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The North American Air Defense Command (NORAD) is attempting to enhance its information processing capabilities with a program known as the 427M improvement program. This program involves the acquisition of new automatic data processing and communications equipment (both hardware and software) to meet expanding operational requirements. Findings/Conclusions: Since the first contract under this program was awarded in early 1972, the program has experienced a variety of problems, including cost overruns exceeding $100 million. Recommendations: Either the Secretary of Defense or the Secretary of the Air Force should take immediate action to: consolidate the remaining Communications System Segment contractual efforts under the Aerospace Defense Command; replace the Communications System Segment with available state-of-the-art computer message switching equipment; accept and use, on an interim basis, the Space Computational Center System and NORAD Computer System hardware and software augmented by the Mission Essential Back Up Computer; start a redesign effort to replace the Space Computational Center and NORAD Computer System hardware and software with available state-of-the-art systems; initiate acquisition of an uninterruptable power supply in the NORAD Combat Operations Center; establish a steering committee to assess problems with current and future system development and monitor corrective actions taken; and direct the Chairman of the Joint Chiefs of Staff to exempt NORAD from using future World Wide Military Command and Control System computers. (Author/SC)

7130

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

NORAD's Information Processing Improvement Program--Will It Enhance Mission Capability?

The North American Air Defense Command is attempting to enhance its information processing capabilities with a program known as the 427M improvement program.

This involves the acquisition of new automatic data processing and communications equipment (hardware and software) to meet expanding operational requirements.

Since the first contract was awarded in early 1972, the program has experienced a variety of problems including cost overruns exceeding $100 million. This report discusses the problems and recommends remedial actions to obtain a responsive information processing system.

LCD-78-117
SEPTEMBER 21, 1978

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-163074

To The President of the Senate and the
Speaker of the House of Representatives

This report describes problems encountered by the Department of the Air Force when attempting to improve the North American Air Defense Command's information processing system. These problems occurred because of weaknesses in the development approach followed, a lack of centralized management, and inadequate contract control.

This review was undertaken to evaluate the progress made by the Department of the Air Force since the improvement program was started. It was made pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report today to the Director, Office of Management and Budget; the Secretaries of Defense and the Air Force; and the Administrator of General Services.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NORAD'S INFORMATION PROCESSING IMPROVEMENT PROGRAM--WILL IT ENHANCE MISSION CAPABILITY?

D I G E S T

The North American Air Defense Command (NORAD) performs a vital role in defense of the North American continent by maintaining aerospace detection and missile early warning capabilities.

This report describes problems encountered by the Air Force in attempting to improve the North American Air Defense Command's information processing system. These problems occurred because of weaknesses in the development approach followed, a lack of centralized program management, and inadequate contract control.

Almost concurrent with the start of operations for the command/control, missile warning and space detection systems in place at the North American Air Defense Command's Combat Operations Center, planning began for the improvement of these systems because it was apparent that they would not satisfy expanding mission requirements. (See p. 7.)

The program established to meet expanded mission information requirements became known as the 427M improvement program and began with the approval of NORAD's Combat Operations Center master plan in March 1969.

The objective was to replace outdated information processing systems, improve communications facilities and add other capabilities serving the NORAD complex.

The 427M program can be described in terms of three major segments

--the NORAD Computer System which is to provide real time processing for command/control and missile warning,

--the Space Computational Center which is supposed to provide the capacity for more

accurate and timely space population monitoring, and

--the Communications System Segment which is supposed to provide an uninterrupted flow of mission essential information. (See pp. 9 and 10.)

In April 1971, technical requirements for the system were validated and specifications developed by March 1972. The approved funding for development was $90.6 million in anticipation that initial operational capability for the new system would be reached by December 1975. (See pp. 10 and 11.)

Since initiation of the 427M program, the Air Force has encountered substantial program slippages and cost escalations, and is on the verge of implementing a system that will have an information processing capability no better than the systems being replaced. There are two basic reasons for these conditions:

--A requirement to use World Wide Military Command and Control computers and software which do not have the capability of handling NORAD's information processing requirements.

--Program management that was divided between the Air Force Systems Command and NORAD. This management approach made it very difficult to establish and maintain effective and efficient administrative control over program and contract operations on a day to day basis. (See p. 13.)

Most of the major problems encountered in the 427M program are attributable to the information processing limitations inherent in the World Wide Military Command and Control System equipment and software. These limitations have made it necessary for NORAD to undertake major software modification and retrofit operations and obtain a considerable amount of additional computer equipment for use as information processors and communications switching devices. These efforts have resulted in escalated program costs of more than $100 million over

originally approved funding and a degradation of expected processing capability. (See pp. 13 and 14.)

GAO found that the NORAD Computer System and the Space Computational Center System, will not be fully capable of performing their intended functions. For example, due to hardware limitations, certain satellite orbit calculations made in the Space Computational Center will be of less than originally specified accuracy and timeliness. In the NORAD Computer System, functions such as automating global weather messages have had to be indefinitely postponed and tests show that processing time, under certain conditions, will not meet specifications. (See pp. 16, 17, and 18.)

The inherent reliability of the Communications System Segment hardware is less than that required by the Air Staff for critical processing functions and software development has been an effective roadblock to completion for the past 3 years. As of April 1978, no successful test of the Communications System Segment has been made. (See pp. 20, 21, and 22.)

The reliability of the 427M system is directly dependent upon the power system that supplies it. The current power system in the NORAD Combat Operations Center is not reliable enough to meet system specifications for critical information processing functions.

The addition of an uninterruptable power supply would greatly enhance this reliability and insure that fluctuations in power will not cause catastrophic damage to data files vital to NORAD's mission performance. (See pp. 23 and 24.)

GAO found that the lack of centralized program management and inadequate contract control, although not the primary causes, were significant contributors to the many development problems encountered with the 427M system. (See pp. 39 and 40.)

For example, an internal Air Force Review in April 1977 pointed out that system management

was fragmented between two commands, that resource performance trade-offs were not addressed in a structured fashion and that comprehensive illumination of system level problems occurred only after reaching crisis proportions. (See p. 31.) Also, objections to the type of contracting procedure used and concern about the possible manipulation of charges between various contracts were expressed by the Defense Contract Administration Service. (See pp. 36 and 37.)

GAO did not solicit written comments from the Secretary of Defense. However, the matters discussed in this report have been presented to various Defense Department personnel, including representatives of the Assistant Secretary, Command, Control, Communications and Intelligence; the Joint Chiefs of Staff; the North American Air Defense Command; and the Aerospace Defense Command. Their comments have been considered in the report. (See p. 43.)

