United States General Accounting Office

GAO

Report to the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives

November 1988

ATTACK WARNING

NORAD's Communications System Segment Replacement Program Should Be Reassessed

GAO/IMTEC-89-1

About Our New Cover. . .

The new color of our report covers represents the latest step in GAO's efforts to improve the presentation of our reports.

GAO

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

Information Management and
Technology Division

B-203028

November 30, 1988

The Honorable Bill Chappell, Jr.
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

In response to your request and subsequent discussions with your office, we assessed the Air Force's efforts to acquire a replacement system for the communications portion of the North American Aerospace Defense Command's tactical warning and attack assessment system. The replacement system will be an integral part of NORAD's ability to provide strategic surveillance and attack warning information to United States and Canadian leaders. We found that the replacement system is behind schedule, over budget, does not meet established requirements, and is incompatible with other NORAD equipment.

We are sending copies of this report to the Secretary of Defense; the Secretary of the Air Force; the Chairmen, House and Senate Committees on Armed Services; the Chairman, Senate Committee on Appropriations; the Director, Office of Management and Budget; and to other interested parties.

Sincerely yours,

Ralph V. Carlone
Director

Executive Summary

Purpose

The North American Aerospace Defense Command (NORAD) is responsible for warning United States and Canadian leaders that North America is under air, missile, or space attack. At the request of the Subcommittee on Defense, House Committee on Appropriations, GAO assessed the Air Force's strategy for acquiring a replacement for the communications portion of NORAD's computer system. Specifically, GAO determined whether a complete replacement is needed, in view of improvements being made or planned through interim upgrades.

Background

The command and control center for tactical warning and attack assessment is Cheyenne Mountain Air Force Station, which houses data processing and communications subsystems supporting NORAD's mission. The Communications System Segment (CSS) computer subsystem handles nearly all communications at Cheyenne Mountain. Since 1982, the Air Force has been developing a replacement for CSS. There are two parts to the replacement, designated block I and block II. Block I is a semi-automated technical control unit, which monitors communication lines and provides for switching to backup lines and equipment when communication quality deteriorates. Block II is a message distribution subsystem that receives messages, checks them for completeness, and forwards them to various NORAD computer systems for processing.

The Air Force expects to spend about $281 million on this replacement program—about $72 million for block I, and $209 million for block II. The system is designed to replace the CSS with completely new hardware, operating system, and application software. Because of delays in the replacement program, the Air Force began an estimated $14 million upgrade to prolong CSS' useful life. New computers were acquired to replace CSS' principal computers. Other equipment is also scheduled to be replaced.

Results in Brief

The block I semi-automated technical control unit has design deficiencies that will preclude its installation and use at Cheyenne Mountain unless substantial changes are made. Besides these deficiencies, the unit as delivered is built to a wiring standard that is not compatible with other computer equipment at Cheyenne Mountain. The Air Force plans to accept the block I unit in November 1988 without having (1) corrected the deficiencies, (2) conducted complete end-to-end testing of the unit (continuous from start to finish without a system failure), or (3) resolved the unit's incompatibility problems with Cheyenne Mountain.

The Air Force intends to have the contractor correct the deficiencies during block II development and install the system sometime in 1990.

The Air Force is also continuing with the planned $209 million development and acquisition of block II. However, the $14 million interim upgrade program for the CSS should satisfy the functional deficiencies that justified the block II program, and meet NORAD's communications needs through 1995, and perhaps through the year 2000. The upgraded CSS will provide the Air Force with a window of opportunity for determining the most efficient and effective approach for achieving Cheyenne Mountain's communication needs.

Principal Findings

Block I Development Problems Are Significant

Block I of the CSS Replacement program has experienced significant schedule and performance problems. The planned installation date has slipped from 1986 to 1990. After 5 years of development, block I cannot fully meet contract specifications. For example, the original block I requirement called for the unit to restore full mission capability within 2 minutes after total loss of power, a requirement that has since been relaxed to 26 minutes. During testing, the software failed and the unit had to be shut down. It took 31 minutes to restart it, a time lapse unacceptable to the Air Force Space Command. The contractor has requested that the restart requirement be further relaxed to 35 minutes.

Even if technical deficiencies were resolved, block I would still not work with other NORAD subsystems because the block I unit was designed to a wiring standard that is not compatible with equipment currently in the mountain. As of September 1988, the Air Force Space Command had not resolved the wiring standard problem and had not requested the funds needed to pursue a resolution. However, the initial estimate is that it will take 2 years and $5 million to resolve the wiring problem.

Divergent views exist within the Air Force concerning the disposition of block I. Some officials believe that parts can be used to build a modified block I unit. Others believe that block I should not be installed, as it would result in an unacceptable risk to the integrity of communications within Cheyenne Mountain. Further, others are convinced that block I is needed, that the deficiencies can be resolved, and that the unit should be installed in Cheyenne Mountain.

Upgrades to Current System Should Resolve Deficiencies Used to Justify Replacement System

The Air Force has been working on block II as a means of correcting various deficiencies in the existing CSS. These deficiencies include unreliable message processing, inadequate computer system availability, difficulty in maintaining system application software and aging computer hardware, and an inability to expand to meet future requirements.

Because of the schedule delays experienced in the CSS Replacement, the Air Force has been upgrading the existing CSS to resolve some of its more immediate communications processing shortfalls. GAO found that these interim upgrades, once completed, should resolve all of the functional deficiencies used to justify the development of block II. While block II will provide some additional capabilities over what the upgraded CSS provides, such as alerting operators to the need to verify missile warning messages and recording performance data, GAO found that the upgraded CSS should satisfy Cheyenne Mountain's identified communications needs through at least 1995, and possibly through the year 2000.

Other Issues Will Affect Replacement Requirements

The Air Force recognizes there are several critical CSS issues that must be resolved before the CSS Replacement can become fully operational. These include the need to establish (1) a common message set or format, (2) a consistent message load, and (3) a standardized communications protocol. Each of these will have an impact on CSS Replacement requirements and could dramatically change the program's design, cost, and schedule. If these issues are not resolved, the Air Force will have developed a system that will not be able to effectively communicate with other Cheyenne Mountain equipment.

Recommendations to the Secretary of Defense

GAO recommends that the Secretary of Defense direct the Secretary of the Air Force not to accept the block I unit as currently planned. The Secretary of Defense should also direct that a single wiring standard be established for Cheyenne Mountain.

Given that the Air Force and the contractor have stated that the deficiencies will be corrected at no additional cost to the government, the Secretary of Defense should direct that the block I deficiencies be corrected immediately and that complete, continuous end-to-end formal qualification testing be conducted to determine and document compliance with block I specifications. The test results should be used to assess whether the system meets specified requirements and whether any additional deficiencies are identified. If formal qualification testing identifies additional deficiencies, the Secretary of Defense should decide

whether the Air Force's best interests are served by correcting any or all of them, and make visible to the appropriate congressional committees the source of funding used to correct the deficiencies.

GAO also recommends that before proceeding with further development of block II, the Secretary of Defense direct the Secretary of the Air Force to resolve critical issues such as protocol standards, message set, and work load capacity. The Secretary of the Air Force should proceed with the planned interim upgrades to the existing CSS and complete an analysis that determines the impact, in terms of performance, cost, and schedule, of critical system design questions. When completed, this analysis should be used to assist in developing a plan for determining the most effective means of meeting future communications processing needs at Cheyenne Mountain. (See ch. 2 for other recommendations.)

Recommendation to the Congress

GAO recommends that the Congress withhold funding for any follow-up communications system until the Air Force has presented an acceptable plan for (1) solving critical issues such as protocol standards, message set, and work load capacity; and (2) determining the most effective and efficient approach for achieving Cheyenne Mountain's future communications needs.

Agency Comments

The Department of Defense concurred with some of the report's findings, but disagreed with all of the recommendations. However, Defense did not offer convincing evidence to support its claims, nor did it adequately explain how the Air Force has resolved the critical issues concerning the replacement system's development and performance. Defense further stated that the report was inconsistent with earlier GAO recommendations to replace obsolete computers at Cheyenne Mountain. GAO's recommendations are not designed to curtail needed computer replacements; rather they are designed to reasonably contain cost growth and ensure that when replacements are made, they will be more likely to provide effective communications for Cheyenne Mountain. See chapters 2 and 3 for a detailed evaluation of Defense's comments.

Contents

Figures

Abbreviations

AUTODIN	Automatic Digital Network
CSS	Communications System Segment
ESD	Electronic Systems Division
GAO	General Accounting Office
GTE	General Telephone and Electronics, Inc.
IMTEC	Information Management and Technology Division
OSI	Open System Interface
NORAD	North American Aerospace Defense Command
TCP/IP	Transmission Control Protocol/Internet Protocol
TW/AA	Integrated Tactical Warning and Assessment
WWMCCS	World Wide Military Command and Control System

Introduction

An interrelated group of military commands is responsible for providing strategic surveillance and attack warning information to U.S. and Canadian leaders. The Integrated Tactical Warning and Assessment (TW/AA) system is the major automated system that supports these roles. Data communications in support of that system are provided by the Communications System Segment (CSS) at the Cheyenne Mountain Air Force Station. The Air Force is currently in the process of procuring a replacement for the CSS, which is becoming outmoded. The Air Force has also initiated an interim program to upgrade the existing CSS while the replacement system is being developed. The House Committee on Appropriations, Subcommittee on Defense, asked us to examine these modernization efforts.

Organizational Relationships

The U.S. Space Command is a unified command made up of three components—the Air Force Space Command, the Naval Space Command, and the United States Army Space Command—that oversees certain missile warning and space surveillance activities. The U.S. Space Command supports the North American Aerospace Defense Command (NORAD), a binational military command consisting of U.S. and Canadian personnel. U.S. and Canadian leaders rely on NORAD to provide surveillance of the airspace over North America and warn of and assess air, missile, and space attacks. The Commander-in-Chief of NORAD also serves as the Commander-in-Chief of the U.S. Space Command.

The U.S. Space Command, located at Colorado Springs, Colorado, has as its mission to (1) operate and protect U.S. space systems and confront enemy space systems during war; (2) provide integrated tactical warning and assessments of space, missile, and air attacks on the continental United States; and (3) plan for defense against ballistic missiles. The Air Force Space Command, as a component of U.S. Space Command, provides most of the TW/AA-related infrastructure that enables the operational commands, NORAD, and the U.S. Space Command to perform their missions.

The command and control center for NORAD and the U.S. Space Command is the Cheyenne Mountain Air Force Station, which houses data processing equipment supporting the command's tactical warning and attack

assessment mission. The TW/AA system, which the Air Force calls a "system of systems," consists of air defense, space defense, and missile warning subsystems, as well as communications links, components for correlating information, and standardized display terminals. The goal of the system is to present, in a timely manner, a composite picture of an attack so that our nation's leaders can assess the nature and intent of an attack. Although the TW/AA system has been modified to accomplish changing missions and accommodate changing threats, it is still comprised of aging and obsolete hardware and software. The TW/AA system has five principal subsystems:

- Communications System Segment,
- Space Defense Command and Control System,
- Intelligence Data Handling System,
- NORAD Computer System, and
- Mission Essential Backup System.

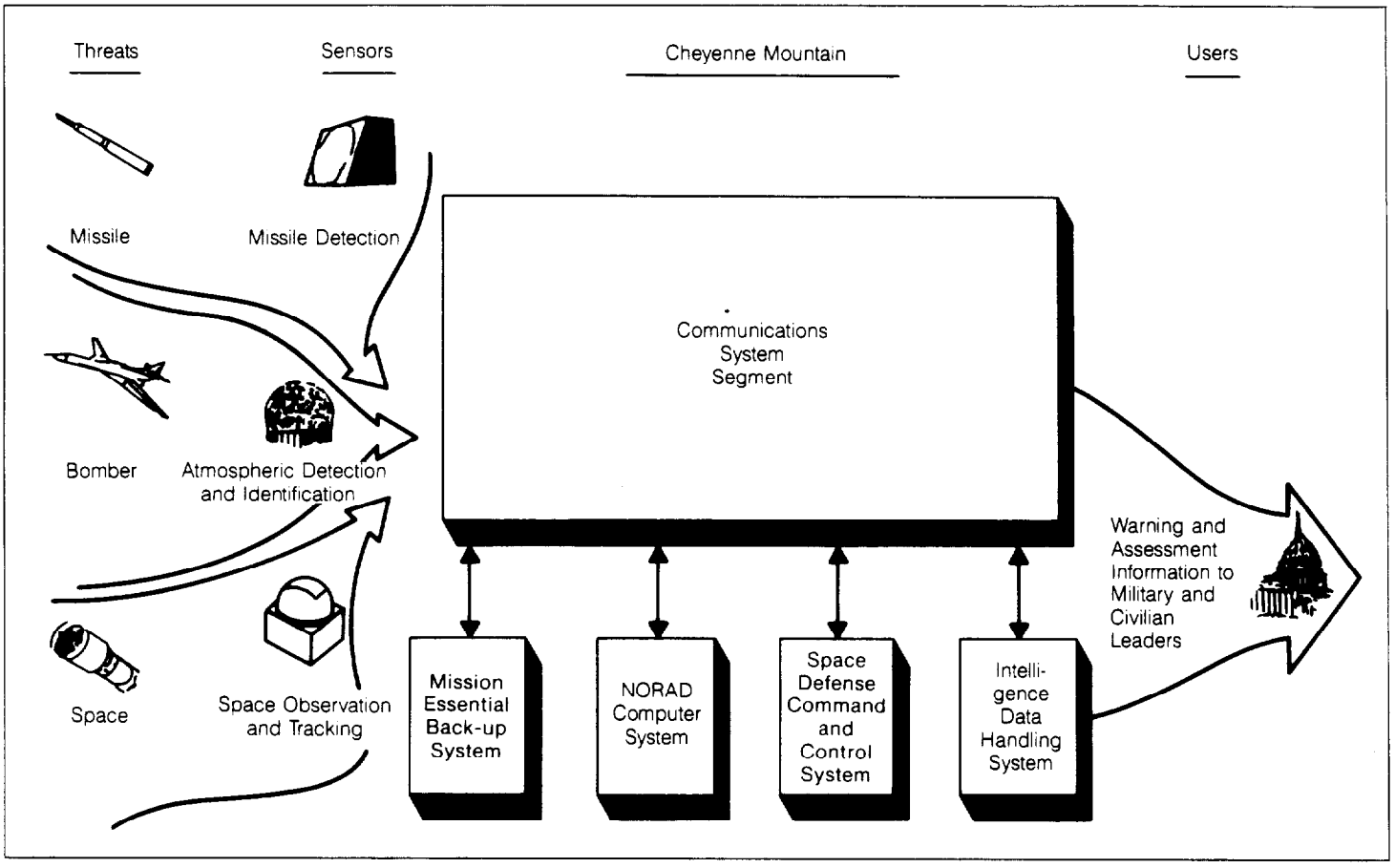
Several projects are underway to modernize or replace these subsystems, including the Communications System Segment.

