USC 2315), which provides separate standards for mission critical computer resources.

- **FINDING G: The Command And Control Segment Software Documentation Is Not Adequate.** The GAO reported that a fourth problem that has affected the ability of the Air Force to upgrade, test, modify, and maintain the Command and Control Segment is poor software documentation. The GAO explained that software documentation should be complete, up-to-date, and well organized--otherwise, software maintenance takes more time and effort, and there is less assurance that software modifications will function as required.

  The GAO found, however, that the Command and Control Segment software documentation is incomplete, out-of-date, and difficult to use. According to the GAO, as of April 1991, the Air Force Operational Test and Evaluation Center had evaluated 12 of 28 Segment software configuration items and found that most were less than acceptable. The GAO reported that the testing officials said that inadequate Segment documentation represents a significant risk to satellite control operations, since it impairs the ability to identity and correct problems in a timely and cost effective way. The GAO reported that Air Force officials attributed the inadequate software documentation to (1) poor management control over the initial Segment development, and (2) an overriding interest in getting the system within budget and on schedule.

  The GAO pointed out that prior audits and studies have shown repeatedly that poor software documentation increases maintenance costs, which comprise the largest percentage of system life cycle costs. The GAO concluded that unless the Air Force corrects deficiencies in the Segment documentation, it will be increasingly difficult to maintain and enhance the Segment as requirements continue to change and evolve, and the costs to maintain the Segment are likely to continue to increase. The GAO also concluded that inadequate Command and Control Segment software documentation, together with the other three problems identified (Findings D, E, and F), raise serious doubts not only about the ability of the Air Force to complete the Segment, but also about the capability of the Segment to meet its mission requirements. (p. 8, p. 26, pp. 36-40, p. 42/GAO Draft Report)

See comment 7.

DoD Response: Partially concur. The Air Force Operational Test and Evaluation Center has identified certain portions of existing documentation that they rate "less than acceptable" in that these portions do not meet certain threshold standards. The fact that some of the Command and Control Segment documentation does not meet the thresholds is not interpreted by the Air Force Operational Test and Evaluation Center or by the Air Force Space Command as indicating unacceptability for turnover. The system is entirely

supportable, especially in modern software engineering support environments, with the present documentation.

The Air Force Operational Test and Evaluation Center reports did not identify any failures to comply with applicable regulations or standards. They reflect an evolving understanding of good engineering practices - the twelve reports cited by GAO used a different set of standards in most evaluations. Therefore, program office responses in terms of actions on each point of the published evaluation were not appropriate. However, many beneficial ideas were taken from the Air Force Operational Test and Evaluation Center reports and have been incorporated into the Command and Control Segment documentation of new requirements and maintenance changes. The program office has worked closely with the Air Force Space Command, the Air Force Operational Test and Evaluation Center, and the Command and Control Segment support contractors to identify and implement improvements to many documents as part of the normal maintenance of the system. In addition, the Air Force Satellite Control Network is increasing the use of development and testing tools, such as the Jovial reverse engineering tool, which was identified by some Air Force Operational Test and Evaluation Center reports as a significant factor in their evaluation but which could not be considered at the time of the evaluations. Thus, while the Command and Control Segment has always met required standards, the Air Force has sought ways to economically improve processes and operational systems. The evolving criteria used by the Air Force Operational Test and Evaluation have all been considered and have been incorporated in Command and Control Segment modifications wherever possible.

The FY 1990 Appropriations Act included Senate Armed Services Committee language, which expressed concerns about the adequacy of documentation -- partially in the context of its sufficiency to support competition for the award of a new sustaining engineering contract. The Air Force Competition Advocate General evaluated the preparations for competition, including documentation, in January 1991, and determined there were no deficiencies that precluded fair competition.

* * * * * *

RECOMMENDATIONS

- **RECOMMENDATION 1:** The GAO recommended that the Secretary of Defense direct the Secretary of the Air Force to ensure that the Command and Control Segment work load requirements (specifically, the peak work load requirements for each of the mission control complex computer systems) are immediately updated and kept current. (p. 8, p. 42/GAO Draft Report)

See comment 8.

DoD Response: Partially concur. The Air Force has defined workload requirements for turnover of operational Mission Control Complexes to the Air Force Space Command in compliance with DoD regulations. The Air Force will continue to define and evaluate evolving peak workload requirements for all Air Force Satellite Control Network Mission

Control Complexes as new missions are added. This information will be maintained in appropriate system documentation.

- **RECOMMENDATION 2:** The GAO recommended that the Secretary of Defense direct the Secretary of the Air Force to ensure that the updated work load requirements are used to (1) operationally test the Command and Control Segment at the mission control complexes before the complexes are turned over to the Space Command, and (2) stress test each Command and Control Segment software release before it is used in the mission control complexes. (p. 8, pp. 42-43/GAO Draft Report)

See comment 9.