The views of officials of NORAD and the Aerospace Defense Command on GAO's findings regarding the 427M system development are summarized as follows:

--They contend that the capabilities provided by the NORAD Computer System and the Space Computational Center will satisfy mission requirements. (See p. 18.)

--They are currently investigating feasible replacements for the Communications System Segment. (See p. 23.)

--They agreed with GAO that an uninterruptable power supply would be desirable for the NORAD Combat Operations Center; however, they had problems regarding engineering such a system into the complex. (See p. 25.)

--They took issue with the GAO method of calculating the program cost overrun. According to these officials, it should only be $62 million. (See p. 28.)

GAO believes that the 427M program demonstrates the need for well organized and

effective management control over large, complex, integrated information processing systems, particularly those that stress huge computer capability and new software technology, and that either the Secretary of Defense or his designee, the Secretary of the Air Force, take immediate action to:

--Consolidate the remaining Communications System Segment contractual efforts under the Aerospace Defense Command (the major component of NORAD).

--Replace the Communications System Segment with available state-of-the-art computer message switching equipment.

--Accept and use, on an interim basis, the Space Computational Center System and NORAD Computer System hardware and software augmented by the Mission Essential Back Up Computer.

--Start a redesign effort to replace the Space Computational Center and NORAD Computer System hardware and software with available state-of-the-art systems. This would require developing functional specifications and obtaining equipment best suited to achieving critical requirements.

--Initiate acquisition of an Uninterruptable Power Supply in the NORAD Combat Operations Center to provide protection for critical information processing equipment.

--Establish a steering committee to assess problems with current and future system development and monitor corrective actions taken. This committee should be accountable for the proper execution of the redesign effort mentioned above.

--Direct the Chairman of the Joint Chiefs of Staff to exempt NORAD from using future World Wide Military Command and Control System computers. However, NORAD should implement a computer system that can compatibly exchange information with other command and control systems. (See pp. 41 and 42.)

Contents

ABBREVIATIONS

ADCOM	Aerospace Defense Command
AFSC	Air Force Systems Command
CSS	Communications System Segment
ESD	Electronic Systems Division
FACC	Ford Aerospace and Communications Corporation
GAO	General Accounting Office
GCOS	General Comprehensive Operating Supervisor
IRG	Independent Review Group
JCS	Joint Chiefs of Staff
MEBU	Mission Essential Back Up
NCOC	NORAD Combat Operations Center
NCS	NORAD Computer System
NORAD	North American Air Defense Command
SAMSO	Space and Missile Systems Organization
SCC	Space Computational Center
SDC	Systems Development Corporation
UPS	Uninterruptable Power Supply
USAF	United States Air Force
WWMCCS	World Wide Military Command and Control System

CHAPTER 1

WHAT IS NORAD?

The North American Air Defense Command (NORAD) is a binational partnership between the United States and Canada for the defense of the North American Continent.

HISTORICAL BACKGROUND

The United States and Canada began collaborating on defense plans in August 1940 when the President and the Canadian Prime Minister met and formulated the "Ogdensburg Declaration" which established a Permanent Joint Board on Defense.

Based on the recommendation of this Board, the two Governments set up an integrated air defense system on August 1, 1957. The organization, established to operate this system, was called NORAD and was headquartered in Colorado Springs, Colorado. NORAD began operations on September 12, 1957. In May 1958, the two Governments exchanged diplomatic notes formalizing the NORAD agreement, and in May 1975, the agreement was renewed for 5 years.

NORAD'S MISSION AND ORGANIZATION

NORAD's original mission was to provide a defense against the manned bomber. However, in recent years this mission has been expanded to include

--providing warning of attack on North America by bombers and/or ballistic missiles;

--surveillance of space to keep track of all man-made objects orbiting the earth;

--maintaining, in peacetime, a surveillance of North America capable of detecting and identifying unknown aircraft; and

--providing a limited defense against bombers in the event of an attack on this continent.

NORAD is the only command in the United States providing all of these early warning and defense capabilities. Without such a system of early warning and space surveillance, a surprise attack on this continent could not be detected easily.

NORAD forces are supplied primarily by the U.S. Air Force Aerospace Defense Command (ADCOM), also headquartered in Colorado Springs, and the Canadian Forces Air Defence Group at North Bay, Ontario.

The heart of NORAD/ADCOM operations is in the NORAD Combat Operations Center (NCOC) which is an underground complex housing the variety of equipment and personnel necesary to accomplish NORAD's mission essential functions.

Aerospace Defense Command

The Commander-In-Chief of NORAD also serves as the Commander of ADCOM and reports to the National Command Authorities through the Joint Chiefs of Staff (JCS) and the Canadian Defence Staff as shown in the chart on page 3. He operates with an agreed upon U.S.-Canadian concept of air defense in accordance with joint intelligence agreements.

ADCOM is the major component of NORAD and the single manager of U.S. Forces for aerospace surveillance, early warning, and defense against aerospace attack in the continental United States and Alaska. It is a specified command 1/ and as such reports to JCS on operational matters.

For purposes of global surveillance and warning of missile attack, the command relies on several systems that complement each other and must provide early warning against a surprise attack. These systems are:

—The Ballistic Missile Early Warning System: An electronic warning fan consisting of huge radars covering the polar approaches to the continent which provide 15 to 25 minutes of warning of an intercontinental ballistic missile attack. Currently, improved intercontinental ballistic missiles, particularly those with multiple nuclear warheads, have substantially reduced the time available for early warning.

--The Sea-Launched Ballistic Missile Detection and Warning System: A system of radar units located along U.S. coasts to protect against