Communications System Segment

The CSS is the subsystem that handles nearly all digital communications[1] entering and leaving Cheyenne Mountain Air Force Station, as well as communications among systems within the complex (see fig. 1.1). The system receives messages from various air, missile, and space surveillance systems, and routes the information to other computers within Cheyenne Mountain. According to the Air Force, CSS is the most critical subsystem at the Cheyenne Mountain Air Force Station because it processes virtually all digital communications at the mountain.

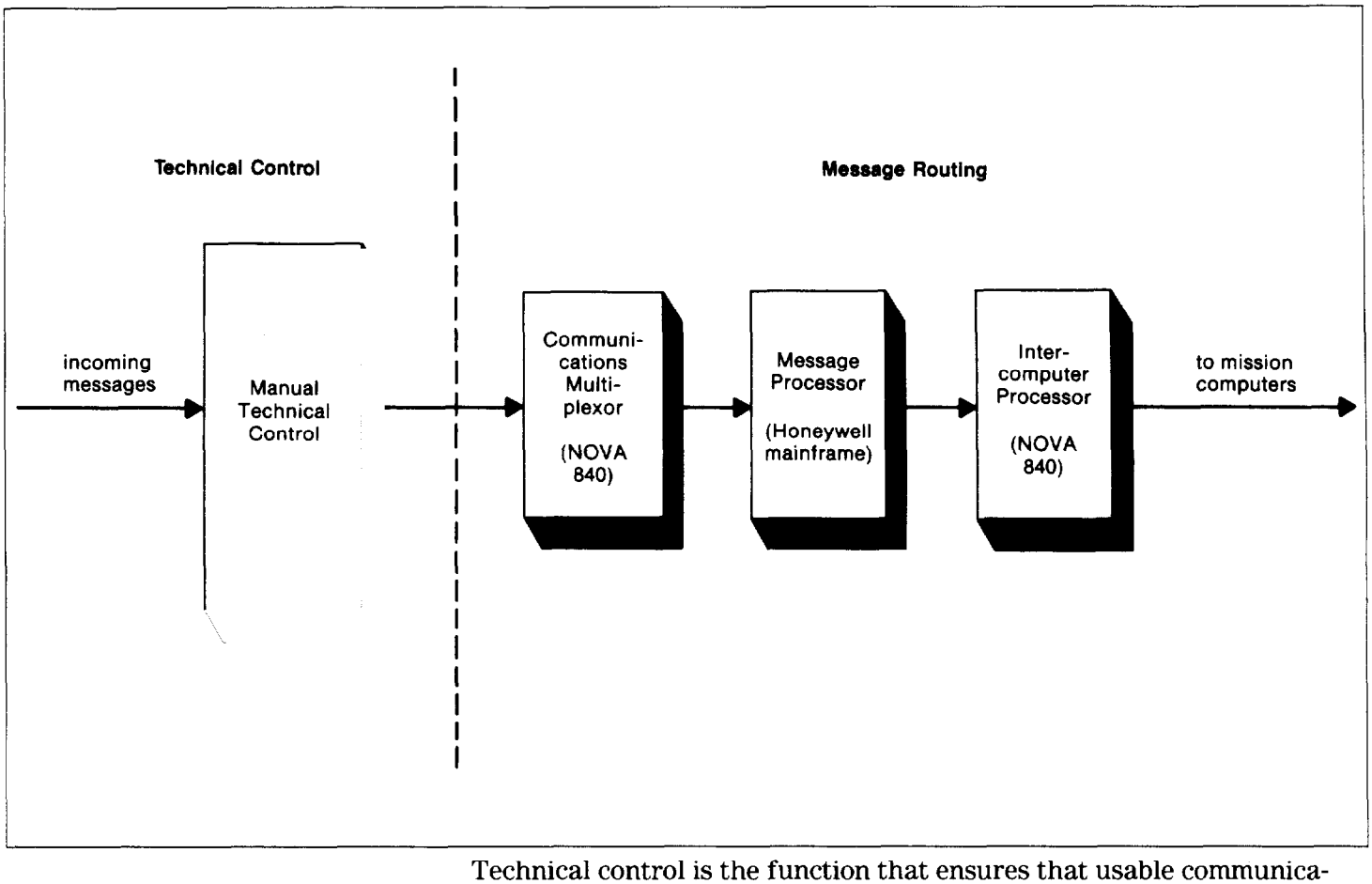
[1] Voice communication and certain classified intelligence information is not processed through the Communications System Segment.

Figure 1.1: NORAD TW/AA System



The CSS, shown in greater detail in figure 1.2, contains two groups of components for performing two basic functions: circuit switching and message routing. Circuit switching involves transferring data from one line to an alternate line and is provided by the technical control component. Message routing is the process of identifying messages and sending them to a particular subsystem. The message routing capability is provided through CSS' message routing components.

Figure 1.2: Communications System Segment



Technical control is the function that ensures that usable communications lines are always available to link sensors and other users outside of Cheyenne Mountain Air Force Station, principally military command authorities, with users inside the complex. This goal is achieved by maintaining spare lines and communications equipment that can rapidly replace any live line or equipment that malfunctions. The technical control function for the CSS is manually performed using patch panels (similar to old telephone switchboards) and test equipment. Operators monitor the quality of circuit performance, test for and diagnose problems, and restore faulty communication lines by manually switching to backup circuits.

Message routing involves several functions in addition to routing a message to its proper destination. Additional functions include examining a message for integrity, retaining a copy of the message, and performing any necessary code and format conversions.

The CSS has two sets of computers—each containing a Honeywell mainframe, a communications multiplexor, and an intercomputer processor—one operating as the prime set, the other as a backup, should the prime set fail. The CSS mainframe is a Honeywell Model 60/60 computer, which functions primarily to identify messages and route them to their proper destinations. The Honeywell also allows operators to manage the configuration of communications lines and collect data for tracking and analyzing system performance.

The Honeywell mainframe is supported by a communications multiplexor and an intercomputer processor, which use NOVA 840 minicomputers. The communications multiplexor collects and organizes message data from the communications lines and forwards it to the mainframe. The intercomputer processor handles communications between the mainframe and other Cheyenne Mountain subsystems.

Over time, the CSS equipment has aged and become increasingly difficult to maintain. For example, Data General, Inc., the NOVA minicomputer manufacturer, no longer makes, services, or provides spare parts for the minicomputers, and the General Services Administration has identified them as obsolete. NORAD personnel have been able to maintain system hardware by manufacturing their own spare parts or salvaging parts from retired NOVAs. Accordingly, in 1981 the Air Force determined that a replacement system was needed in order to provide a maintainable, flexible, and available system with potential for growth.

CSS Replacement Authorized to Satisfy Communications Requirements

A January 1982 Air Force program management directive authorized a CSS Replacement program. That directive, which has been updated several times, establishes as the program objective obtaining, at the lowest overall life-cycle cost, a reliable and maintainable system that conforms to the Air Force's approved Tactical Warning and Attack Assessment architecture. The CSS Replacement is to provide sufficient growth potential to satisfy NORAD's strategic communications requirements through 1999.

The CSS Replacement program is being developed in two separate blocks. Block I is intended to automate the monitoring and technical control of

the communications lines entering Cheyenne Mountain. This will replace the CSS manual technical control facility. Block II is planned to provide message processing and distribution capabilities to replace the message routing functions of the CSS. Blocks I and II are discussed in greater detail in chapters 2 and 3, respectively.

Role of Electronic Systems Division and Air Force Logistics Command

Although the Air Force Space Command uses the CSS and plans to use the CSS Replacement system, it is not responsible for acquiring the replacement system. This is because automated data processing systems for Air Force command, control, communications, and intelligence are acquired by the Air Force Systems Command through its Electronic Systems Division, located near Boston, Massachusetts. Electronic Systems Division also plans and manages the development of these systems. The Air Force Logistics Command is responsible for maintaining some equipment at Cheyenne Mountain, including the NOVA 840 minicomputers.

Cost of the Replacement Program

In 1981, when the Air Force determined that a replacement system was necessary, Electronic Systems Division estimated that the CSS Replacement would cost $202 million. The contract for the full-scale development[2] of block I was awarded to General Telephone and Electronics, Inc. (GTE) in June 1984. The contract included an unpriced option for block II development. This latter effort was added to the contract in February 1987.[3] By October 1985, Electronic Systems Division was estimating that the total cost of the program would reach $350 million, an increase of $148 million (73 percent) over the original estimate.

Commanders of the Air Force Space Command and Electronic Systems Division decided that these costs were unacceptable and began looking for ways to reduce requirements, in order to bring down costs. They jointly initiated a special requirements review in 1985 to determine if requirements could be eliminated or modified, thus reducing costs. The review team recommended that requirements be reduced in 11 areas. The reduction with the greatest impact on cost involved eliminating a requirement for physical separation of major processing functions. The

[2]The full-scale development phase includes developing, engineering, fabricating, and testing all items necessary for the system support.

[3]Although two other potential offerors responded to a notice in the Commerce Business Daily of Electronic Systems Division's intent to negotiate block II with GTE, both withdrew their responses without participation in the block II acquisition. Consequently, the price of the block II effort has not been subject to competition.

review team noted that by separating functions only within the software instead of within different pieces of hardware, the cost of hardware and software would be reduced.

The review team's recommended changes were accepted, and program costs were re-estimated in April 1987 at $242 million, an overall reduction of $108 million. However, by May 1988, estimated costs for completing the CSS Replacement had climbed again, to $281 million—39 percent more than originally planned.

Delays Have Contributed to the Need for a Planned Interim Upgrade Program

At the time of the CSS Replacement special requirements review in 1985, the review team noted that the milestone for initial operational capability had slipped 2 years, from September 1989 to September 1991. As development of the CSS Replacement has progressed, the existing CSS has grown older and the hardware has grown increasingly more difficult for the Air Force to maintain. In May 1987, Honeywell advised the Air Force that it was discontinuing production of computers suitable for replacing the existing CSS mainframe computers, and that orders would be accepted on an "as available" basis until about June 1987. The Air Force recognized that the CSS Replacement schedule was optimistic and that block I was beginning to experience delays. As a result, the Air Force became concerned that by 1992 it would not have a fully functional system in place. Air Force Space Command officials therefore decided to replace the aging Honeywell equipment (Model 60/60) with more modern, compatible Honeywell equipment (Model 6000 DPS).

Efforts also have been underway to replace the NOVA 840 minicomputers. They are becoming difficult to maintain and support because of their age and outdated technology. Other problems with the NOVA 840s include serious limitations on memory capacity, processing power, and expansion capability. Recently, the Air Force decided to install a high-speed local area network to replace the intercomputer processors. A decision also has been made to replace the NOVA 840 minicomputers within the communications multiplexor with a custom-designed circuit chip using very high speed integrated circuit technology. The effects of these upgrades are discussed in detail in chapter 3.

Objectives, Scope, and Methodology

At the request of the Chairman, House Committee on Appropriations, Subcommittee on Defense, we assessed the Air Force's strategy for acquiring a replacement CSS. To meet our objective, we addressed three major issues: (1) whether the block I semi-automated technical control

unit should be accepted and installed as planned by the Air Force, (2) the extent to which interim Communications System Segment upgrades will satisfy requirements and extend the system's life, and (3) whether the block II automated message distribution capability should be developed now in light of reductions in requirements, current system upgrades, and high development risks.

Information for this report was obtained from pertinent management, technical, and contract documents provided by the Air Force. We performed technical analyses of performance data, where available, and analyses of systems specifications for the existing and planned systems. We did not however, validate any of the test procedures used in testing the CSS Replacement. We also held discussions with Air Force officials responsible for operating and managing the existing communications system and acquiring the replacement.

Our work was conducted at Air Force Systems Command at Andrews Air Force Base, Maryland; Electronic Systems Division at Hanscom Air Force Base, Massachusetts; United States Space Command and Air Force Space Command at Peterson Air Force Base, Colorado; at the Cheyenne Mountain Air Force Station, Colorado; and at the Sacramento Air Logistics Center, McClellan Air Force Base, California. We also discussed technical issues with several companies under contract with the Air Force, including General Telephone and Electronics, Inc., the CSS Replacement prime contractor, Mitre Corporation, which provides engineering support to the Electronic Systems Division, and Kaman Sciences Corporation, the software maintenance contractor for CSS.

Our audit work was conducted between November 1987 and June 1988. Information has been updated through September 1988. Our work was performed in accordance with generally accepted government auditing standards.

Technical Problems Preclude Use of the Semi-automated Technical Control Unit

The Air Force has invested about $72 million in the block I semi-automated technical control unit for the CSS Replacement—a program phase that has experienced serious design and development problems. Block I does not currently meet contract specifications, nor is it compatible with other equipment in Cheyenne Mountain. The user community within Air Force Space Command is divided as to what to do with block I. Some are opposed to continuing acquisition and engineering support; others believe the unit can be salvaged and modified. Electronic Systems Division is planning to accept block I, with its known deficiencies, and give the contractor time to correct identified deficiencies during the development of block II.

Initially anticipated to be accepted and installed by the Air Force in October 1986, block I is now scheduled for formal acceptance in November 1988. However, the Air Force does not plan to install block I in Cheyenne Mountain until 1990. Further, even if the current deficiencies in block I were corrected, it could not be installed and used in Cheyenne Mountain because of several technical problems, primarily an incompatible wiring standard between block I and Cheyenne Mountain.

Block I, As Developed, Does Not Meet Contract Specifications

Formal qualification testing, which is conducted under Air Force supervision at the contractor's plant, is designed to ensure that a system performs in accordance with contract specifications. Successful completion of formal qualification testing generally leads to operational system testing and final payment by the government. While testing for block I was planned for a 2-month period, actual testing was done over almost 10 months, from late March 1987 through early December 1987. Test results demonstrated that block I did not meet all system specifications.