DoD Response: Partially concur. The System Program Office and the Air Force Space Command are identifying those tests necessary to validate the Command and Control Segment for operational turnover to the Air Force Space Command, consistent with Consolidated Space Operations Center program requirements. That effort is expected to be completed by December 1991 with issuance of the updated Consolidate Space Operations Center Test and Evaluation Master Plan. While the requirements do not necessarily represent current peak workloads in all Mission Control Complexes, the Air Force Satellite Control Network Improvement and Modernization Program will ensure that modifications to the Command and Control Segment are made, as necessary, to meet evolving operational workload requirements. The Air Force recognizes that current software test tools do not have the capability to stress test, at peak workloads, each Command and Control Segment software release before it is used in the Mission Control Complexes. As indicated in the DoD response to Finding E, the Air Force has identified requirements to upgrade the test environment, and these requirements will compete for funding with other requirements in the budget cycle.

- **RECOMMENDATION 3:** The GAO recommended that the Secretary of Defense direct the Secretary of the Air Force to ensure that a comprehensive Command and Control Segment capacity and performance management program is immediately established. (p. 8, pp. 42-43/GAO Draft Report)

See comment 10.

DoD Response: Partially concur. Current methods are sufficient for tracking and managing the operational system. However, the Air Force will assess the capabilities in place and will determine what steps should be taken to improve capacity and performance management. That analysis is to be completed by August 1992.

- **RECOMMENDATION 4:** The GAO recommended that the Secretary of Defense direct the Secretary of the Air Force to ensure that the Command and Control Segment software documentation deficiencies are corrected before the system is turned over to the Space Command, and that documentation is adequately prepared and maintained in the future. (p. 8, pp. 42-43/GAO Draft Report)

See comment 11.

DoD Response: Partially concur. Although some of the earlier documentation does not satisfy some of the Air Force Operational Test and Evaluation Center criteria fully, the documentation complies with all applicable regulations and standards and is fully successful in meeting day-to-day maintenance and upgrade needs. The program office incorporated many of the Air Force Operational Test and Evaluation Center recommendations into the documentation together with updates to incorporate new mission requirements. Process improvements addressed by the Air Force Operational Test and Evaluation Center, such as automation of documentation and testing environments, are also being incorporated into Air Force Satellite Control Network activities, completely changing the basis for future evaluations. The Air Force will ensure updates to the documentation adequately support a competitive contractor maintenance concept as required by program direction.

The following are GAO's comments on the Department of Defense's letter dated November 4, 1991.

GAO Comments

1. DOD incorrectly characterizes the cost information in the report, which clearly discloses that the costs include those for developing CCS and those for the sustaining engineering needed to complete development and to satisfy new requirements. Since the purpose of CCS was to replace the old, out-of-date CDS, we believe it is appropriate to report all costs until all original requirements for CCS have been completed and CDS is deactivated. As noted in the report, the Air Force was not able to determine how much of the sustaining engineering costs were for meeting original requirements and how much were for new requirements.

2. DOD partially concurred with our finding that CCS cannot perform key operations. Its partial nonconcurrence appears to center on the Air Force's position that, today, CCS is supporting virtually all scheduled satellite contacts—a position that was clearly recognized in our draft report. However, DOD agreed that most MCCs cannot make five simultaneous contacts under all expected work-load scenarios. We, therefore, continue to believe that CCS may not meet the five simultaneous contact requirement at turnover in July 1993, particularly as work loads continue to change and grow. The Air Force stated that the MCCs requirements vary from three to six simultaneous contacts. We have revised the report accordingly.

3. DOD partially concurred with our finding that critical deficiencies still remain, and concurred with our finding that correcting some critical deficiencies has taken longer than originally expected. However, DOD objected to what it characterized as our combining deficiencies associated with the development phase and those that are the result of subsequent normal operational requirement evolution and it asserts that the last six turnover critical deficiencies are scheduled to be corrected by June 1992.

The 321 critical deficiencies we identified were based, as the report clearly states, on (1) the Air Force's criteria—deficiencies that must be fixed before CDS can be deactivated and CCS turned over to Space Command, and (2) the latest data available when we completed our field work. We analyzed the additional information the Air Force recently supplied to support its assertion that the last six critical deficiencies are scheduled to be corrected by June 1992. The Air Force's information was inconsistent with the information previously provided and the Air

Force did not provide explanations for these inconsistencies. Further, the Air Force did not provide sufficient information for us to determine the disposition of any of the 321 critical deficiencies—it did not explain if they were resolved, reprioritized, or no longer considered critical to turnover and deactivation of CDS. Finally, the Air Force's latest data showed that 13 critical deficiencies had not even been scheduled to be corrected by June 1992. Therefore, we did not revise the information in the report.

4. We believe that the actions the Air Force said it took respond to our concerns, as we explain in the analysis of their response to our recommendation (see number 8). DOD's basis for only partially concurring with our finding is not clear.