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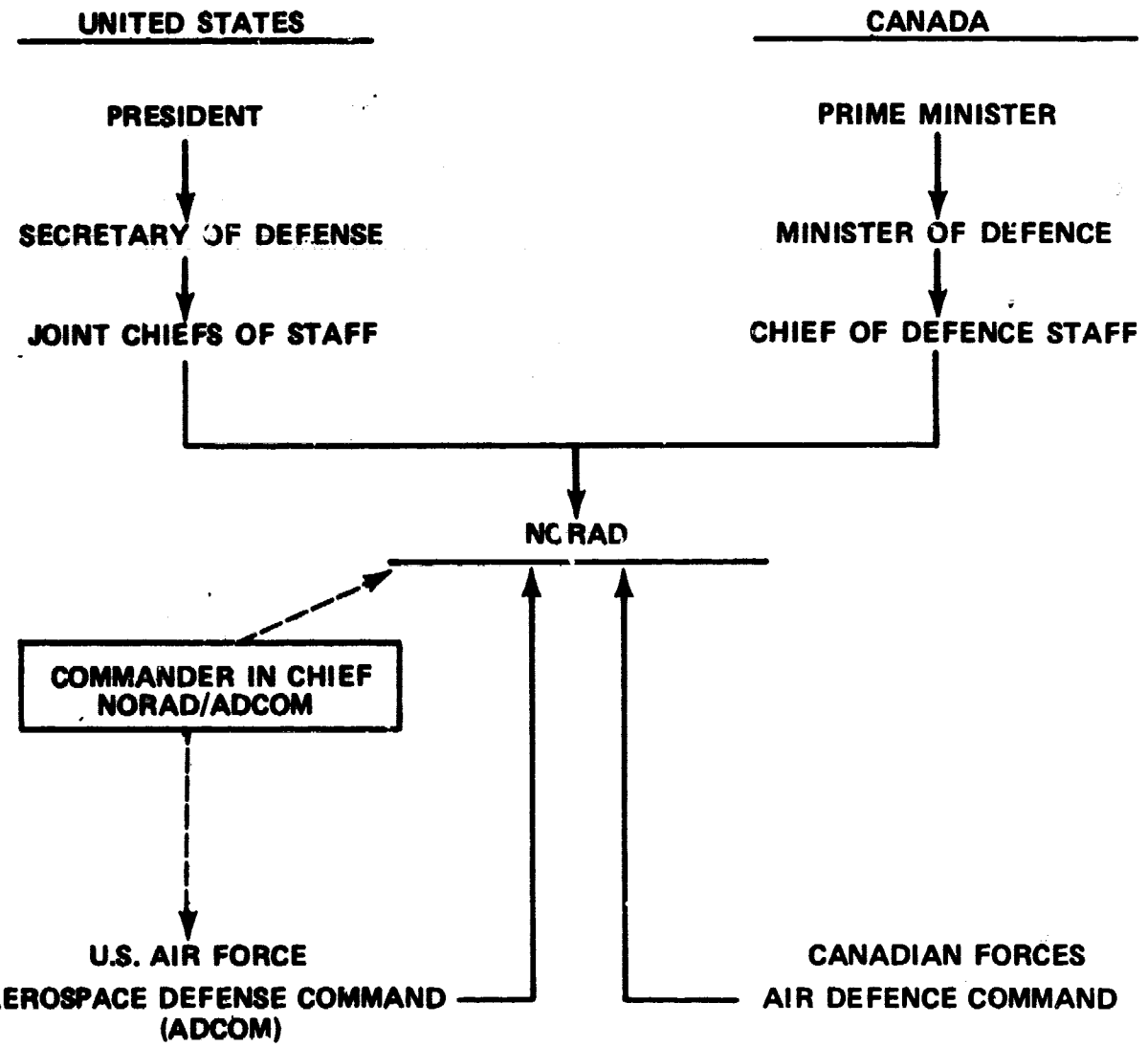
1/A command which has a broad continuing mission and which is established and so designated by the President through the Secretary of Defense with the advice and assistance of JCS. It is comprised normally of forces from one service.

NORTH AMERICAN AIR DEFENSE COMMAND (NORAD)

RESPONSIBILITY



BY U.S. - CANADIAN AGREEMENT, THE COMMANDER OF NORAD IS A U.S. AIR FORCE FOUR STAR GENERAL WHO IS ALSO COMMANDER IN CHIEF OF ADCOM.

this hazard. The time available to detect and to provide an early warning for sea-launched missiles is even less than that available for intercontinental ballistic missiles.

--The Satellite Early Warning System: A system that can give virtually immediate warning of ballistic missile launches.

--The Spacetrack System: A network of space watching sensors located in various parts of the world to feed NORAD data on earth-orbiting satellites. The sensors range from a huge phased-array radar in Florida that uses electronic scanning to peer at large areas of space to telescopic cameras in California, Italy, New Zealand, and Korea. Along with data from other tracking sensors, Spacetrack information flows into NORAD, whose Space Computational Center (SCC) 1/ catalogs manmade earth-orbiting objects and charts their movements and positions.

For aircraft detection, ADCOM has ground-based radars throughout the continental United States. Some of these radars are shared with the Federal Aviation Administration. Future plans call for a full joint-use program.

Defense against manned bomber attack is maintained by a fighter-interceptor force. In the event of war, this force would be augmented with similar aircraft from other Air Force commands, the U.S. Navy, the U.S. Marine Corps, and Canadian forces.

NORAD Combat Operations Center

The overall mission of NCOC is to manage a large, complex, integrated information processing system and to train personnel to:

--Provide a survivable, self-sustaining command and control facility where the Commander-in-Chief, NORAD, can execute the NORAD directed missions of strategic warning, space surveillance, and U.S.-Canadian control of North American air space.

1/Known as the Space Defense Center in the 496L system.

--Gather, assemble, and provide the Commander-in-Chief, NORAD, all necessary information to discharge his responsibilities to the National Command Authorities of the United States and Canada.

Organizationally, NCOC is composed of a commmand post and five operating centers, which are the (1) Battle Staff Support Center which is the NORAD Commander's wartime staff, (2) Weather Support Unit which provides worldwide and localized weather data, (3) Intelligence Center which provides analysis of intelligence data, (4) System Center which serves as the focal point for consolidation of all data furnished and displayed in the Command Post, and (5) Space Computational Center which catalogs earth-orbiting satellites and other manmade objects in space and charts their movements and positions.

The chart on page 6 shows the information processing systems currently used to manipulate all data in NCOC including the 425L Command/Control and Missile Warning system, the 496L Spacetrack system, the Command Center Processing system, and the Intelligence Data Handling system. The equipment used in these various systems can be described as follows:

--The 425L Command/Control and Missile Warning system uses a Philco 212 computer in conjunction with two Univac 1218 processors and the Display Information Processor, a custom built unit provided by RCA. In addition, another Philco 212 computer acts as an on-line backup for this system.

--The 496L Spacetrack system uses a Philco 212 computer as its primary processor.