Although program officials from Electronic Systems Division and the development contractor believe that the methodologies used during testing were proper, some Air Force Space Command and engineering support contractor officials believe that complete end-to-end retesting is needed to ensure that the system will perform as designed. The contract specifications for the CSS Replacement program require that formal qualification testing be conducted to verify that all system specifications are met. Our analysis shows that block I does not meet all contract specifications.

Six separate rounds of formal qualification tests were conducted over the 10 months; however, the Air Force-approved test sequence was never run in its entirety during any of the testing sessions. Instead,

retesting was started at a position prior to the test procedure that failed, and the testing sequence was continued until another failure occurred. For example, on the basis of results from the third round of formal qualification tests, Mitre notified Electronic Systems Division in September 1987 that it does "not believe GTE's software fixes are being thoroughly integrated and tested before resuming formal regression testing. Software problems reappear, once fixed, or new software problems manifest themselves in the same test steps where previous fixes were applied. Software stability is suspect because of apparently poor software configuration control practices being applied by GTE."

Complete end-to-end testing (continuous from start to finish without a system failure) is needed to ensure that corrections do not induce errors in the software that previously had tested successfully. The sixth and final round of formal qualification testing, approved by program officials from Electronic Systems Division and the Air Force Space Command, consisted of testing a limited number of procedures that did not meet all criteria in the test program.

Formal qualification testing has shown that block I, as developed, does not meet a number of critical system specifications. Left unresolved, these deficiencies, which include (1) unstable software, (2) an unacceptable amount of time needed to restart the system, and (3) poor quality monitoring for critical communication circuits, could degrade the technical control unit's mission performance.

Unstable Software Identified During Formal Qualification Testing

Unstable software is a term applied to software that is unpredictable, that may or may not perform as expected, or may not produce consistent results when run against a known set of operating conditions. Because of the critical mission of this system, the risk of unstable software is unacceptable. Block I software is unstable.

On one occasion during testing, the software failed, locking up the system and preventing operators from issuing new commands. Block I had to be completely shut down and the software restarted. This process involves reloading the system software from back-up copies—a process that takes 31 minutes. In a rerun of this test, operators were unable to recreate the same failure even though no corrections had been made. Until the problem can be resolved, the software cannot be considered stable (i.e., without known risks) because the problem could recur at any time, causing loss of communications. As of June 1988, the contractor had not identified the source of this problem, and it remained an

open action item. A failure of this nature during actual operations could seriously affect the Air Force's ability to satisfy mission requirements during a crisis.

Time Needed to Restart the System Is Unacceptable

When a system goes down for any reason, the process used to initiate and resume full operations is called restart. Another critical concern identified during formal qualification testing involves the time needed to restart the system. To restart the system after a total loss of power, all systems software (i.e., operating system and applications programs) are loaded into the computer's memory from a backup copy. Completely restoring the system software from a backup copy is the only way to ensure that the software loaded is error free.

The current CSS can be restored to full operation within 12 to 15 minutes after a total loss of power. The block I unit, on the other hand, takes 31 minutes to become fully operational. This length of time exceeds the original block I requirement—that the system should meet full mission capability within 2 minutes of total loss of power—by more than 1500 percent. The contractor was given relief from the original requirement and told that the restart needed to occur within 26 minutes 95 percent of the time. The contractor is now asking the Air Force to further relax this requirement to allow a restart within 35 minutes.

We were told by Electronic Systems Division's program manager that the contractor will not be granted relief from the current 26-minute requirement. We were further told by Air Force Space Command officials in June 1988 that, because of the critical nature of this system to provide timely notice of bomber or missile attack, they believe the present 26-minute requirement is not acceptable and should be lessened. However, after we forwarded a draft of this report to the Department of Defense for comment, Air Force officials determined that the requirement to restart the system in 26 minutes would be acceptable.

Quality Signal Monitoring Has Not Been Achieved

The third critical problem concerns how 40 of the 270 circuits in the CSS Replacement should be monitored. One of the primary functions of block I is to monitor the quality of communication signals being received, and to switch to different communication circuits when the quality degrades. A Mitre consultant stated that, due to the area allocated for the CSS Replacement and the requirement for the placement of test equipment, the contractor designed and built a system with circuit test equipment located adjacent to operator consoles. This equipment is

located about 100 feet away from the circuit monitoring points on the communication lines. According to Electronic Systems Division's program manager and a Mitre consultant, at this distance, the quality of the communication signal cannot be accurately measured. The Mitre consultant informed us that he does not know at what distance the test equipment has to be placed to ensure integrity of the measurement data. Resolution of this problem requires a determination of (1) the distance between the test equipment and the circuit monitoring points on the communication lines that would ensure integrity of the measurement data; (2) whether it is physically possible to put the test equipment within that distance in Cheyenne Mountain; (3) if impossible, whether the performance degradation is acceptable; and (4) whether other technologies provide possible solutions.

Air Force Plans to Accept Block I With Problems Unresolved

Although these and other problems remain unresolved, Electronic Systems Division plans to accept delivery of block I from the contractor during November 1988, but list 12 problems as open action items. (App. I lists the 12 open action items.) Electronic Systems Division's program manager plans to provide the contractor time to correct these open action items as it develops the block II CSS Replacement. The program manager and a contractor official have stated that these corrections will be made at the contractor's expense. The program manager also plans to have the contractor rerun end-to-end formal qualification tests after block I acceptance but prior to acceptance of block II. This set of tests, however, could be deferred until April 1990—almost 2 years after the government formally accepts block I.

Once block I units are accepted by the Air Force, they will be returned to GTE as government-furnished equipment. One unit, already installed at Air Force Space Command's Test, Development, and Training Center at Peterson Air Force Base during July 1987, is intended for operational training. The other unit will remain at GTE to be used for (1) clearing the 12 open action items remaining from formal qualification testing, (2) rerunning block I formal qualification testing, (3) developing the block I interface to the block II CSS Replacement unit, and (4) formal qualification testing with the block II unit.

When block I units are accepted, they become government property and the Air Force becomes responsible for maintaining them. The Air Force

is negotiating a preoperative maintenance contract with GTE, to commence on the date of block I acceptance. These preoperative maintenance activities are expected to cost about $3.3 million through fiscal year 1991.

Block I Is Not Compatible With Other Equipment at Cheyenne Mountain

If block I were completely tested, accepted, and free of deficiencies, it still could not be installed and used at Cheyenne Mountain Air Force Station. There are several configuration problems, not related to contract performance, between the CSS Replacement and Cheyenne Mountain that must be corrected before block I can be installed. These problems include (1) an incompatible wiring standard between block I and other Cheyenne Mountain equipment, and (2) incomplete site preparation for cable installation.

Block I Wiring Not Compatible With Cheyenne Mountain

There is no uniform wiring standard for computer and telecommunications equipment at Cheyenne Mountain. In an effort to begin to achieve standardized wiring in Cheyenne Mountain, the Air Force's 1984 specifications required building the block I unit to several standards, including RS-232C. The Air Force knew that this standard would be incompatible with other equipment in Cheyenne Mountain. However, the seriousness of the incompatibility was not identified until the contractor tried to integrate government-furnished equipment with technical control hardware during formal qualification testing. The contractor found that the equipment would not work correctly when connected. The problem relates to the polarity of the circuits. GTE noted that it did not know the extent of the problem, but suspected that other government-furnished equipment was not compatible. The extent of the problem in Cheyenne Mountain is believed by the Air Force to be much larger than earlier identified and could affect nearly every system interface (connection).

Minutes of a January 1988 Interface Control Working Group meeting note that one of the Command's engineering support contractors had prepared an interface study on installation problems and the issue of connecting government equipment to the commercial RS-232C interface being used for block I. The study, although not final at that time, recognized that standardizing Cheyenne Mountain interfaces to meet an

RS-232C standard would require a major engineering effort by the government.[1] These same minutes note that Air Force Space Command was also examining whether to implement a different electrical interface wiring standard (RS-449). Any change from the RS-232C standard will mean a change to the CSS Replacement. As of June 1988, Air Force Space Command had not resolved the wiring standard problems and had not requested funding to pursue a resolution.

Cabling Congestion Restricts Installing Block I

Site preparation for telecommunications cables within Cheyenne Mountain Air Force Station is also a problem. A 1988 Air Force Space Command analysis recognized that site preparation was needed within the complex before block I could be installed. The analysis noted that there are approximately 2,700 cables that need to be placed in the technical control area, and that there is an extremely high risk that communications will be disrupted during installation.

Minutes of a January 1988 CSS Replacement Interface Control Working Group meeting indicated additional concerns about cable access to government-furnished equipment. According to the minutes, the contractor's installation proposal is based on a concept of zero cable growth. Since GTE's proposal in April 1986, the amount of cable growth in the manual technical control area appears to have preempted the possibility of the zero-growth option.

At the heart of the installation problem is severe under-floor cable congestion in Cheyenne Mountain. Equipment growth in the manual technical control area has resulted in a rat's nest of cabling under the floor, and the contractor believes that its equipment installation efforts will be adversely affected by this cable congestion. This congestion will impede the installation of more than 200,000 feet of new cable.

Users and Acquirers Do Not Agree on the Disposition of Block I

Divergent views exist between major organizations within Air Force Space Command and Electronic Systems Division concerning the disposition of the block I semi-automated technical control unit. Some users at Air Force Space Command believe that block I can be salvaged and used to build a modified block I unit. Others believe that block I should not be installed in Cheyenne Mountain. Electronic Systems Division, on the

[1] In a meeting with the Commander, Air Force Space Command, and key deputies on June 15, 1988, the Deputy Chief of Staff for Planning estimated that this effort could take up to 2 years and cost approximately $5 million.

other hand, is convinced that block I is needed and should be installed in Cheyenne Mountain. However, since block I has not been thoroughly tested and the cost and schedule impact of problem resolutions determined, these positions are based, to varying degrees, on speculation.

User Views

An Air Force Space Command official stated that the users and maintainers of the system within Air Force Space Command raised three concerns to the Deputy Chief of Staff for Systems Integration, Logistics, and Support regarding the block I semi-automated technical control unit as it is currently designed. The users believe that (1) the open action items from the formal qualification tests clearly show the system does not meet requirements; (2) the problems of installing the block I unit, including the use of a wiring standard in block I that is not compatible with Cheyenne Mountain equipment, cannot be easily surmounted; and (3) there are inherent problems with the nature of a semi-automated technical control unit (i.e., it would be more difficult to integrate new government-furnished equipment into a semi-automated technical control unit than a manual technical control unit).

On March 10, 1988, Air Force Space Command's Deputy Chief of Staff for Systems Integration, Logistics, and Support directed his staff to withdraw support for installation of the block I unit and stated that his office was prepared to lead an effort in identifying how much of the unit's equipment, if any, could be salvaged and effectively used. He stated that the block I, as demonstrated during formal qualification testing, would not meet current mission requirements. In addition, he stated that engineering studies conducted by his staff showed that proceeding with block I installation "as is" would represent a very high risk to overall communications for Cheyenne Mountain.

On the basis of the assumption that block I would not be installed, a study was undertaken by Air Force Space Command staff to focus on the existing manual technical control facility and determine what steps are necessary to ensure that it meets the present and future needs of Cheyenne Mountain systems. The preliminary study report recommended totally rebuilding the present technical control unit and incorporating state-of-the-art fiber optic connections, which would greatly reduce cable congestion throughout Cheyenne Mountain. The study estimated that this approach would take about 2 years and cost approximately $4.5 million. The study further noted that physical constraints within Cheyenne Mountain are concerns to technical control personnel.

The study concluded that problems such as cable congestion and lack of a wiring standard must be addressed.

Acquirer Views

In contrast to Air Force Space Command positions, Electronic Systems Division officials are firmly convinced that a semi-automated technical control unit is needed to accommodate new programs and future work load requirements at Cheyenne Mountain. These officials told us that block I problems can be resolved and that the block I semi-automated technical control unit can be used. They are also convinced that part of the user resistance to block I is a natural resistance to new technology. These Electronic Systems Division officials believe that once users have an opportunity to receive training and operate the semi-automated technical control unit, they will realize the significant advantages it offers over a manual technical control operation.

Air Force Space Command Believes Block I Will Not Be Installed As Developed

In a June 1988 meeting, the Commander, Air Force Space Command, told us that the Command was considering a modified technical control unit, which is a compromise between a manual switch and block I. He further stated that considering the advanced development of block I, which Air Force Space Command is fully committed to, and the government's investment in it, totally scrapping block I is not an acceptable solution. We were told by an Air Force official that under the modified block I approach, some block I equipment would be retained, but the software may need to be modified or rewritten. Specific details regarding the impact of this alternative on the cost and schedule of the CSS Replacement program were not available.

Conclusions

The users and acquirers of block I of the CSS Replacement are confronted with system design and development deficiencies, including unstable software and an unacceptable length of time for restarting the system after a total loss of power. Further, the system, as configured, cannot currently be used in Cheyenne Mountain Air Force Station. It is important to determine how best to proceed with block I, which has already cost the government $72 million.

Opinions differ on what should be done with block I. Air Force Space Command's Deputy Chief of Staff for Systems Integration, Logistics, and Support stated that proceeding with block I installation "as is" would represent a very high risk to overall communications for Cheyenne Mountain. Other officials believe that parts of block I can be salvaged

and used to build a modified block I unit. Electronic Systems Division officials believe that the deficiencies with block I can be resolved, and that the unit should be accepted by the government and installed in Cheyenne Mountain. However, no one really knows what the system can or cannot do and each opinion is therefore dependent, to some degree, on speculation.

Electronic Systems Division plans to accept the block I unit from the contractor in November 1988 and allow the contractor to correct block I deficiencies during development of block II. The program manager plans to defer the entire set of end-to-end formal qualification testing until 1990—almost 2 years after its planned acceptance by the Air Force. However, we believe that any additional delays in correcting and testing block I are ill-advised and that block I will not have been adequately tested until a complete end-to-end formal qualification test has been performed. These test results can then be used in deciding whether the block I unit should be accepted and installed or other actions taken. If block I is accepted, it cannot become operational until Cheyenne Mountain Air Force Station configuration problems such as the lack of a wiring standard, the lack of space at Cheyenne Mountain to physically place the monitoring equipment near the communication lines, and cable congestion are resolved.

Recommendations to the Secretary of Defense

The Secretary of Defense should direct the Secretary of the Air Force to correct Cheyenne Mountain configuration problems by eliminating cable congestion, establishing a single wiring standard, and determining minimum acceptable performance levels, given limited physical space.