5. While DOD partially concurred with our finding that CCS testing is inadequate, it was difficult to determine with what it disagreed. The Air Force agrees that its current test tools are not adequate to test CCS at peak work-load conditions. Further, the Air Force recognizes the need to upgrade its testing capabilities.

6. DOD states that while no formal capacity and performance program exists, the Air Force has found its current method of assessing capacity and performance to be effective. We disagree. Our analysis showed that the Air Force does not have a method to measure actual computer use or reliably assess performance on a regular basis.

Further, DOD notes that the federal regulations on capacity and performance management discussed in the report do not apply to CCS. We did not mean to imply that the Air Force is required to follow the specific regulations we cited and have revised the report to eliminate any such implication. The regulations and guidance were cited because they are good examples of what should be done. We believe that both DOD and the Air Force agree on the main point—every system, especially one the size and complexity of CCS, should have a capacity and performance management program to assure that information is processed efficiently, effectively, and economically.

7. DOD partially concurred with our finding on documentation, stating that AFOTEC found that some documentation is less than acceptable, but that this is not interpreted by AFOTEC or by Space Command as indicating that the documentation is unacceptable for turnover. We disagree with this interpretation. AFOTEC's evaluation found that 8 of the 12 software configuration items it evaluated had documentation that would

make it difficult to maintain the software and that some documentation needs to be changed before it can be used as an effective maintenance tool. AFOTEC's conclusion—that the poor documentation would make the system difficult to maintain and that improvements were needed—makes it clear that portions of the documentation are unacceptable for turnover.

Further, DOD cited the Air Force's Competition Advocate General's evaluation of the competition for the new sustaining engineering contract as support for CCS' software documentation being adequate. We discussed the evaluation with the Competition Advocate General and do not believe his evaluation is relevant to our finding. The Competition Advocate General said that he did not independently evaluate the documentation nor did he review AFOTEC's findings. To evaluate the documentation, he discussed its adequacy with one potential bidder. His conclusion that there were no documentation deficiencies that precluded fair competition is entirely different from any assessment of how the documentation will help in maintaining the software.

8. DOD concurred with our recommendation to update and keep current work-load requirements. DOD stated that the Air Force has defined work-load requirements for turnover of the MCCs and that it will define and continue to evaluate evolving peak work-load requirements for all MCCs as new missions are added. DOD stated that the Air Force had updated the requirements, but it did not provide this information to us. Therefore, we were not able to evaluate the adequacy of the updated requirements.

9. DOD partially concurred with our second recommendation. DOD stated that the Air Force is identifying the tests necessary to validate CCS for operational turnover to Space Command consistent with satellite program requirements. DOD noted that while these requirements do not necessarily represent current peak work loads, the Air Force will ensure that modifications to CCS are made as necessary to meet evolving work-load requirements. DOD's response recognizes the need to ensure that the updated work-load requirements are used to operationally test CCS at MCCs before they are turned over to Space Command.

However, while DOD agreed that the Air Force's current software test tools are not adequate to stress test CCS at peak work loads before it is used in the MCCs, DOD did not require the Air Force to conduct the stress tests. DOD stated the Air Force has plans to upgrade the test environment, but noted that these requirements will compete for funding in the

budget cycle. While we recognize that DOD and the Air Force are under funding constraints, testing is extremely important to assuring that CCS can meet its mission. In addition, correcting problems before, instead of after, implementation should save funds over the long run.

10. DOD partially concurred with our recommendation. While DOD stated that the current methods are sufficient, DOD also directed the Air Force to assess its current methods and determine what steps should be taken to improve capacity and performance management. We believe that the Air Force's current efforts to manage CCS do not provide the information necessary to adequately manage system capacity and performance. However, we believe that getting the Air Force to assess its current efforts is a step in the right direction and should demonstrate that it needs a capacity and performance management program that regularly monitors system performance and capacity utilization using hardware and software monitors and analytical modelling tools.

11. DOD stated that it partially concurred with our last recommendation. DOD also stated that although the documentation is fully successful in meeting day-to-day maintenance and upgrade needs, it will require the Air Force to ensure the documentation adequately supports a competitive contractor maintenance concept. We disagree that the documentation is adequate for maintaining the software. AFOTEC's evaluation concluded that the documentation will make it difficult to maintain the software and that some portions will need changes before the documentation can be used as an effective maintenance tool. AFOTEC's conclusion makes it clear that portions of the documentation are unacceptable for turnover. Therefore, we believe DOD needs to take another look at this issue.

Major Contributors to This Report

Information Management and Technology Division, Washington, D.C.	Robert P. Cavanaugh, Assistant Director Dr. Rona B. Stillman, Chief Scientist Leonard J. Latham, Technical Adviser Terie M. Schlee, Reports Analyst
Los Angeles Regional Office	Allan Roberts, Assistant Director Larry J. Bridges, Evaluator-in-Charge David G. Hubbell, Evaluator James D. Nolan, Evaluator