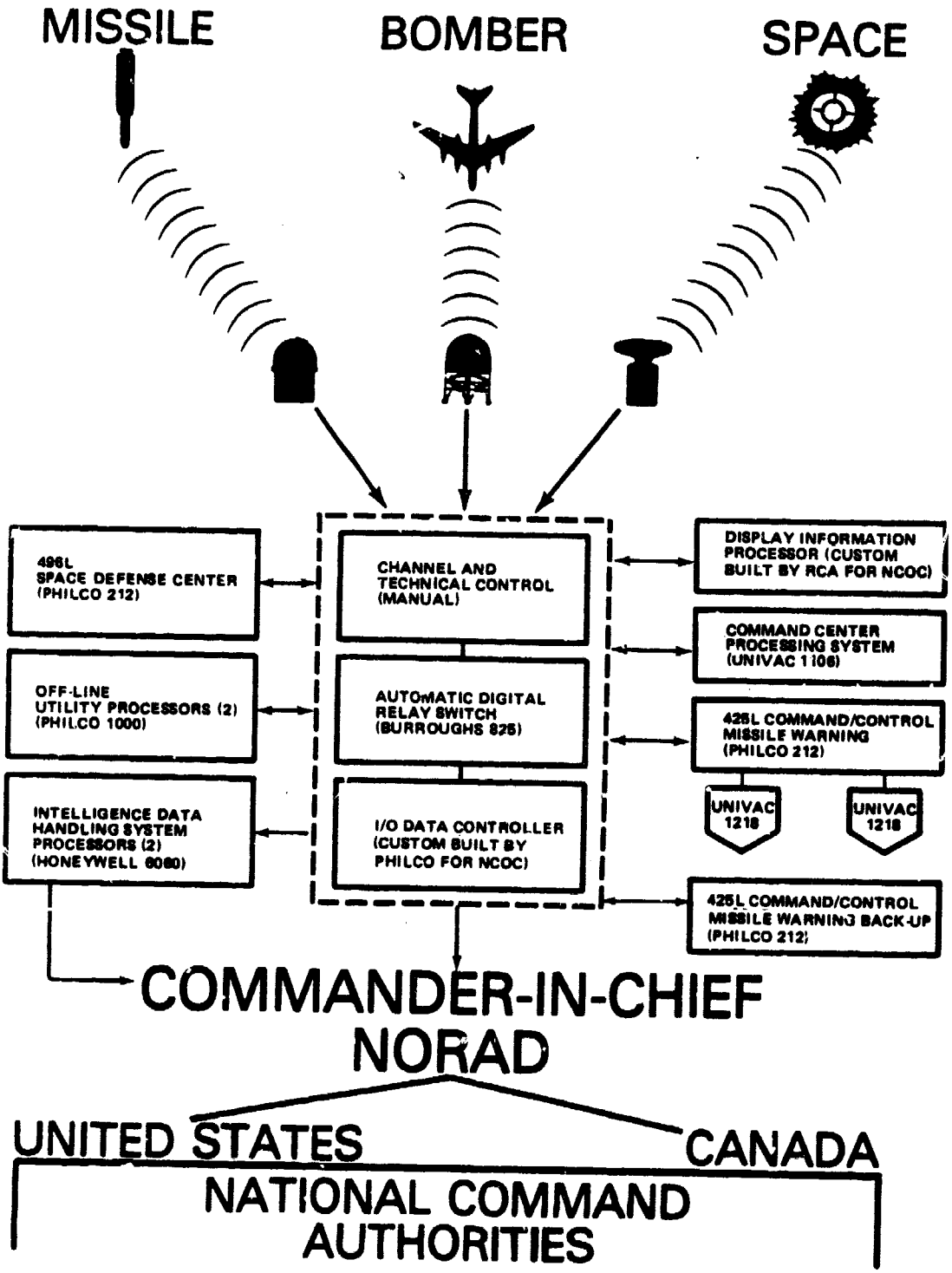
--The Command Center Processing system uses a Univac 1106 computer and provides all Commanders-In-Chief with simultaneous situation displays.

--The Intelligence Data Handling system uses two Honeywell 6060 computers to process intelligence data for the Commander-In-Chief, NORAD.

--The off-line utility processors are two Philco 1000 computers which can also serve as backup processors for the 496L system and the Automatic Digital Relay Switch, if necessary.

--The manual channel and technical control, the Automatic Digital Relay Switch, and the I/O Data Controller collectively function as the

DATA FLOW OF
NORAD'S 425L AND 496L
INFORMATION PROCESSING SYSTEMS



data communication switching device for the other systems. (See the chart on p. 6.)

As a result, NCOC and the Commander-In-Chief of NORAD depend heavily on computers and computer-related equipment to process and display rapidly information needed to support NORAD's assigned missions.

NEED FOR IMPROVED PROCESSING CAPABILITIES

Almost concurrent with the accomplishment of the initial operating capabilities of the 425L and 496L systems in 1966, NORAD began planning to improve these systems. According to ADCOM officials, NORAD's expanding mission responsibilities, the increase in the size and complexity of ballistic missiles, and the increase in the number of manmade earth-orbiting objects rapidly made the 425L/496L systems inadequate to provide the computational and tracking capabilities necessary to satisfy NORAD's mission requirements.

In addition, the equipment presently used to process mission essential information has been subject to an increasing frequency and duration of downtime due to the lack of readily available spare parts. Many of the needed spare parts have not been manufactured for the past several years. Finally, the present equipment is not supported by uniform and independent sources of power. Minor fluctuations in the power supply could disconnect computer-related equipment from the central processing unit with a corresponding loss or alteration of data and information. Some of this data cannot be reconstructed because it is the original data received from sensors.

Thus, command and control mission needs and information processing projections require greater and more reliable computer capability than can be provided by the current equipment.

CONCLUSIONS

NORAD performs a vital role in the defense of the North American continent by maintaining an aerospace surveillance and early warning capability. NCOC, which is the heart of NORAD operations, must be capable of satisfying the needs of the National Command Authorities for rapid and reliable information. To provide this information, NCOC depends greatly on computers and computer-related equipment. For this reason, use of the latest automated data processing and communications technology is highly desirable.

Current equipment and related software of the 425L and 496L systems are not adequate to meet current mission essential requirements and we agree that there is a valid need to improve the information processing capability within the NORAD environment.

CHAPTER 2

WHAT IS THE 427M IMPROVEMENT PROGRAM?

The 427M improvement program is intended to replace and improve the 425L Command and Control system, the 496L Spacetrack system, the Command Center Processing system, and the related data communication switching devices. The basic objective of the program is to enhance NORAD's mission effectiveness by providing greater and more reliable information processing capabilities than can be accomplished with the current computer equipment and software.

SYSTEM SEGMENTS

The 427M program can be described in terms of three major segments: (1) a NORAD Computer System (NCS), (2) a Space Computational Center, and (3) a Communications System Segment (CSS). Each segment is intended to achieve the following information processing improvements.