The Secretary should also direct the Secretary of the Air Force not to accept the block I unit as currently planned until the deficiencies are corrected. Given that Electronic Systems Division and the contractor have stated that the deficiencies will be corrected at no additional cost to the government, the Secretary of Defense should direct that the deficiencies be corrected immediately and that complete, continuous end-to-end formal qualification testing be conducted to determine and document compliance with block I specifications. The test results should be used to assess whether the system meets specified requirements and whether any additional deficiencies are identified.

If formal qualification testing identifies additional deficiencies, the Secretary of Defense should decide whether the Air Force's best interests are served by correcting any or all of them, and make visible to the

appropriate congressional committees the source of funding used to correct the deficiencies.

Agency Comments and Our Evaluation

In commenting on a draft of this report, the Department of Defense stated that we were misinformed about its posture on block I acceptance. According to Defense, the Air Force has no plans to accept (underscoring supplied) block I during 1988, as we reported, and will not do so until all contract specifications are met. Defense goes on to say that our report contains a major misunderstanding of the CSS Replacement contract and the Air Force's acceptance procedure, as the Air Force plans to close (underscoring supplied) the block I contract in November 1988 and transfer remaining block I tasks to block II.

Notwithstanding Defense's comments, our report accurately depicts the Air Force's plans and correctly states the implications of its actions. Defense's comments do not explain the difference between accepting the system and closing the contract. After receiving Defense's comments, we confirmed with Electronic Systems Division that in November 1988 it plans to sign a DD Form 250 (contract acceptance form), accepting the system on behalf of the government and releasing approximately $1.8 million in residual payments due to the contractor.

The program manager plans to take these actions in November 1988, at which time the government will assume ownership and maintenance responsibility for the block I system. The Electronic Systems Division has negotiated a separate $3.3 million contract with GTE to maintain the system until its planned installation in Cheyenne Mountain in 1992. According to the Assistant Deputy Commander for Strategic Systems at the Electronic Systems Division, acceptance requires the program manager to certify that the system meets contract specifications. Since the system does not meet all requirements, the program manager is effectively modifying block I specifications by transferring block I's unresolved problems to the block II contract.

Defense disagreed with our recommendations to defer block I acceptance until all deficiencies are corrected. However, the Air Force has not demonstrated why the block I contract either needs to be or should be closed out before the contractor corrects and delivers a system that meets all block I requirements. Further, the Air Force has not explained what it gains from closing out block I early, other than an opportunity to realign its resources and the contractor's promise to make corrections in

the future. Although the contractor receives significant monetary benefits, we continue to believe that the Air Force should keep the block I contract open and continue to withhold final payment until the contractor produces an acceptable system that fully meets specifications.

Defense agreed with the facts we presented regarding wiring configurations and cable congestion in Cheyenne Mountain. However, Defense disagreed with our recommendation to correct Cheyenne Mountain configuration problems, stating that the Air Force is already committed to eliminating cable congestion and establishing greater standardization of the technical control wiring. We have noted the Air Force's commitment to fixing these problems, but as of September 1988, Air Force had not determined what corrections to make, how to make them, what they will cost, or what effect these corrections will have on operations. While Defense appears to agree with the spirit of our recommendations, the Air Force has not determined to what extent it will actually act on them. Therefore, we reaffirm our recommendations to the Secretary of Defense.

Upgrades Should Correct CSS Deficiencies Used to Justify Block II of the CSS Replacement

Since 1982, the Air Force has been working on block II of the CSS Replacement, which is designed to correct various CSS deficiencies. This replacement was also intended to increase NORAD's communication capability by adding more functions, such as automatic verification of missile warning messages and an improved simulation and test capability. Pending delivery of the CSS Replacement, the Air Force has been modifying and upgrading the existing CSS to keep the system operational. While these upgrades will not satisfy all CSS Replacement block II specifications, they should resolve the deficiencies used to justify the replacement system and meet NORAD's communications needs through 1995, and possibly through the year 2000.

Furthermore, the Air Force has also identified several critical issues, including an increased work load capacity and the need for a standard communications protocol that will affect the performance of the CSS Replacement program. The Air Force does not yet know the total performance, cost, and schedule impact these issues will have on the CSS Replacement system. Given that the upgraded CSS should meet current and immediate future communications needs, the Air Force has a window of opportunity to assess how these critical issues will affect the CSS Replacement system before proceeding with further development of block II.

Status of Block II

Block II of the CSS Replacement contract was added in February 1987 and is in the initial stages of acquisition. Of the $209 million currently planned to be spent on block II development, about $68 million has been committed for block II and, according to Electronic Systems Division, will be paid to the contractor for work performed through September 1988. The system's funding levels have been set, and the initial critical design review was completed in June 1988.

Deficiencies Used to Justify the CSS Replacement Should Be Corrected Through System Upgrades

The Air Force justified block II on the basis that it would correct the five deficiencies: (1) unreliable message processing, (2) inadequate computer system availability, (3) difficulty in maintaining system application software, (4) difficulty in maintaining aging computer hardware, and (5) CSS' inability to expand to support future requirements. However, our analyses show that the upgrades the Air Force has made to CSS since 1982 and those it plans to make before the replacement system becomes fully operational in 1992 as planned should resolve these deficiencies, as discussed below.

Reliable Message Processing Has Been Achieved

The need for achieving acceptable system reliability became apparent on June 3 and 6, 1980, when false attack indications were generated. The false indications were caused by a faulty component in the CSS, which began inserting erroneous data into missile warning messages sent to various command posts. The CSS Replacement is designed to assure message processing reliability through a series of automated message checks and manual verification. However, in the interim, the Air Force has corrected the reliability problem in the current CSS by changing system software and operating procedures. Specifically, NORAD (1) added computer programs that trace a message through the entire message preparation phase to ensure that the transmission accurately reflects what is input through the message system; (2) added a NORAD command post display that shows what is being transmitted to other command posts; and (3) changed the format of test messages.

Since the introduction of these corrective measures following the 1980 incidents, no false warning messages have been released by the Cheyenne Mountain Air Force Station. According to an Air Force Space Command official, in a series of tests conducted by the Command's Systems Integration Office the CSS properly handled all messages.

Computer System Availability Is Adequate

In 1981, availability of the CSS computer system was at a level unacceptable to the Air Force. An Air Force Space Command official stated that various initiatives have improved the system's availability. According to the chief technical adviser to the Deputy Chief of Staff for Systems Integration, Logistics, and Support, the increased system availability is due to numerous changes made to CSS, such as new hardware and modifications to the computer software. From February 1987 through January 1988, CSS' average availability was 99.95 percent. CSS now exceeds the availability requirement (99.5 percent) for the CSS Replacement.

Application Software Maintainability Is No Longer a Problem

During the late 1970s and early 1980s, CSS software was difficult and time-consuming to maintain. Over time, the software has been modified. Contractor officials who maintain the current software said maintaining it is not very difficult. An Air Force Space Command official concurred with this statement, noting that adequate software maintenance is being provided. The contractor added, however, that the CSS software would be easier to maintain if the computer operating system were upgraded, which would allow for more state-of-the-art operating system software enhancements. According to Air Force officials, such upgrades are being considered for implementation as part of the interim upgrade program,

after the Honeywell mainframe upgrades are installed in late 1988. (See p. 38 for a further discussion of software maintenance.)

Maintenance Is Available for Upgraded Computer Hardware

The Air Force is in the process of or plans to upgrade most of CSS' aging computer hardware. The Air Force is making these upgrades because the CSS Replacement system's initial operational date has been delayed from 1989 to 1991 and, in the interim, Air Force officials believe it necessary to acquire more modern replacement components for the CSS. As explained in chapter 1, the computers used in the communications multiplexor and the intercomputer processors are obsolete and are no longer supported by the manufacturer, and the Honeywell computers are nearing obsolescence. As a result, Air Force officials have decided to replace the CSS Honeywell computer system with a newer model and replace the CSS intercomputer processor with a high-speed, commercially available local area network. Air Force officials are also planning to replace part of the CSS communications multiplexor with very high speed integrated circuit technology.

Each of these CSS component replacements will occur in phases, with completion dates ranging from December 1988 to the third quarter of fiscal year 1991. According to Air Force engineering officials, these CSS component replacements, at a total cost of about $14 million, will make the CSS maintainable at least through the year 2000.

The Department of Defense's current contract with Honeywell for maintenance of the upgraded Honeywell computer equipment expires in 1991. However, according to Honeywell's federal contracting manager, Honeywell is willing to negotiate support for the upgraded computer equipment through the year 2000.

CSS Message Processor Meets Expansion Needs

The Air Force's 1981 statement of operational need determined that CSS could not be expanded to provide enough circuits to meet Cheyenne Mountain's needs projected beyond 1986. The CSS Replacement was therefore designed to accommodate 270 circuits, compared with CSS' 220 circuits. On the basis of a February 1987 study, an Air Force Space Command official determined that CSS' 220 circuits could meet Cheyenne Mountain's communication needs through at least 1995. Further, according to engineering officials from the Air Force Space Command, CSS can probably supply enough circuits through the year 2000. One official told us that newer radar resulted in reducing the number of circuits required.

Costs and Benefits Vary Between the Upgraded CSS and the Block II CSS Replacement

While block II of the CSS Replacement program will replace the message processing functions, the upgraded CSS will be very different from the CSS that existed in 1981 when the replacement program was planned. As explained below, the CSS Replacement offers some advantages and capabilities over what the upgraded CSS will provide, while the upgraded CSS will offer some additional capabilities and advantages over the replacement system. However, the cost difference between the two systems is substantial: about $14 million for the upgraded CSS, and more than $209 million[1] for block II of the replacement program.

The upgrades to CSS are only intended to serve as an interim solution until the replacement system is operational. Accordingly, the Air Force has not evaluated the two systems' comparative benefits and costs. Moreover, the Air Force has not evaluated (1) what the cost would be to include the additional capabilities of the CSS Replacement in the upgraded CSS, or (2) whether the additional capabilities offered by the replacement program are worth their higher cost. In the absence of such evaluations, the Air Force does not know the most cost-effective way to meet NORAD's future communications needs.

Upgrades Will Increase CSS Capabilities and Offer Advantages Over Its Replacement

The planned upgrades to CSS will (1) replace the message processing computers (Honeywells) with newer, more powerful models; (2) replace the obsolete intercomputer processors with a flexible, commercially available, high-speed local area network; and (3) replace an obsolete minicomputer, a component of the communications multiplexor, with a very high speed integrated circuit device. Although Air Force officials view the upgrades as interim measures intended to extend the life of the CSS until the CSS Replacement is delivered, these upgrades, at a cost of $14 million, will also substantially increase some CSS capabilities.

At a cost of about $2.2 million, the new Honeywell processors will provide about a 100-percent increase in computational capability over the older Honeywell models, as well as improvements in performance (see app. II for additional details). Additionally, if needed, the new Honeywells' memory can be further upgraded (i.e., without a change in models). However, the Air Force has not analyzed the benefits offered by these upgraded computers.

[1] About $68 million has been committed for block II and, according to Electronic Systems Division, will have been paid to the contractor for work performed through September 1988.

Efforts are underway to replace CSS' obsolete intercomputer processors with a high-speed local area network at a cost of about $6.8 million. The local area network is planned to be operational in Cheyenne Mountain by December 1989. The local area network will provide expanded capabilities over the current intercomputer processors. For example, it will be able to interface with new programs as they become operational. Another advantage of the local area network over the replacement system is its transmission capacity. The local area network is designed to transmit nearly three times the amount of data that the replacement system's proposed network can transmit.

Finally, at an estimated cost of about $5 million, a very high speed integrated circuit is being planned for use in replacing the obsolete processor that is part of the communications multiplexor. This replacement, scheduled for completion in late 1991, will extend the multiplexor's maintainability, but it will not increase the capability or performance of the CSS system.

The upgraded CSS will have two additional advantages over the replacement program. First, as the current CSS does, the upgraded CSS will be able to directly interface with AUTODIN,[2] while the CSS Replacement will not, under current contract specifications. Although the replacement system originally included an AUTODIN interface capability, this requirement was subsequently dropped to reduce costs. According to Air Force officials, the replacement system will have to be modified to interface with AUTODIN, at an unknown cost. Standard AUTODIN processing equipment has been purchased for the CSS Replacement, for about $4 million, but the interface has not yet been designed, and is neither funded nor under contract.

Second, Air Force Space Command's ongoing software maintenance process will keep the upgraded CSS compatible with other TW/AA system elements. The replacement system, in contrast, is being built to interface with the TW/AA system as it was in 1986. Because the TW/AA has since undergone many changes, and will continue to change, the replacement system will have to be modified at an unknown additional cost before it can become operational.

[2]The Automatic Digital Network (AUTODIN) is a Department of Defense network for automated message communications.

The CSS Replacement Will Offer Certain Advantages Over the Upgraded System

Block II of the CSS Replacement program, at a cost of about $209 million, is designed to replace the CSS with completely new hardware and operating system and application software. The CSS Replacement program is intended to perform all functions that the CSS performs (except directly interfacing with Defense's AUTODIN network), as well as several additional functions. These additional functions are:

- To alert operators through an alarm that missile warning messages need to be verified before they are sent from Cheyenne Mountain. (This function is now done manually.)
- To interface with the System Control Operations Center, which monitors and controls computer systems in Cheyenne Mountain.
- To operationally record up to 24 hours of historical performance data for later analysis.

According to Air Force officials, the CSS Replacement system will perform some functions better than the upgraded CSS does. For example, the CSS Replacement system will provide better simulation and test capability than is provided by the upgraded CSS. However, the Air Force has not determined whether this function could also be achieved—or at what cost—through the upgraded CSS.

In addition, the CSS Replacement system will provide for 270 communications circuits, while the upgraded CSS is expandable to 220 circuits. However, an Air Force engineering study completed in February 1987 estimated that only 207 circuits may be needed through 1995.

Appendix II compares the capabilities (as identified by the Air Force) of the interim upgrades with those of the replacement system.

Other Issues Will Affect CSS Replacement Requirements

The Air Force has identified several critical issues that will have an impact on the existing requirements for the CSS Replacement program and could dramatically change the CSS Replacement's design, cost, and schedule. These include the need to establish (1) a standardized communications protocol, (2) a consistent message load, and (3) a common message set or format. If these needs are not addressed, the Air Force will have developed a system that will not be able to effectively communicate with other subsystems in Cheyenne Mountain.

Standardized Communications Protocol

A communication protocol is a set of rules that govern communications among computer systems. By implementing standard protocols, different manufacturers' computer systems can communicate. The CSS Replacement and other warning and assessment subsystems are being built using two different protocols. The Air Force recognizes that a single protocol standard is needed for all Cheyenne Mountain computer subsystems to effectively communicate with the CSS Replacement, but it has not yet converted all Cheyenne Mountain subsystems to a standard protocol and does not plan to do so until the mid-1990s.

Consistent Message Load

Cheyenne Mountain computer subsystems process messages and the subsystems are sized based, in part, upon the number of messages that must be processed—the more messages to be processed the larger the system. As noted in chapter 1, the CSS is the principal subsystem that handles nearly all the messages among subsystems in Cheyenne Mountain. Several of Cheyenne Mountain's computer subsystems are being sized to different message-load requirements. The CSS Replacement system, which must handle nearly all messages among the subsystems in Cheyenne Mountain, is being sized to process a smaller message work load than the other subsystems involved. Mitre has expressed concern regarding inconsistent message-load requirements between these computer subsystems—particularly with the CSS Replacement. Air Force Space Command and Electronic Systems Division are aware of the problem but have not decided what the message-load requirement should be for Cheyenne Mountain.

Common Message Set (Format)

A message set, or format, is the form in which data is transmitted from the sensors, or radar, to computer subsystems. A message set consists of a certain amount of information that has a defined beginning and end. The CSS Replacement is being designed to accommodate current message sets with variable formats. The Air Force is designing other computer subsystems that must communicate with the CSS Replacement, but use a standardized message set with fixed formats. The Air Force is aware that these subsystems will not be compatible and has been trying to resolve which message set to use since April 1985.

The Air Force recognizes that each of these critical issues must be resolved before the CSS Replacement can become fully operational. However, it may take the Air Force a year or more to resolve them. Furthermore, the Air Force does not know how the solution ultimately adopted

will affect the CSS Replacement system in terms of performance, cost, and schedule.

Conclusions

The CSS computer system, when upgraded as planned, will be significantly different from the system that operated in 1981 when the Air Force initiated plans to replace it. The upgrades to CSS should correct deficiencies in the system that the Air Force used to justify the block II CSS Replacement program. The upgraded CSS computer system should be capable of supporting NORAD's communications needs until at least 1995 and, according to some Air Force engineers, possibly to the year 2000.

While there is no doubt that the Air Force needs to move toward more modern communications technology, either an updated or replacement system can provide an acceptable technical solution for identified Air Force functional requirements. Both the CSS Replacement and the upgraded CSS will offer some additional advantages and capabilities not provided by the other. However, the $14 million cost of the upgraded CSS is considerably less than the estimated $209 million cost for the CSS Replacement.

The Air Force intended that the upgraded CSS would serve as an interim solution until the CSS Replacement became operational. As such, the Air Force did not evaluate comparative costs and benefits of the two systems, but the increased cost of block II appears substantial for little additional benefit.

Moreover, the Air Force has also identified several critical issues, including an inconsistent message load and message set, and the need for a standard communications protocol, that will affect the performance of the CSS Replacement program. The Air Force does not yet know what performance, cost, and schedule impact these issues will have on the CSS Replacement. Given that the upgraded CSS should meet Cheyenne Mountain's current and immediate future needs, we believe the Air Force has a window of opportunity to assess how these critical issues will affect the CSS Replacement before proceeding with further development of block II. Such an assessment can be used by the Air Force to define its current needs for and requirements of the CSS Replacement program and to evaluate the best methods to satisfy Cheyenne Mountain's long-term communications needs.

Recommendations to the Secretary of Defense

We recommend that before proceeding with further development of block II, the Secretary of Defense direct the Secretary of the Air Force to resolve critical issues such as protocol standards, message set, and work load capacity. The Secretary of the Air Force should proceed with the planned interim upgrades to the existing CSS and complete an analysis that determines the impact, in terms of performance, cost, and schedule, of critical system design questions. When completed, this analysis should be used to assist in developing a plan for determining the most effective means of meeting future communications processing needs at Cheyenne Mountain.

Recommendation to the Congress

We recommend that the Congress withhold funding for any follow-up communications system until the Air Force has presented an acceptable plan for (1) solving critical issues such as protocol standards, message set, and work load capacity; and (2) determining the most effective and efficient approach for achieving Cheyenne Mountain's future communications needs.

Agency Comments and Our Evaluation

In its detailed comments on a draft of this report, the Department of Defense concurred with some of the findings but none of our recommendations. According to Defense, the critical issues cited in the report have been substantially resolved. A standard communications protocol and a common message set have been established. The Air Force and the Defense Intelligence Agency have established a common threat scenario to evaluate Cheyenne Mountain Complex command and control systems. Defense further stated that its analysis, although incomplete, indicates that the CSS Replacement can handle the expected message load. Message load, according to Defense, is the only issue we cite that has not been fully resolved.

Defense does not believe these issues will adversely affect the CSS Replacement design, cost, or schedule. While the Air Force has taken some action on the critical issues we identified, Defense's response provided little evidence to support its statements that it has corrected problems to the extent it claims, or to support its estimates of cost and schedule impact.

Standard Communications Protocol

In a September 2, 1988, Air Force Interim Report on the CSS Replacement program, the Air Force advised the Congress that it had decided to stay with the Transmission Control Protocol/Internet Protocol (TCP/IP) and

that it intends to implement the Open System Interface (OSI) protocol within Cheyenne Mountain only after CSS Replacement is installed and operational, thus avoiding increased contract costs now.

In a May 1987 study, Mitre informed the Air Force that converting to OSI, if done at that time, would actually save money. In January 1988, the Air Force approved OSI. At this point, the Air Force asked GTE for an engineering change proposal to incorporate OSI protocols in the CSS Replacement contract. During May 1988, GTE submitted an engineering change proposal to the Electronic Systems Division showing an estimated cost of $13 million to retrofit OSI into the CSS Replacement contract and estimated a 6-month schedule impact. In July, a GTE official said that costs to convert the CSS Replacement protocol from TCP/IP to OSI would continue to rise as program development continued. As of September 1988, the Air Force had not completed any analysis on cost and schedule impact for converting to OSI after CSS Replacement becomes operational.

While delaying OSI conversion reduces CSS Replacement program costs in the short term, we believe it may not be the best long-term solution, as costs will be substantially higher in the future. Defense needs to determine the cost and operational consequences of delaying OSI conversion to a later date and choose the best long-term approach to the overall TW/AA system, rather than simply the most expedient short-term approach to CSS Replacement.

Message Load

Mitre is analyzing a message load scenario (Granite Vista II attack scenario) for the Air Force to determine what impact the scenario will have on all of the Cheyenne Mountain upgrade programs. In May 1988, the Electronic Systems Division program director and his Mitre support staff said that unless major scenario assumptions were changed, the Air Force could be faced with a $150-million increase on CSS Replacement alone. Although the scenario had already been validated at that time, the Air Force has apparently changed scenario assumptions, and now states that this will not increase costs or delay the CSS Replacement program. A final analysis on message loading was scheduled to be completed on October 15, 1988. However, the Mitre official performing the analysis could not support Defense's statements because (1) the analysis is still being performed, and (2) in this official's estimation, it will not be complete until at least January 1989.

Common Message Set

In our draft report, we pointed out that the Air Force needs to decide on the type of message set or format that should be designed into block II. The CSS Replacement is being designed to accommodate current message sets, which are not compatible with message sets being designed in other TW/AA modernization programs at Cheyenne Mountain. We further reported that the Air Force has been aware of the need to standardize sets since April 1985. In response, the Air Force claims that it has established a common message set—the Standard Survivable Message Set—and that the estimated cost to modify the CSS Replacement contract is less than $1 million, which is included in the Air Force estimate of the program cost. According to the Air Force, changing the CSS Replacement contract at this time will not significantly reduce performance, raise costs, or delay the program.

Although Defense estimates the costs for the Standard Survivable Message Set to be less than $1 million, the exact costs will not be known until the contractor gives Electronic Systems Division an engineering change proposal that sets forth cost and schedule impact. When these cost estimates are received, these costs will be added to the contract price. As of September 1988, the contractor had not submitted the engineering change proposal.

Extended Maintenance for CSS

Defense further stated that the report contains a misunderstanding of the efforts to extend the maintenance life of CSS. Defense noted that the communications multiplexors are not being replaced. Only the NOVA 840 minicomputers, which are part of the communications multiplexor, are being replaced. Defense also said that the Honeywell upgrades are upgrades of only the processors and do not affect memory, peripherals, or other equipment. Defense goes on to say that none of these changes will affect the most costly part of the aging CSS system—the software. According to Defense, the software, which is largely written in assembler language, is not written in a modular or easily maintainable form, is inflexible in meeting new mission requirements, and would require a large investment to bring it up to modern, flexible, maintainable standards.

Chapter 3 of the report explicitly stated that the Air Force is replacing the NOVA 840 minicomputers used as the principal computers for the communications multiplexors with very high speed integrated circuit chip technology. The NOVA minicomputers are a major component of the communications multiplexors, and have been a principal source of multiplexor problems in the past.

Further, Defense statements about upgrading the Honeywell computer's memory, peripherals, and other equipment are inconsistent with information previously provided by the Air Force Space Command. The Honeywell upgrades include a 100-percent increase in memory, faster processing speeds, and updating the older model disk drives to newer model disk drives, which are faster and can store more data. Information about the upgrades was obtained and verified with the Air Force Space Command as well as with the vendor, Honeywell Information Systems, Colorado Springs, Colorado.

Software Maintenance

The software, although largely written in assembler language, is still being routinely maintained, modified, and improved. New version releases are being issued, as required, by the maintenance contractor. The contractor indicated that the software is relatively easy to maintain. When asked to grade the maintainability of the software on a scale from 1 to 5, 1 being the easiest and 5 the most difficult, the contractor rated the CSS software as ranging between 2 and 3. After completing the upgrades, however, the contractor expects the ease of maintenance to improve.

Although the CSS software is written in assembler language, it has become more reliable over time. Version releases of this software are still being issued with no apparent difficulty. During our audit, we noted that the capability to receive new sensor data had recently been added to the software and we found no evidence presented by either the Air Force or the software maintainer that more functions could not be added to the current CSS software if needed to meet new mission requirements.

In its comments, Defense reported that CSS had recently experienced 21 software failures during a 6-month period (March through August 1988). Since Defense did not present any details on its 21 cited software failures, we obtained software maintenance records from the contractor covering the past year. The records show that at least 11 of the failures were due to one-time configuration problems between the CSS software and the new Honeywell computers being installed. These failures required reprogramming and have been resolved. Further, Defense concurred with our finding that overall CSS availability was being maintained at 99.9 percent—which tends to contradict any assertion of major software problems.

Hardware Maintenance

Defense further stated that although the vendor for the upgraded computer equipment may be willing to negotiate for support through the year 2000, the Air Force has no authority to enter into a multiyear contract with the vendor. However, the Honeywell model 6000 DPS computers being used in Cheyenne Mountain are also being used by Defense's World Wide Military Command and Control System (WWMCCS). The CSS Replacement computers have been purchased under the WWMCCS contract and, as such, will fall under its maintenance agreements, which Honeywell is committed to supporting.

Prior Report Recommendation

Finally, in its transmittal letter, Defense said that this report is a major departure from our earlier report,[3] which recommended replacing all obsolete components of the NORAD Cheyenne Mountain computer system as quickly as practical. We do not agree that our current report is a departure from our earlier recommendation. In our current report, we clearly state in several instances that the Communications System Segment is becoming obsolete and that a replacement system is essential to Cheyenne Mountain's long-term communications needs.

Our previous report is not inconsistent with our current recommendation to curtail developing the replacement system until significant development issues are resolved. Since upgrades will keep the current system operating through at least 1995, the Air Force has time to resolve critical issues that affect the replacement system's development and performance. Eliminating cable congestion and establishing a uniform wiring standard in Cheyenne Mountain, developing a consistent message set, standardizing communications protocols, and determining the message-load requirement for Cheyenne Mountain subsystems, are all issues that could dramatically affect NORAD's communications system. Our recommendations are not designed to curtail needed computer replacements; rather, they are designed to reasonably contain cost growth and ensure that when replacements are made, they will be more likely to provide effective communications for Cheyenne Mountain.

[3] Attack Warning: ADP Replacement for Warning and Assessment System Still Years Away (GAO/IMTEC-86-15, June 11, 1986).

Listing of 12 Open Action Items From Block I Formal Qualification Testing

Item Number	Item Description	Electronic Systems Division Comments
1	Page selection function not developed in accordance with requirements.	Item developed by the contractor is an improvement to the specification. Contractor will be granted relief from the requirement. Low risk.[a]
2	Printer displays a test classified message as unclassified.	No classified material used in contractor's test area. Printer will be programmed to print security classification and actual classified material will be used at the test development training center. Low risk.
3	Distorted signal obtained on oscilloscope monitoring the block I unit.	Problem believed attributable to inadequate contractor grounding grid at contractor's plant. Informal contractor testing at the test development training center indicates no signal distortion. Problem will be officially retested at the training center. Moderate risk.[b]
4	System recovery time does not meet system requirement time (e.g., after total loss of power, the system will be operational in 26 minutes, 95 percent of the time).	Contractor has requested requirement be increased to 35 minutes 95 percent of time—a time the contractor can meet. This request will not be approved. Problem possibly relates to software or equipment used to perform this function. More powerful equipment may be needed to resolve the problem. High risk.[c]
5	Access controls in the operating system are not providing required security protection.	Contractor plans to use a later version of the operating system containing features that will resolve the block I security problems. Moderate risk.
6	Circuit restoration time does not meet system requirement of 2 minutes.	Excluding the use of government-furnished equipment, the contractor is meeting the requirement. The government- furnished equipment cannot meet the requirement; the contractor will be granted relief from this requirement. Low risk.
7	Problems with the monitoring of special communications circuits (T-1).[d]	Contractor is monitoring the circuits at consoles about 100 feet away from the circuits. Because of the distance, there can be a distortion in measuring the signal when test equipment is activated. In addition, monitoring these lines can disrupt the signal, which can cause message errors. Measurements also can't be made at any significant distance from the communications lines. A decision must be made to resolve the problem. High risk.
8	T-1 communication signal did not reach test equipment rack.	Contractor has shown the problem can be fixed. However, item is not being closed because it is a problem associated with item 7 above. Low risk.
9	Memory reserve times do not meet requirements.	Problem appears to be in the control console. The system was tested under wartime loads and maintained a 40-percent idle time versus a 50-percent requirement. More powerful equipment will probably solve the problem, but this may be a question of cost versus benefit. Moderate risk with more powerful equipment.
10	Command response times do not meet requirement of 5 seconds 99.9 percent of the time.	To solve this problem, the contractor will need to restructure how the system processes commands. Moderate risk.
11	Alarm response times do not meet 2- and 5-second requirements.	In tests, it has been demonstrated that all 60 required responses can be activated within 1 minute, as required, but the alarms do not individually meet requirements. Contractor will be granted relief from this requirement. Low risk.
12	Software code for the man-machine interface module failed.	This type of problem causes the entire system to fail and requires about 30 minutes for the system to become fully operational. The test has been rerun and the system passed, but the cause of the problem is still unknown. The contractor needs to ensure that the problem does not recur. High risk only if the contractor cannot find the cause of the problem.