NORAD Computer System

The NCS segment will replace the 425L Command and Control system including the Univac 1218s, the 425L Back-up system, the Command Center Processing system, and the Display Information Processor. The Univac 1106 presently used in the Command Center Processing system will be used for a Mission Essential Back-up Capability (MEBU).

NCS is supposed to provide an automated capability for processing command and control information for the Command Post and the Operating Centers. The major system improvements resulting from development of this segment include (1) enhancement of on-line display capabilities, (2) centralization of several data bases into a single NORAD data base, and (3) consolidation of missile warning information processing and transmission into a single-computer system for a more timely and reliable early warning capability.

Space Computational Center

SCC will replace the 496L Spacetrack system, including the off-line utility processors.

SCC is intended to be capable of processing and displaying space and missile data. The new system capabilities

being designed in this segment include (1) increased computational capacity, (2) increased automation and integration of manual functions, (3) integration of functions of several data processing systems into a single system, (4) additional capability for data base manipulation, and (5) additional capability for input/display consoles for control of system computations for more accurate and timely space population monitoring.

Communication System Segment

CSS will replace the Channel and Technical Control, Automatic Digital Relay Switch, and the I/O Data Controller. (See pp. 5 and 6.)

CSS is supposed to assure an uninterrupted flow of information between NCOC and the worldwide surveillance systems feeding data into NORAD. The successful development of this segment would include two steps. First, a control facility would be developed to monitor data communication circuits including an automatic re-route and restoral capability and a comprehensive historical file containing information on the operability and quality of all circuits equipment and messages. Secondly, a data communications processor would be developed to receive, process, store and forward data entering and leaving NCOC.

The chart on page 6 shows the systems presently in operation, which are to be replaced by the 427M improvement program. The chart on page 19 shows the information processing configuration intended to result from this program.

PROGRAM MANAGEMENT AND ESTIMATED COSTS

The 427M program began in December 1968 when NORAD developed a master plan to replace the 425L and 496L systems. JCS and the Secretary of Defense approved this master plan in March 1969. Management responsibility for the program was assigned to the Air Force Systems Command, Electronic Systems Division (AFSC/ESD), and a 427M program office was established at Hanscom Air Base, Massachusetts, in September 1969.

The Air Force implemented the master plan in June 1969 by publishing a Systems Management Directive. Basic information requirements were validated by April 1971 and a

second System Management Directive was issued requiring preparation of more definitive system specifications. Preparation of these specifications was given to the MITRE Corporation which completed the task in March 1972. The Air Force later awarded the first of several implementing contracts. 1/

In April 1972, the Air Force estimated the total program cost to be $100.8 million but only approved $90.6 million for system development as follows:

	(millions)
Equipment procurement	$32.8
Operation and maintenance Spacetrack	23.5
Operation and maintenance NCOC	13.5
Facility construction	20.8
Total	$90.6

In September 1972 the Air Force established milestones which indicated that initial operational capability 2/ would be completed by June 1975 for CSS/SCC and December 1975 for NCS. June 1976 was stipulated as the time when the system should have full operational capability. 3/

1/See chapter 4, Inadequate Contract Control, for a general discussion of the contracting procedures for this program.

2/Initial operational capability--A point in time when the system is accepted/qualified to perform its operational mission on a sustained basis.

3/Full operational capability--We found no current documentation defining this term. However, ADCOM informed us that, in relation to the 427M program, it means the time when all capabilities defined in the General System Specifications are fully tested and available for operation. In April 1977, an AFSC independent review group reported that this condition could not be achieved and suggested the term "Equivalent Operational Capability" be adopted and should be considered to have been achieved when 427M operation was essentially the same as the 425L/496 systems.

CONCLUSIONS

The 427M program was established to improve the overall information processing capability of NCOC by automating functions previously performed manually, increasing the reliability and timeliness of the information, and providing for an expanding workload capability through the 1980s.

We believe the improvements expected from the 427M program are necessary and the development of this complex integrated information processing system is essential to the enhancement of NORAD's mission capabilities.

CHAPTER 3

WHAT IS WRONG WITH THE 427M PROGRAM?

Since the 427M program began, the Air Force has encountered substantial program slippages and cost escalations, and is on the verge of implementing a system that will have an information processing capability only equal to that of the 465L systems it is to replace. There are two basic reasons for these conditions.

First, NORAD was required to use computer equipment and software also used in the World Wide Military Command and Control System (WWMCCS). The WWMCCS equipment and software does not have the capabilities necessary to handle NORAD's information processing requirements. NORAD was required to use the WWMCCS equipment and software in spite of the NORAD Commander's objections. (The impact of the use of this equipment and software is more fully described in the following sections of this chapter.)

Second, program management has consistently been divided between the Air Force Systems Command and NORAD. Divided program management has made it exceedingly difficult to establish and maintain effective and efficient administrative control over the program and contractor operations on a day-to-day basis. (The impact of divided program management is more fully described in chapter 4.)

NORAD's attempts to resolve problems inherent in the WWMCCS equipment and software have resulted in the development of an information processing system that will not significantly improve its mission capability. Also, achievement of the operational capability intended for the 427M system has been hampered because the system lacks an uninterruptable and independent source of electrical power.

DIRECTION TO USE WWMCCS COMPUTER EQUIPMENT AND SOFTWARE

During March 1969 JCS and the Secretary of Defense approved the 427M program master plan. At that time the NORAD Commander was directed to use WWMCCS computer equipment and related software, General Comprehensive Operating Supervisor (GCOS), as the principal information processing equipment and software for the 427M program. On August 12, 1970, the NORAD Commander wrote to the Air Force Chief of Staff expressing his dissatisfaction with the WWMCCS equipment and software because they were not designed to operate in an on-line real-time environment. An on-line real-time environment is essential to NORAD's mission capability because of the short time frames in which to provide early warning of a bomber or

missile attack. On August 31, 1970, the Air Force Vice Chief of Staff advised the NORAD Commander that the WWMCCS equipment and software must be used in the 427M program since NORAD is part of the World Wide Military Command and Control system. An underlying reason for this decision was to provide system-wide responsiveness to defined military needs and economies of equipment acquisition, software development and system operation, and maintenance. However, as discussed in subsequent sections of this report, this approach was not cost effective and resulted in a degradation of various essential mission capabilities of NORAD. The objectives sought could have been achieved by the development of a system using state-of-the-art equipment and providing an appropriate NORAD interface with the WWMCCS community. (See app. I for the Commander's letter to the Air Force Chief of Staff and app. II for the Air Force Vice Chief of Staff's reply.)