[a]Low risk—Problem presents a small technical risk; little or no retesting required.

[b]Moderate risk—Problem presents a significant technical risk. Once fixed, it requires a sizable retest.

[c]High risk—Problem presents a significant technical risk; significant retesting required.

[d]The T-1 circuit is a high-speed, high-capacity communications circuit capable of processing voice or digital communications at a rate of 1.544 million bits per second.

Comparison of Enhancements to Be Realized Through CSS Upgrade Versus CSS Replacement

Capability	Current CSS	Upgraded CSS	CSS Replacement Block II	GAO Comments
Message rate	2400 messages per minute	2400 messages per minute	Incoming: 2400 messages per minute Mission: 3600 messages per minute	New Honeywell Model H 6000 DPS computers in the upgraded CSS can possibly provide increases in performance in the areas of throughput and transaction (message processing speed). The upgrade to the present CSS will achieve at least the same capability as the current CSS.
Line capacity	Maximum of 220 lines	Maximum of 220 lines	Maximum of 270 lines	In a memorandum prepared by an Air Force Space Command official, he determined, on the basis of a February 1987 study, that the CSS' 220 communications circuits could meet known communications needs (e.g., 207 circuits). This would leave 13 circuits available for communications work load growth. Also, the demand for circuits within the CSS has been decreasing with the new radar replacements. Therefore, the number of available circuits in the upgraded CSS may be sufficient to accommodate known communication work load requirements.
Availability	99.9 percent	To be determined	99.5 percent	The existing CSS has been available 99.9 percent of the time for processing communications requirements at Cheyenne Mountain over a 12-month period ending January 1988. Availability for the upgraded CSS has not yet been determined. It is expected that the availability rate for the upgraded CSS will equal that of the existing system. The availability rate for the CSS Replacement has been established at 99.5 percent—less than that being experienced with the existing CSS, and possibly that of the upgraded CSS.
Simulation and test	On-line	On-line	Isolated on- and off-line	At the time of our review, the Air Force Space Command had not performed any cost/benefit or tradeoff analyses concerning the block II CSS Replacement and the upgraded CSS system to determine if this feature could be cost-effectively added to the upgraded CSS. It is possible that these features may be able to be added to the upgraded CSS. The upgraded CSS computers (Honeywell Model H 6000 DPS processors), along with the GCOS 8 operating system, additional memory, and available features such as virtual memory, disk cache buffering, and local area network capabilities, may provide those resources needed to achieve this feature.
Security	Multi level mode—top secret minimum acceptable	Multi level mode—top secret minimum acceptable	Controlled mode secret—hardware/ software enhanced	Officials of the National Computer Security Center estimate that commercially available computer systems capable of implementing controlled mode security requirements will not be available until at least the early 1990s. Blocks I and II of the CSS replacement will use STRATUS computers. According to an official of the STRATUS Computer Corporation, the company has no National Security Agency-certified trusted computer systems, and has no plans to request certification. There must be an explicit and well-defined security policy enforced by the system. Given identified subjects and objects, there must be a set of rules that is used by the system to determine whether a given subject can be permitted to gain access to a specific object. Computer systems of interest must enforce a mandatory security policy that can effectively implement access rules for handling sensitive (e.g., classified) information.

(continued)

Capability	Current CSS	Upgraded CSS	CSS Replacement Block II	GAO Comments
Missile warning verification	Manual	Manual	Automated	Missile warning messages processed on the existing CSS are verified manually in an effort to avoid false warnings being sent from Cheyenne Mountain. The Air Force Space Command expects to use this same approach with the upgraded CSS, and with the CSS Replacement. After being alerted to missile warning messages through an automated approach in the CSS Replacement, system operators will continue to manually review all of these messages prior to sending them to their addressees.
Operational recording	Single channel	Single channel	16 channels	Currently, the CSS performs operational recording for all messages on all circuits using the Honeywell computer systems. It is not clear what additional information will need to be recorded, unless the new operational recording features offered by the CSS Replacement will simply record more specific information about messages, such as format, protocol, and frame length. No studies have been done to determine if the added functions desired in operational recording can be achieved using the upgraded computer resources, or if the functionality specified is worth the cost to develop.
Store and forward	Yes	Yes	Via Air Force Automated Message Processing Exchange	The ability to store and forward messages currently exists in the CSS, and will also be available in the upgraded CSS. Our technical analyses show that use of this feature in the Air Force Automated Message Processing Exchange does not provide an important or higher degree of functionality than that being provided by the current CSS, or that to be provided by the upgraded CSS using the Automatic Digital Network.
Maintenance	1992	1995+	2010	A Honeywell official told us that a maintenance and support contract for the Honeywell Model H 6000 DPS computers and associated peripherals can be negotiated through the year 2000.

(continued)

Capability	Current CSS	Upgraded CSS	CSS Replacement Block II	GAO Comments
Architecture	Monolithic	Hybrid	Distributed	Upgrading the Honeywell Model 66/60 computers to the Honeywell Model 6000 DPS machines will double available memory (from 256 kilowords to 512 kilowords). Users of the Honeywell Model 6000 DPS computers in the World Wide Military Command and Control System told us that they have experienced significant improvements in system performance through similar upgrades. The GCOS 3 operating system, while aging, is still being used by many of Honeywell's commercial customers. Honeywell officials told us that they fully support GCOS 3 and have no immediate plans to discontinue this support. The GCOS 8 operating system allows GCOS 3 based software to operate using the GCOS 8 accommodation mode with little or no modification. Such modifications, if any, are limited to programs that contain master mode code. This includes the majority of the real-time controller modules, which override functions of the GCOS 3 operating system. The GCOS 8 operating system also offers enhanced features, which could provide opportunities for improved performance, reliability, and maintenance for the CSS Honeywell software. Such features include: •virtual memory architecture, •improved computer input and output services, •networking capability (in accordance with International Organization for Standardization standards for Open Systems Interconnection, •memory management, and •disk optimization (using the available software disk cache buffering option). The current model DSU 190 disk drives can be replaced by faster and larger capacity model MSU 451 disk drives. Such a replacement can provide a 60-percent increase in storage capacity for the upgraded CSS. At the time of our review, the Air Force Space Command had not thoroughly explored the possible increase in functionality and performance offered by the Honeywell Model 6000 DPS upgrades. The added memory, use of faster and higher capacity disk drives, and the implementation of GCOS 8 and its available enhancements may provide resources needed to implement some of the enhanced features that were specified for the CSS Replacement.

Comments From the Department of Defense

ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301-3040

COMMAND, CONTROL, COMMUNICATIONS AND INTELLIGENCE

29 SEP 1988

Mr. Ralph V. Carlone
Director
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, "ATTACK WARNING: NORAD's Communications System Segment Replacement Program Should Be Reassessed," dated August 18, 1988 (GAO Code 510266, OSD Case 7740).

On June 11, 1986, the GAO issued a report, "ATTACK WARNING: ADP Replacement for Warning and Assessment System Still Years Away," (GAO/IMTEC-86-15, OSD 7002-A). The GAO reported the NORAD computer system software was difficult to modify and that the computer modernizations were behind schedule. The GAO recommended that, as quickly as practicable, the Secretary of Defense replace all obsolete components of the NORAD Cheyenne Mountain Complex computer system and require that current replacement schedules be maintained. This current draft report is a major departure from the previous report, especially in view of the progress the DoD has made on these programs in the intervening time, as explained below.

Since the June 1986 GAO report, the U. S. Air Force has awarded contracts for the programs critical to missile warning processing, including the Communications System Segment - Replacement (CSS-R) Block II. The Air Force restructured these programs to fully fund them based on the actual contract costs. The DoD and the Air Force maintained the funding for these programs, despite the budget cuts for the adjustments to the FY 1989 President's Budget and to the build of the FY 1990-1991 budget, which were the largest budget cuts the DoD has ever made. In addition, the Air Force has initiated a management structure to identify and resolve technical issues and to ensure general officer approval of any change to the cost, schedule, or content of the programs. The CSS-R program completed the first phase of Block I development testing and evaluation. The CSS-R Block II program has completed both preliminary design reviews and one of two critical design reviews. In summary, the DoD has made considerable progress in replacing the obsolete computer systems in the Cheyenne Mountain Complex and has strengthened

the management oversight of those programs. The DoD, therefore, while concurring with some of the draft report findings, concurs with none of the recommendations.

The detailed DoD comments on the GAO findings and recommendations are enclosed. The Department appreciates the opportunity to comment on the report in draft form.

Sincerely,

Gordon A. Smith

GAO DRAFT REPORT - DATED AUGUST 18, 1988
(GAO CODE 510266) OSD CASE 7740

"ATTACK WARNING: NORAD'S COMMUNICATION SYSTEM SEGMENT REPLACEMENT PROGRAM SHOULD BE REASSESSED"

DEPARTMENT OF DEFENSE COMMENTS
* * * * *

FINDINGS

- FINDING A: Replacing The Communication System Segment. The GAO observed that the Integrated Tactical Warning and Attack Assessment (TW/AA) system is the major automated system supporting strategic surveillance and attack warning information to U.S. and Canadian leaders and the Communication System Segment (CSS) at Cheyenne Mountain Air Force Station, Colorado provides data communications support for the TW/AA. The GAO found that, while the CSS has been modified to accomplish changing missions and accommodate changing threats, it is comprised of aging and obsolete hardware and software. The GAO reported that the Air Force (1) is in the process of procuring a replacement for the CSS, which is becoming outmoded, and (2) has initiated an interim program to upgrade the existing CSS, while a replacement is being developed. The GAO further reported that the CSS, which is the most critical subsystem of TW/AA, performs two basic functions--(1) circuit switching and (2) message routing. The GAO found that, over time, the CSS equipment has aged and become increasingly difficult to maintain, noting that Data General, Inc. (manufacturer of the minicomputers that are a part of CSS) no longer makes, services or provides spare parts for the minicomputers. The GAO further found that, in 1981, the Air Force determined that a replacement was needed, which would provide the lowest overall life cycle cost, was reliable and maintainable, and conformed to the Air Force approved TW/AA architecture. The GAO reported that, since 1981, the CSS Replacement Program has been split into two parts: Block I to automate the monitoring and technical control of communication; and Block II to provide message processing and distribution capabilities. The GAO also reported that, while the Air Force Space Command is the CSS user, the Electronic Systems Division of Air Force System Command is responsible for acquiring a replacement system and the Air Force Logistics

Page 1

Command (with responsibility for some equipment maintenance at Cheyenne Mountain) is responsible for any upgrades to the CSS minicomputers. (pp. 9-15/GAO Draft Report)

- DOD POSITION: Concur. The Integrated Tactical Warning and Attack Assessment (TW/AA) system is, however broader than an automated system. It encompasses sensors, communications, facilities and, most importantly, the people that use or operate the system and the procedures they use. The Air Force Space Command is the primary organization responsible for providing communications support for the TW/AA system. The Air Force Space Command works with the Air Force Communications Command and Air Force Logistics Command to operate and maintain the CSS and with Air Force Systems Command's Electronic System Division to acquire a replacement for the CSS.

- FINDING B: Cost Of The Replacement Program. The GAO reported that, in 1981, when the Air Force determined that a replacement system was necessary, the Electronic Systems Division estimated that it would cost $202 million. The GAO further reported that, in October 1985, just over a year after the Block I award to GTE, the estimated total program cost had risen to $350 million, a 73 percent increase over the original estimate. The GAO found that an Air Force review team subsequently recommended system changes to reduce costs, leading to an April 1987 re-estimated cost of $242 million--a reduction of $108 million. The GAO further found, however, that by May 1988, the estimated cost had already risen to $281 million. (pp. 14-15/GAO Draft Report)

- DOD POSITION: Concur.

- FINDING C: Delays Have Contributed To A Planned Interim Upgrade Program. The GAO found that, by 1985, (1) the milestone for initial operational capability of the CSS Replacement had slipped two years (to September 1991), (2) the existing CSS hardware had grown increasingly more difficult to maintain, and (3) Honeywell had advised the Air Force that, by June 1987, it would discontinue production of computers suitable for replacing the existing CSS mainframe computers. According to the GAO, this led the Air Force Space Command to decide to replace the aging Honeywell Model 6060 equipment with more modern, compatible Honeywell equipment (Model 6000 DPS). The GAO found that other interim upgrades are also underway, including replacing the communication multiplexors and the intercomputer processors. (pp. 17-18/GAO Draft Report)

Page 2

- DOD POSITION: Nonconcur. The GAO report contains a misunderstanding of the various efforts to extend the maintenance life of the CSS. The communications multiplexors are not being replaced. The NOVA 840 computers, which are part of the communications multiplexors, are being replaced. This effort will replace 28% of the integrated circuit cards in the communications multiplexor. The upgrades to the Honeywell computers are upgrades of the processors only and do not affect the memory, peripherals, or other equipment. None of the efforts will affect the most costly part of the aging CSS system--the software, which is largely written in assembler language, is not written in a modular or easily maintainable form, is inflexible in meeting new mission requirements, and would require a large investment, more than the amount required to complete the CSS-R, to bring it up to modern, flexible, maintainable standards.

- FINDING D: Block I Does Not Meet Contract Specifications. The GAO reported that formal Block I qualification testing, scheduled to occur over a two month period, actually occurred over a 10 month period, from March through early December 1987. The GAO found that Block 1 has yet to meet all system specifications. According to the GAO, while the Electronic Systems Division and the development contractor believe that the methodologies used during testing were proper, some Air Force Space Command and engineering support contractor officials believe that complete end-to-end retesting is needed to ensure that the system will perform as designed. (The GAO observed that the contract specifies that formal qualification testing be conducted to verify that all system specifications are working. The GAO found that Block I does not meet all contract specifications.) The GAO also found that the Air Force-approved test sequence was never run in its entirety during any of the test sessions. The GAO noted, for example, that based on results from the third round of formal qualifications tests, in September 1987, Mitre notified Electronic Systems Division it did not believe the GTE software fixes were being thoroughly integrated and tested before resuming formal regression testing. The GAO concluded complete end-to-end testing (continuous from start to finish without a system failure) is needed to ensure that corrections do not induce errors in the software that previously had tested successfully. (pp. 20-22/GAO Draft Report)

- DOD POSITION: Concur. The development of Block I is not complete. The formal Block I qualification testing (FQT) is only the beginning of the development testing and evaluation (DT&E) for Block I and the Communications System Segment - Replacement system. Further, the DT&E will include an Operations Evaluation in the Test, Development,

and Training Center (TDTC), a complete FQT of Block I and an FQT of the Block I/II system, a systems test, maintenance demonstration, and operations readiness test in the TDTC. In addition, a systems test and an Initial Operational Test and Evaluation will be conducted in Cheyenne Mountain Complex. Although there were 12 action items identified in the initial FQT that covered 120 procedures and over 5000 steps, it is unfair to characterize a system still under development as not meeting contract specifications.

Although the GAO was given free and open access to all Government personnel and files, the GAO has failed to distinguish in this report between personal opinions of officials who may or may not be knowledgeable about the subject of their opinions and the official Government position. In addition, the GAO is using the opinions of non-Government personnel who may not fully understand the testing policies and procedures of Electronic Systems Division and may have conflicts of interest regarding the testing and installation of the CSS-R.

With respect to the Mitre and Electronic System Division differences, the Mitre concerns over testing procedures were resolved by modifying the testing procedures prior to the completion of the FQT.

- FINDING E: Unstable Software. The GAO reported that formal qualification testing has shown that Block I, as developed, does not meet a number of critical system specifications, including unstable software (which is software that is unpredictable, may not perform as expected, or may not produce consistent results when run against a known set of operating conditions). The GAO found that, on one occasion during testing, the software failed to properly interpret and transfer the operators command, locking up the system and preventing operators from issuing new commands, which resulted in Block I being shut down and the software having to be restarted. According to the GAO, in a test rerun the operators were unable to re-create the same failure even though no corrections had been made and, as of June 1988, the contractor had not identified the source of the problem. The GAO concluded that, until the problem can be resolved, the software cannot be considered stable and the problem could recur at any time causing a loss of communications, which could seriously affect the Air Force ability to satisfy mission requirements during a crisis. (pp. 23-24/GAO Draft Report)

- DOD POSITION: Concur. The software error that the GAO references has been isolated by the contractor. It was caused by a very high test load being processed through the CSS-R. The high load caused a buffer area to overflow. The

Air Force is having the contractor fix the problem that caused the overflow condition at high loads. To put the CSS-R software error in perspective, the current CSS also has software errors that cause one of the CSS sets to lock up. Over the 6 month period of March - August 1988, 24 lock ups occurred, 21 caused by software and 3 caused by unknown errors.

- FINDING F: Unacceptable Restart Time. The GAO reported that formal qualifications testing identified that Block I did not meet a number of critical system specifications, including an unacceptable amount of time needed to restart the system when it goes down for any reason. The GAO found that the Block I unit takes 31 minutes to become fully operational, compared with 12 to 15 minutes for the current CSS, or compared with 2 minutes, the original Block I requirement. The GAO futher found that the contractor has been given relief from the original requirement and told that the restart needed to occur within 26 minutes, 95 percent of the time. The GAO reported that the contractor requested the Air Force further relax the requirement to allow restart within 35 minutes, but the Electronic Systems Division program manager indicated that the 26 minute requirement would continue. The GAO observed, however, that Air Force Space Command officials believe that, because of the critical nature of the system to provide timely notice of bomber or missile attack, the present 26 minutes requirement is not acceptable and should be shorter. The GAO concluded that, as of June 1988, an acceptable length of time for restart had not been determined. (pp. 24-25/GAO Draft Report)

- DOD POSITION: Concur. The specification requires that Block I must restore critical circuit outages within two minutes. This is a critical mission capability and analogous to what the CSS technical control does today. The specification also requires initialization within 26 minutes 95% of the time and 30 minutes 99% of the time. The contractor has demonstrated Block I can restore data flow through all circuits within two minutes of a total outage. The capability that the CSS-R Block I adds to the present technical control equipment took 31 minutes to initialize during the FQT. Although this initialization time exceeds the time allowed in the specification, the initialization time is for capabilities (automatic circuit monitoring and semi-automatic switching) not present in the existing technical control. The Air Force is having the contractor fix this problem.

  It is inaccurate to imply that the CSS-R Block I would inhibit the timely notification of a bomber or missile attack during the full initialization period. The CSS-R Block I will begin passing critical warning

information less than two minutes after the system initialization begins. Furthermore, by design, the TW/AA system has sufficient robustness that the failure of any single component of the system will not deny timely warning of attack. Because of its critical function, however, the failure of the CSS or the CSS-R would reduce the amount of information on which the timely warning would be based.

The Government has determined the acceptable time for restart and it is the contract specification. If the contractor requests relief in this area because of difficulty in complying with the specification, the Air Force could again examine the requirement.

- FINDING G: Quality Signal Monitoring Has Not Been Achieved. The GAO reported that formal qualification testing has shown that Block I, as developed, has a number of unresolved deficiencies, including poor quality monitoring for critical communication circuits, which could degrade the technical control unit mission performance. This problem affects 40 of the 270 circuits the CSS-R should monitor. The GAO reported that, due to the area allocated for the CSS Replacement and the requirement for the placement of test equipment, the contractor designed and built a system with circuit monitoring equipment located adjacent to operator consoles and about 100 feet away from the circuit monitoring points on the communication lines. The GAO further reported that, according to Electronic Systems Division and a Mitre consultant, at that distance the quality of the communication signal cannot be measured accurately. The GAO concluded that resolution of this problem requires a determination of (1) the minimum distance between the test equipment and the circuit monitoring points on the communication lines that would ensure integrity of the measurement data, (2) whether it is physically possible to put the test equipment within the minimum distance in Cheyenne Mountain, (3) if possible, whether the performance degradation is acceptable, and (4) whether other technologies provide possible solutions. (pp. 25-26/GAO Draft Report)

- DOD POSITION: Concur. The Air Force is having the contractor fix this problem.

- FINDING H: Air Force Plans To Accept Block I. The GAO reported that the Air Force has invested about $72 million in the Block I semi-automated control unit and, despite serious unresolved design and development problems, the Electronic Systems Division plans to accept delivery of Block I from the contractor during September 1988. The GAO further reported that acceptance will be made with the reservation that 12 open action items be corrected by the contractor, at contractor expense, and the contractor rerun

end-to-end formal qualification tests after Block 1 acceptance, but prior to acceptance of Block II. The GAO found, however, that this set of tests could be deferred until April 1990; almost 2 years after the Government formally accepts Block 1. The GAO observed that when Block 1 units are accepted, they become Government property and the Air Force becomes responsible for maintaining them. The GAO reported that the Air Force is negotiating a preoperative maintenance contract with GTE (to commence on the date of Block 1 acceptance), which is expected to cost $5 million through FY 1991. (pp. 27-28/GAO Draft Report)

- DOD POSITION: Nonconcur. The Air Force has no plans to accept Block I during 1988, as described in the GAO report. The Air Force will not accept the Block I system until all contract specifications are met. The GAO report contains a major misunderstanding of the CSS-R contract and the Air Force acceptance procedure. The Air Force plans to close the Block I contract in November 1988, and transfer remaining Block I tasks to a task in Block II. The remaining tasks are the system test and the 12 open action items to be fixed at no cost. The Air Force will accept Block I with Block II, as a complete system, after the CSS-R system meets all contract specifications. The negotiated price for preoperative maintenance is $3.3 million through FY 1991.

- FINDING I: Block I Wiring Is Not Compatible With Cheyenne Mountain. The GAO found that, even if Block I were completely tested, accepted, and free of deficiencies, it could not be used at Cheyenne Mountain Air Force Station because of several configuration problems including an incompatible wiring standard between Block I and other Cheyenne Mountain equipment. The GAO further found that there is no uniform wiring standard for computer and telecommunications equipment at Cheyenne Mountain and, in order to begin to achieve standardization, the Air Force specified that Block I meet several standards, including RS-232C, knowing that this standard would be incompatible with other equipment. The GAO also found that the seriousness of the incompatibility was not identified until the contractors tried to integrate Government-furnished equipment with technical control hardware during formal qualification testing and the equipment would not work. The GAO reported that Air Force now believes the extent of the problem in Cheyenne Mountain is much larger than was earlier identified, and could affect nearly every system interface. The GAO noted that one of the Command engineering support contractors prepared an interface study, which recognized that standardizing Cheyenne Mountain interfaces to meet an RS-232 standard (1) would require a major engineering effort by the Government, (2) could take up to 2 years and (3) would cost approximately $5 million. The GAO concluded

that, as of June 1988, the Air Force Space Command had not resolved the wiring standard problem nor had funding been requested to pursue its resolution. (pp. 28-30/GAO Draft Report)

- DOD POSITION: Concur. Block I was built to the circuit interface standards specified by the Air Force. The Air Force will modify the Cheyenne Mountain Complex technical control wiring to meet the specified circuit interface standards prior to installation of the CSS-R Block I.

- FINDING J: Cabling Congestion Restricts Installing Block I. In addition to the incompatible wiring problem, the GAO reported that site preparation for telecommunications cables within Cheyenne Mountain Air Force Station is also a problem in the installation of Block I. The GAO further reported there are approximately 2,700 cables that need to be placed in the technical control area and there is a high risk communications will be disrupted during installation. The GAO also pointed out that the original contractor proposal of zero cable growth has already been preempted. The GAO found that at the heart of the installation problem is severe under-floor cable congestion due to equipment growth in the manual technical control area, resulting in a "rats nest" of underfloor cabling. The GAO observed that the contractor is concerned equipment installation will be adversely affected by the cable congestion and will impede the installation of the more than 200,000 feet of needed new cable. (pp. 30-31/GAO Draft Report)

- DOD POSITION: Concur. The Air Force effort to modify wiring interfaces will also reduce the cable congestion.

- FINDING K: Users And Acquires Do Not Agree On The Disposition Of Block I. The GAO reported that divergent views exist among major organizations within the Air Force Space Command and Electronics Systems Division concerning the disposition of the Block I semi-automated technical control facility. The GAO observed that some users at the Air Force Systems Command believe that Block I can be salvaged and used to build a modified Block I unit, while others believe it should not be installed; and on the other hand, the Electronic Systems Division believes Block I is needed and should be installed. The GAO pointed out that no one knows what the system can or cannot do. The GAO reported that the Air Force Space Command stated that the users and maintainers of the system have raised three concerns regarding Block I, as follows:

  - the open action items from the formal qualification tests clearly show the system does not meet requirements;

- the installation problem of Block I, due to incompatible wiring, cannot be easily surmounted; and

- there are inherent problems in a semi-automated technical control unit, such as the difficulty in integrating new Government-furnished equipment into a semi-automated control unit compared with a normal one.

The GAO found that, on March 10, 1988, the Air Force Space Command Deputy Chief of Staff for System Integration, Logistics and Support withdrew support for installation of Block I "as is", stating that it would not meet current mission requirements and would represent a very high risk to overall communications for Cheyenne Mountain. The GAO noted that, based upon the assumption that Block I would not be installed, a preliminary Air Force Systems Command study recommended totally rebuilding the present technical control unit and incorporating state-of-the-art fiber optic connections, which would reduce cable congestion, cost about $4.5 million and take about 2 years to complete. The GAO reported that, in contrast to the Air Force Space Command position, the Electronic Systems Division officials are concerned that a semi-automated technical control unit is needed to accommodate new programs and future workload requirements at Cheyenne Mountain. According to the GAO, the Electronic Systems Division officials maintained that the Block I problems can be resolved. The GAO also reported that these same officials contend that part of the user concerns are natural resistance to new technology and, after training and initial operation, the advantage of the semi-automated technical control unit will become apparent. (pp. 31-34/GAO Draft Report)

o DOD POSITION: Nonconcur. The concerns for Block I "as is" reflect concerns for a system on which development is not complete. Both the user and acquirer agree that CSS-R should be installed in Cheyenne Mountain Complex after development is complete and testing shows all contract specifications have been met.

o FINDING L: Air Force Space Command Believe Block I Will Not Be Installed. The GAO reported that, in June 1988, the Commander, Air Force Space Command, was considering a modified technical control unit, a compromise between a manual switch and Block I. The GAO noted that, given the Government investment in Block I, the Space Command is fully committed to the advanced development of Block I and scraping it is not an acceptable solution. According to the GAO, the modified Block I approach would retain some Block I

equipment, but the software may need to be modified or rewritten. The GAO reported that specific cost and schedule details on this alternative were not available at the time of its onsite audit work . (pp. 34-35/GAO Draft Report)

- DOD POSITION: Nonconcur. The Air Force Space Command position is as stated in the DoD response to Finding K.