Most of the major problems encountered in the 427M program are attributable to the information processing limitations inherent in the WWMCCS equipment and software. As described below, these limitations have required NORAD to undertake major software modification and retrofit operations and to obtain a considerable amount of additional computer equipment for use as information processors and data communication switching devices. These efforts have resulted in costs that have escalated to more than $100 million over the originally approved program funding and a degradation of NORAD's needed information processing capability to a level only equal to that of the systems being replaced.

IMPACT OF WWMCCS COMPUTER EQUIPMENT AND SOFTWARE ON THE 427M PROGRAM

As a part of the WWMCCS contract with the Honeywell Corporation, NORAD was given two 6080 computers and related GCOS WWMCCS standard software for use in the 427M program. In addition, NORAD was provided Data Net 355 computers to serve as data communication switching devices for exchanging NCS and SCC information with the input/output system of NCOC. As originally conceived, the 6080 computers would be used as the heart of the NCS and SCC systems while the Data Net 355 computers would serve in the same capacity for CSS. The Univac 1106, used in the Command Center Processing system, would provide a MEBU capability while the Intelligence Data Handling system would remain unchanged but be able to communicate with the other systems through the Data Net 355s. These systems and their interrelationships are shown on page 19.

However, as the 427M program progressed, it became apparent that using the WWMCCS equipment and software would

inhibit the achievement of the program's basic objective and, in March 1974, the Commander, AFSC, directed a review of the program to determine the reason for cost growth and to identify the corrective action necessary to meet the program's objective.

The review group reported that the requirements and procedures for maintaining WWMCCS standardized computer systems--both equipment and software--have created problems for the 427M and other programs within AFSC and would continue to do so. Specifically, GCOS software will not meet 427M requirements because it was not designed for handling real time applications. Consequently, Joint Programming Group (Air Force), Systems Development Corporation (SDC), Philco-Ford--now Ford Aerospace and Communications Corporation (FACC), and other WWMCCS users must write complex subroutines to meet their real-time requirements.

Another problem associated with the WWMCCS software is that JCS did not buy unlimited data rights; therefore, some users must negotiate separately with Honeywell for data to complete their program developments. Also, the Joint Technical Support Agency (now the Command and Control Technical Center) will only support standard WWMCCS and not user-unique changes even though approved by JCS.

Based on this review group's determinations, the Commander, AFSC, directed that a Joint Operational and Technical Review with ADCOM and the Air Force Logistics Command be convened to analyze system performance. The results of this analysis, completed in April 1974, stated:

> "Headquarters, USAF, directed AFSC to analyze the system performance achievable utilizing the standard WWMCCS operating system software. This study allowed comparison of the system performance using WWMCCS software with operational requirements. The WWMCCS Impact Study clearly shows that the WWMCCS standard GCOS will not meet 427M requirements principally in Response Time and Maximum Allowable Down Time Areas."

The Joint Operational Technical Review did not stop NORAD from using the WWMCCS computer equipment and software in the system. Instead, a third Honeywell 6080 processor was added and efforts continued to develop software for a real-time, on-line operation. Problems continued to surface with the result that some critical system requirements and processing capabilities were affected.

NCS AND SCC WILL NOT HAVE PLANNED CAPABILITIES

NCS and SCC functions will be performed on three WWMCCS standard Honeywell 6080 computers. However, since NCS and SCC are essentially distinct and have relatively minor electronic connecting links, they are generally regarded as separate functional segments.

Unlike the CSS software effort being undertaken by a contractor, the NCS and SCC software development programs are being accomplished in-house by military and civilian personnel. The problem of making WWMCCS standard software perform in a real-time, on-line environment has placed a burden of nearly $3 million annually on ADCOM's in-house software development capability. This amounts to about 25 percent of its total in-house software effort. According to the ADCOM Director of Software Development, overhead of this magnitude has forced ADCOM to limit software development to available funds. Being charged with NCS, SCC, and the MEBU software development, ADCOM has been forced to defer operational requirements submitted by NCOC operations personnel unless they were absolutely vital. It simply cannot provide the resources to make any changes. In some cases, the problems encountered have resulted in the degradation of critical system requirements.

For example, in March 1977, after reviewing changes to the NCS baseline requirements, the NCOC Deputy Commander for Operations corresponded with the ADCOM Directorate of Operations listing 49 program and modification requests outstanding for NCS. He stated:

> "The NCS baseline specifications changed to incorporate the Program Change/Modification Requests listed below, are "absolutely essential" for the NCOC to accomplish its mission using the 427M system as the primary system for missile warning and command and control information. * * * The NCS will not be adequate to perform the primary NCOC mission of missile warning and Command/Control in place of the present 425/496 system until the capabilities stated * * * above are present."

Of those 49 essential changes and/or modifications necessary to NCOC's mission, 13 dealt with automating global weather messages. We found that plans to automate this function have been postponed indefinitely.

In addition, we found a 1978 MITRE Corporation study on throughput process testing for the NCS segment indicating that certain problems still exist with the processing time which may impair the NCS capabilities.

Similar problems exist in the SCC segment. Of the previously mentioned $3 million spent annually on in-house software development to overcome GCOS deficiencies, $2 million is spent directly on SCC. When the requirements for SCC were first stated, it was estimated that a large scientific computer would be necessary to perform its mission essential functions. However, since ADCOM was directed to use the WWMCCS standard hardware and software, the specifications were subsequently reduced to meet the capabilities of these computers.

For example, ADCOM officials stated that there are currently 3 out of 5 space computational programs that can be run on the 6080 with GCOS to perform orbital calculations in SCC. The accuracy of these programs varies from low to very high, and the more accurate the program, the greater the amount of machine time required to run it. The following schedule illustrates how the programs compare as to speed and accuracy.

Program symbol	Accuracy	Speed
DP-4	Low	High
SGP-4	Low	High
IGP-4	Medium	Medium
AFGP-4	High	Low
Special Perturbations	Very high	Very low

Originally, it was planned that all space objects would be tracked with AFGP-4 accuracy; however, due to the limited capabilities of the WWMCCS equipment, DP-4 and SGP-4 (programs with relatively low accuracy and high machine speed) will be used to keep the SCC orbital catalog for most of the 4,000 plus objects in space and only a few high interest satellites will be tracked with the accuracy of the Special Perturbations program. IGP-4 and AFGP-4 have been eliminated as functioning programs because of the above mentioned machine processing limitations.

Further evidence of the limited capabilities of the WWMCCS standard equipment and software was indicated when ADCOM prepared the SCC baseline requirements in April 1976. The purpose of the baseline requirements was to identify the functions to be performed by SCC at initial operational capability. This document cautioned:

"The Space Computation Center computer program system will be designed to accommodate all data, and provide all required controls and necessary logic to enable space system operations to satisfy all mission requirements. However, the capability of the SCC, with any design, to support any scenario of space operations is restricted by the processing limitations of the Honeywell 6080. Therefore, it must be emphasized that although SCC computer programs will be designed for efficient performance, system processing throughput will be limited by computer hardware capacity."

In discussing system requirements at our closeout conference, ADCOM officials stated that there has been a continuous review of requirements since the NCOC master plan was published and that the most recent review was completed in January 1978. Based on their most recent review, they contend that the capabilities being provided will satisfy NORAD/ADCOM mission requirements.

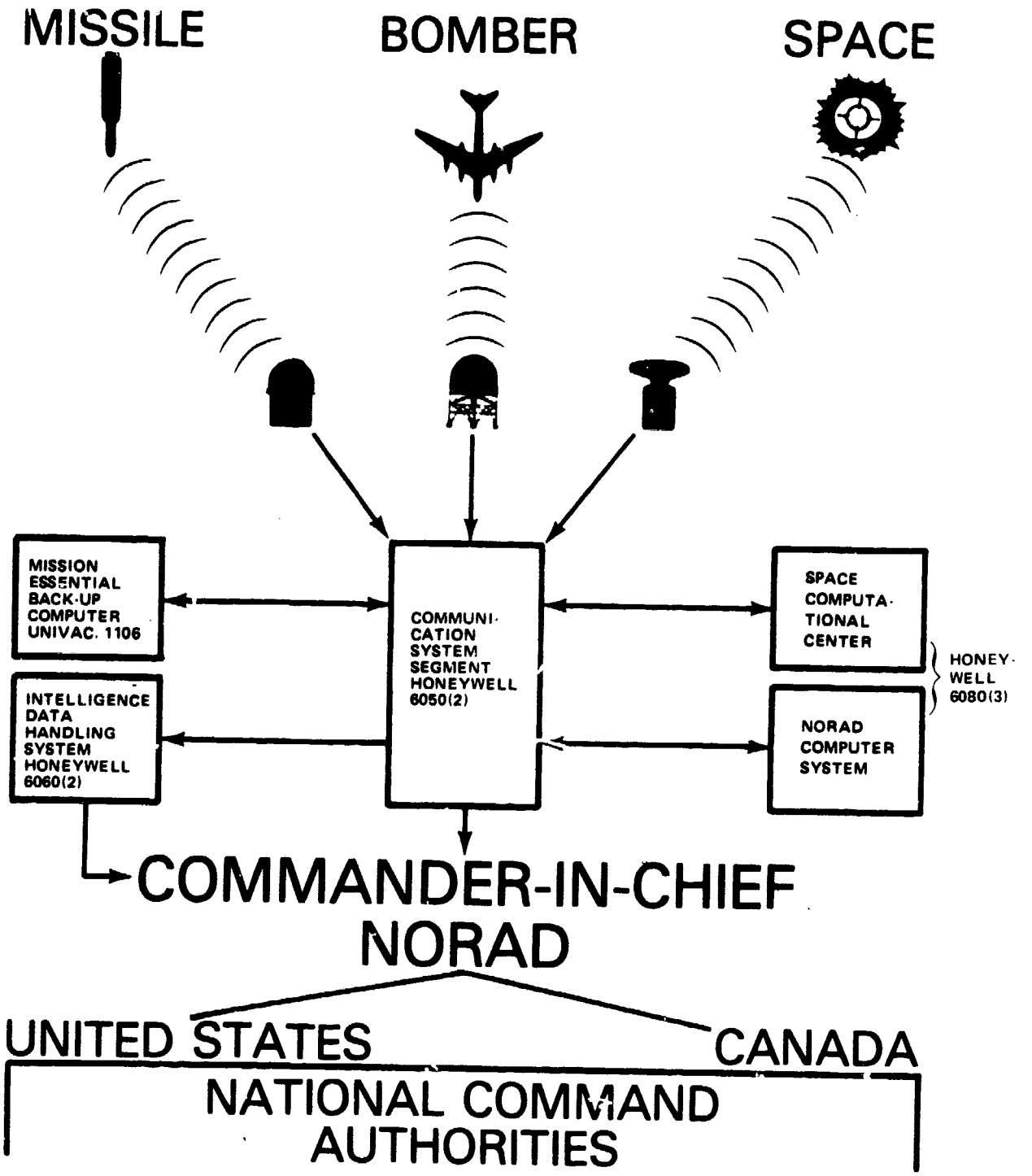
It should be noted that the January 1978 requirements mentioned above . reduced requirements because of machine processing limitat.. ns and are not the same as the General System Specifications. These reduced requirements are not the validated specifications (which are classified) approved by the Air Staff.

PROBLEMS WITH CSS

Communication circuits are brought to the NORAD Combat Operations Center by commercial facilities. As currently configured, CSS is the connecting link between the external communication circuits and the internal information processing systems (i.e., it handles all data communications for the NORAD Computer system, the Space Computational Center, the Intelligence Data Handling system, and the MEBU computer). The chart on page 19 shows how CSS connects the NORAD Combat Operations Center with the outside world. For this reason, it is considered to be the most critical single segment in the system.

The equipment procurement, software development, and integration of this segment are being implemented through a cost-plus-incentive fee contract. This contract, awarded to FACC, is under the management of AFSC/Electronic Systems Division.

DATA FLOW OF
NORAD'S PROPOSED 427M
INFORMATION PROCESSING SYSTEM



The segment generally consists of two Honeywell 6050 computers used as communications processors and a semiautomated technical control system for centralized circuit management. These processors were not part of the WWMCCS update program, but were selected because the WWMCCS-provided communications equipment (Data Net 355s) were not capable of adequately exchanging the NCS and SCC information with NCOC's input/output system. The 6050s were chosen by ESD relying on the manufacturer's information regarding the similarities in maintaining these processors and software and the WWMCCS standard equipment and software. In addition to the 6050 processors, a substantial amount of other assorted equipment and software is needed to connect this segment with adjacent systems.

Hardware difficulties

The CSS hardware is redundant with input circuits coupled to what are designated "hot" and "shadow" communication processors. In this type of configuration, the hot machine is the active processor and the shadow processor should be ready to assume CSS functions if the hot processor fails. The two processors can be automatically switched to provide for recovery without loss of either messages or technical control.