- FINDING M: Reliable Message Processing. The GAO reported that, pending delivery of the CSS Replacement, the Air Force has been modifying and upgrading the existing CSS to meet immediate communication processing needs and to keep the system operational. The GAO observed that, while these upgrades will not satisfy all the CSS Replacement Block II specifications, they should (1) resolve the deficiencies used to justify the replacement system and (2) meet the NORAD communications needs through 1995 (and possibly through the year 2000). The GAO noted that the Air Force has also identified several critical issues, including an increased work load capacity and the need for a standard communications protocol, which will affect the performance, cost and schedule of the CSS replacement program. The GAO reported that, in February 1987, the CSS Replacement contract was awarded and is in the initial stages of acquisition; to date, $68 million has been committed of the $209 million planned. The GAO reported that the development of Block II was based upon a number of deficiencies including unreliable message processing. The GAO observed that the need for achieving system reliability became apparent on June 3 and 6, 1980, when false attack indications were generated due to faulty CSS component. According to the GAO, in the interim, since the CSS was designed, the Air Force corrected the reliability problem in the current CSS by changing system software and operating procedures. The GAO found that, with the introduction of the corrective measures, no false warning messages have been released by the Cheyenne Mountain Air Force Station and the CSS properly handled all messages processed during system testing by the Space Command Systems Integration Office. (pp. 38-41/GAO Draft Report)

- DOD POSITION: Nonconcur. As noted in the DoD response to Finding C, the GAO report contains substantial factual errors regarding the upgrades to the CSS. Those upgrades will not resolve the deficiencies used to justify the replacement system. The upgrades are designed to preserve the availability of the aging computer hardware and ease the transition to the replacement systems. The Air Force Logistics Command in a logistic supportability analysis concluded that the upgrades will not extend the life of the present system beyond 1995. If the CSS-R program was terminated, a new program to replace the CSS in form, fit,

and function by 1995 would be required. The critical issues the Air Force has identified and GAO has cited in its report have been substantially resolved. The Air Force has established a standard communications protocol, which is the DOD standard communications protocol, for all Cheyenne Mountain Upgrade programs. The CSS-R contract specifies that standard protocol. The Air Force has established a common message set. The estimated cost to modify the CSS-R contract to specify the new message set is less than $1 million, which is included in the Air Force estimate of the program cost. The Air Force and the Defense Intelligence Agency have established a common threat scenario to evaluate Cheyenne Mountain Complex command and control systems. Analysis, although not complete, indicates the CSS-R can handle the expected message loading. The message loading is the only GAO-cited issue which has not been fully resolved. The final analysis on message loading is scheduled to be completed 15 Oct 88. The Air Force does not believe these issues will cause any significant performance, cost, or schedule impact. The reliability problems in the CSS have not been corrected. The CSS had 69 single system failures in the last six months (March - August 1988), including 21 software and 3 unknown failures.

- FINDING N: Computers System Availability. The GAO reported that another deficiency, which was a part of the Block II justification, was inadequate computer system availability. The GAO found, however, that system availability has increased since 1981, due to numerous changes made to the CSS, such as new hardware and modifications to computer software. The GAO further found that, from February 1987 through January 1988, the average availability of the CSS was 99.9 percent, actually exceeding the requirement for the CSS Replacement (99.5 percent). (pp. 38-41/GAO Draft Report)

- DOD POSITION: Concur.

- FINDING O: Difficulty In Maintaining System Application Software. The GAO reported that another deficiency, which served as a part of the basis for justifying the CSS Replacement, was the difficulty in maintaining system application software. The GAO found the CSS software that was difficult to maintain during the late 1970s and early 1980s has been modified and is no longer difficult to maintain. The GAO reported that the software would be even easier to maintain if the computer operating system were upgraded, which the Air Force is considering as part of the interim upgrade program, after the Honeywell mainframe upgrades are installed in late 1988. (pp. 41-42/GAO Draft Report)

Page 11

- DOD POSITION: Nonconcur. The CSS software is written in older, assembler-level languages. The software was not written in accordance with modular, flexible software standards. It cannot be easily expanded to meet new mission requirements.

- FINDING P: Difficulty In Maintaining Aging Computer Hardware. The GAO reported that, because the CSS Replacement System operational date has slipped from 1989 to 1991, the Air Force is in the process of or plans to upgrade most of the CSS aging computer hardware. The GAO further reported that, because the computer used in the communication multiplexor and the intercomputer processors are obsolete and no longer supported by the manufacturer, the Air Force decided to replace the CSS Honeywell computer system with a newer model and to replace the CSS intercomputer processor with a high-speed, commercially available local area network. According to the GAO, the CSS component replacement will occur in phases, from December 1988 to the third quarter of FY 1991, at an estimated cost of about $14 million, making the CSS maintainable through at least the year 2000. The GAO also found that Honeywell is willing to negotiate support for the upgraded computer equipment through the year 2000. (pp. 42-43/GAO Draft Report)

- DOD POSITION: Nonconcur. As noted in the DoD response to Finding C, the GAO report contains substantial factual errors regarding the upgrades to the CSS. In addition, some of the proposed upgrades will require development and the associated system documentation is not complete. As such, there is no basis for determining the CSS or even the hardware components upgraded are maintainable through the year 2000. Although the vendor for the upgraded computer equipment may be willing to negotiate for support through the year 2000, as suggested by the vendor's employee in the GAO report, the Air Force has no authority to enter into a multi-year contract with the vendor. Further, recent experience with the vendor indicates such support would become increasingly expensive and may be conditional on sole source upgrades to hardware or software. This should not imply criticism of the vendor; as the equipment and software become older and the commercial customer base declines, overhead costs must be spread over a declining number of customers. In addition the $14 million costs do not include installation or implementation costs.

- FINDING Q: Inability To Expand. The GAO reported that the final deficiency, which served as a part of the basis for the justification of Block II, was the CSS inability to adequately expand to support future requirements. The GAO noted that a 1981 Air Force statement of need determined that the CSS could not be expanded to provide enough

circuits to meet Cheyenne Maintain needs projected beyond 1986. The GAO observed, however, that a subsequent 1987 Air Force Space Command study determined the current CSS circuits could meet Cheyenne Mountain communication needs through at least 1995 and perhaps through the year 2000. (pp. 43-44/GAO Draft Report)

- DOD POSITION: Nonconcur. Even though the CSS, as upgraded, may be able to accommodate circuit expansion, the CSS software cannot be easily expanded to meet new mission requirements.

- FINDING R: The Upgraded Vs The Replacement CSS. The GAO reported that, while Block II of the CSS Replacement program will replace the message processing functions of the CSS, the upgraded CSS will be very different from the CSS that existed in 1981 when the replacement program was planned. The GAO further reported that each system has certain advantages and capabilities over the other system, but the cost difference is substantial, $14 million for the upgraded CSS compared with more than $209 million for the CSS Replacement Block II. The GAO found that, because the CSS upgrades have only been an interim solution, the Air Force has not evaluated the competitive benefits and costs and has not evaluated the cost to include the additional capabilities of the CSS Replacement in the upgraded CSS or whether the additional capabilities offered by the replacement program are worth their higher cost. The GAO noted that, while upgrades are interim measures intended to extend the useful life of the CSS, they will substantially increase some CSS capabilities. The GAO also observed that the upgraded local area network is designed to transmit nearly three times the amount of data that the replacement system proposed network can transmit. According to the GAO, the upgraded CSS will have two additional advantages over the replacement program--i.e., (1) the capability to directly interface with AUTODIN and (2) the Space Command ongoing software maintenance process will keep the upgraded CSS current with other TW/AA system elements, while the replacement system will be modified at an unknown additional cost before it can become operational. The GAO reported that the CSS Replacement is intended to perform all CSS functions (except direct interface with AUTODIN), as well as the following additional functions:

  - alerting operators through an alarm that missile warning messages need to be verified before they are sent from Cheyenne Mountain (now done manually);

  - interfacing with the System Control Operations Center, which monitors and controls all computer systems in Cheyenne Mountain; and

- operationally recording up to 24 hours of historical performance data for later analysis.

In addition, the GAO reported that the CSS Replacement will perform some functions better than the upgraded CSS, including improved simulation and test capability, as well as provide 270 communication circuits compared to 220 for the upgraded CSS (although the Air Force estimates that only 207 are needed through 1995). (pp. 44-49/GAO Draft Report)

o DOD POSITION: Nonconcur. The GAO analysis is based on incorrect information, as noted in the DoD responses to Findings C and P. The upgraded CSS is not expected to be maintainable beyond 1995.

o FINDING S: Other Issues Affecting CSS Replacement. The GAO reported that the Air Force has identified several critical issues, which will have an impact on the existing requirements for the CSS Replacement program and could dramatically change the CSS Replacement's design, cost, and schedule. According to the GAO, these include the need to establish (1) a standardized communications protocol, (2) a consistent message load, and (3) a common message set or format. The GAO noted that, if these issues are not addressed, the system will not be able to effectively communicate with other subsystems in Cheyenne Mountain. The GAO found, however, that contractors are currently building the CSS Replacement and other warning and assessment subsystems to specifications that require different protocols. The GAO observed that the Air Force has not decided what system changes are needed to establish a single standard protocol. The GAO also found that several of the Cheyenne Mountain computer subsystems are being developed to different message load requirements, with the CSS Replacement having a smaller message load capacity than other subsystems. The GAO noted that the Air Force Space Command and Electronic Systems Division is aware of the problem but hasn't decided what the message load requirement should be for Cheyenne Mountain. The GAO also found that the CSS Replacement is being designed to accommodate current message sets with variable formats, while other subsystems are being designed to use a standard message set with fixed formats. The GAO stated that the Air Force is aware that the subsystems will not be compatible and has been trying, since April, 1988 to resolve which message set to use. The GAO concluded that (1) each of these critical issues must be addressed before the CSS Replacement becomes operational, (2) it may take more than a year to resolve the issues, and (3) the Air Force does not know the total effect possible solutions will have on the CSS Replacement System performance, cost and schedule. The GAO further concluded that, given the upgraded CSS should meet Cheyenne Mountain's

current and immediate future needs, the Air Force has a "window of opportunity" (1) to assess how a number of critical issues will affect the planned CSS replacement system, (2) to define current needs for the CSS Replacement program, and (3) to evaluate the best methods of achieving the long-term Cheyenne Mountain communication needs. (pp. 49-53/GAO Draft Report)

- DOD POSITION: Nonconcur. The issues cited by the GAO in this report will not dramatically change the CSS-R design, cost, or schedule. (These issues are addressed in the DoD response to Finding M). As noted in the DoD response to Finding R, the GAO analysis is based on incorrect information. No "window of opportunity" exists; Air Force analysis shows a replacement is needed by 1995. The Air Force needs for a CSS replacement are well defined and the CSS-R program is the best way of meeting those needs.

RECOMMENDATIONS

- RECOMMENDATION 1: The GAO recommended that the Secretary of Defense direct the Secretary of the Air Force to correct Cheyenne Mountain configuration problems by eliminating cable congestion, establishing a single wiring standard and determining minimum acceptable performance levels, given the limited physical space. (p. 37/GAO Draft Report)

- DOD POSITION: Nonconcur. The Air Force is already committed to eliminating cable congestion and establishing greater standardization of the technical control wiring. A single wiring standard is however, neither possible not desirable. The Air Force already has a workable structure, with participation of general officers from Air Force Space Command and Electronic Systems Division, which reviews all requirements. That is an appropriate level for resolving these matters.

- RECOMMENDATION 2: The GAO recommended that the Secretary of Defense direct the Secretary of the Air Force not to accept the Block I unit, as currently planned, until the deficiencies are corrected. (The GAO suggested that, given the Air Force Electronic System Division and the contractor have stated the deficiencies will be corrected at no cost to the Government, the Secretary should direct that the deficiencies be corrected immediately and continuous end-to-end formal qualification testing be conducted to determine and document compliance with Block I specifications and identify any additional deficiencies. (p. 37/GAO Draft Report)

Page 15

- DOD POSITION: Nonconcur. As noted in the DoD response to Finding H, the GAO is misinformed regarding the Air Force plans to accept Block I. The Air Force will only accept Block I when it meets all contract specifications.

- RECOMMENDATION 3: The GAO recommended that, if formal qualification testing identifies additional deficiencies, the Secretary of Defense decide if the best interests of the Air Force are served by correcting any of or all of them and seek congressional approval before proceeding to correct them. (p. 37/GAO Draft Report)

- DOD POSITION: Nonconcur. The Air Force and DOD will comply with all statutory and regulatory requirements for notification, approval, and oversight within the DOD and for Congress. The GAO recommendations for prior Secretary of Defense and Congressional approval prior to correcting additional CSS-R deficiencies, no matter how small, is unreasonable and unnecessary.

- RECOMMENDATION 4: The GAO recommended that before proceeding with further development of Block II, the Secretary of Defense direct the Secretary of the Air Force to resolve critical issues such as protocol standards, message set, and workload capacity. The GAO further recommended the Secretary expeditiously incorporate the upgrades into the existing CSS and complete an analysis that determines the impact, in terms of performance, cost, and schedule of critical system design questions in order to assist in developing a plan for determining the most effective means of meeting future communication processing needs at Cheyenne Mountain.

- DOD POSITION: Nonconcur. The Air Force is already planning to upgrade the CSS to extend its hardware maintainability. As noted in the DoD response to Finding M, the Air Force has already resolved the issues with protocol standards and message set. The message loading issue is scheduled to be resolved by October 15, 1988. Since the CSS program has already obligated half the programmed $281 million cost, it does not make sense to terminate this program. Although the Air Force has no provision in the contract to put the contractor on "hold," the Air Force could negotiate with the contractor, spending about $3 million per month, to put his effort on hold for a cost approximating the contractor's cost. The potential cost of terminating the program and starting over or the potential cost of putting the contractor on hold for even a few months exceed the potential costs of resolving the critical issues. The prudent action therefore, is to proceed with the CSS program, while expeditiously resolving the remaining issue. The Department feels the best

plan for meeting the immediate and future communications processing needs at Cheyenne Mountain is the current plan.

- RECOMMENDATION 5: The GAO recommended that the Congress withhold funding for any follow-on communications system until the Air Force has presented an acceptable plan for (1) solving critical issues such as protocol standards, message sets, and workload capacity and (2) determining the most effective and efficient approach for achieving Cheyenne Mountain's future communications needs. (p. 54/GAO Draft Report)

- DOD POSITION: Nonconcur. The GAO recommendation is based on incorrect facts. The Air Force has already presented the Congress with a plan to resolve the critical issues the Air Force has identified and GAO has cited in this report. The final resolution of those issues is scheduled to occur by October 15, 1988. The Air Force will immediately provide the Congress a final report on the resolution of the issues. The Air Force is already proceeding on the most effective and efficient approach for achieving the immediate and future Cheyenne Mountain Complex communications needs.

Major Contributors to This Report

Information Management and Technology Division Washington, D.C.	Daniel C. White, Deputy Director (202) 275-8598 Gregory McDonald, Group Director Leonard J. Latham, Technical Adviser Michael Blair, Evaluator
Boston Regional Office	Frederick Cross, Evaluator-In-Charge Joseph Rizzo, Evaluator Robert Dziekiewicz, Evaluator
Denver Regional Office	Paul Alcocer, Evaluator

*U.S. G.P.O. 1988-241-164:80322