If the shadow processor has failed or is operating in a different mode and the hot processor fails, a catastrophic failure is considered to have occurred. Under these circumstances, the 427M system cannot process missile warning messages. When the shadow processor is merely in another mode, communications could be restored in about 15 minutes. However, failures in both processors could take up to 2 hours to repair and this could be disastrous because of the short time frames available to make decisions regarding threat assessment and response.

In May 1977, the MITRE Corporation compared the availability of missile warning processing in the old and the new systems. They found that, considering only hardware faults, the availability of the new system would be equal to the old system's, which was subject to an increasing frequency and duration of equipment failure. Because MITRE considered these failures an "intolerable situation," they recommended developing an alternative missile warning message path, one method being to wire around CSS directly to the MEBU computer or to the NCS 6080 computer.

MEBU, a Univac 1106, 1/ is required to meet NCS missile warning performance requirements and also to receive missile warning data from the various sensor systems. In the event of an NCS failure, it processes the data and transmits the appropriate messages. This reliance on MEBU to obtain the high reliability required of NCS caused MITRE's concern about CSS's ability to channel required information to and from MEBU.

According to NCOC officials the major problem with CSS is that it could cause a catastrophic failure because equipment failure in CSS could stop all data traffic to other systems. This precludes data processing and automatic transmission of critical warning information.

The ADCOM Director of the Systems Control Division recognized this possibility and, in August 1977, requested the program be modified to hardwire various MEBU functions around CSS. This request, however, did not cover automatic message output capability from MEBU. In this regard, the Deputy Commander for Operations, NCOC, in a letter dated September 9, 1977, added the requirement for a direct automated message output for MEBU.

As of April 1978, the decision to hardwire the MEBU computer around CSS had not been implemented, and concern over the inherent reliability and/or unreliability of CSS continues to be a problem. At the conclusion of our review, in May 1978, ADCOM officials informed us that the NORAD/ADCOM staff is currently reviewing the feasibility of bypassing CSS via MEBU for missile warning message traffic.

Software development difficulties

The 427M system is extremely dependent upon the software capabilities of CSS. We found that the GCOS software used in CSS is not the standard WWMCCS software that is used in the other Honeywell computers in the 427M system. It is an off-the-shelf business application type software, and there is no WWMCCS software support for it. Therefore, the contractor will only use this GCOS to establish initial operational conditions for this segment, at which time, the GCOS software will be shut off and a contractor-developed "Real Time Controller" software program will take over.

1/In August 1978 we were advised by ADCOM officials that the 1106 has been upgraded to a Univac 1141 computer.

This software replacement is necessary because neither WWMCCS standard nor off-the-shelf GCOS can operate in a real-time, on-line environment.

Contractor development of CSS software began in 1972 and the product was to be a software package for message switching and circuit control. This package was to be completed by June 1975; however, because of problems with both circuit switching and technical control, development is still in progress. We found no successful test evidence or documentation indicating that CSS would be operational during 1978. In this regard, we discussed potential replacements with NORAD/ADCOM officials and contractor representatives and were advised that suitable alternatives to CSS do exist. However, ADCOM officials believe that although there are alternatives to CSS, they represent future replacements. CSS with its limitations will have to be used on at least an interim basis until the best replacement can be developed and installed.

Potential replacements for CSS

Our discussions with representatives of MITRE Corporation, ADCOM, and FACC indicated that CSS could be replaced. Suggested replacements included the following:

--The currently operational NCOC Communications system could be overhauled and its life extended up to 5 years. This would facilitate the development of a replacement hardwire switching system using currently available microprocessing technology.

--The NOVA 840 computers currently used for Communications Multiplexors and Inter-computer Processors for the HIS 6050s could be used to perform the 6050 functions.

--Microprocessors, front-ending mini-computers, would provide a modular communications switching system with extremely high reliability and potential for unlimited system capability growth.

--Use the Mission Essential Back Up system in a bypass configuration to obtain reliability not possible with only CSS. This parallel system would be used as the foundation for evolution of a 427M replacement utilizing state-of-the-art technology.

--An Automatic Digital Network switch could replace CSS. This time-proven, readily available Air Force resource could be adapted to the 427M.

In this regard, at our close-out discussions with ADCOM officials, they informed us that the NORAD/ADCOM staff is currently investigating these CSS alternatives with the aid of the MITRE Corporation.

LACK OF AN UNINTERRUPTABLE POWER SUPPLY IS A POTENTIAL PROBLEM

The original General System Specifications stated reliability requirements for the 427M information processing system in definitive reliability figures for equipment and software. At the time these specifications were developed, the power supply that supported the system was assumed to have essentially 100-percent availability and reliability.

NCOC currently has an independent diesel power supply comprised of high reliability generators that would run the system in the event that commercial power was not available. However, NCOC does not have a system that protects data integrity against power fluctuations or disturbances developing in either the commercial power or their self sustained generator system. The need for this type of protection has been studied and recommended in the past. For example, in 1975, an electrical engineering firm 1/ under contract to ADCOM analyzed the energy systems of the NORAD Combat Operations Center and recommended the use of uninterruptable power supplies.

The engineers, in their report, noted that the electrical loads within the complex could be grouped into three categories (critical, critical support, and noncritical) according to tolerable downtimes. A load may be critical for either operational or technical reasons. Examples of a critical load would be communications and display devices, computers, memories, and tape or disk storage units. These critical loads cannot tolerate a power interruption or deviation without defeating the mission (operational) or causing temporary or permanent loss of information or damage to equipment (technical). The engineers stated that even if actual equipment damage did not occur because of the power outage, the loss of data and equipment disruption could

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1/Stearns and Rogers, Inc., Denver, Colorado, October 1975--under contract FO 5604-65-90207, S-R Proj. No. C-16860.

effectively disable a system for several hours or more. The recommended type of power is termed "precise" power or "no-break" and is most often provided by an Uninterruptable Power Supply (UPS) which totally isolates the load from the utility system.

In view of the preceding power system characteristics and the critical requirements of the computer processing system, the engineers recommended that the critical loads of the complex be served by a series of six battery-supported, non-redundant static inverter, UPS systems for the power center. Each UPS could be located on the roof of the building adjacent to the power center or, if possible, in the power center room itself to take advantage of the electromagnetic shielding.

They also recommended that each of the UPS systems be equipped with a battery bank to support full output for 15 minutes. They believed that this period of time would be sufficient to maintain the critical loads until other engine generators could be brought on line, or the system fails due to a lack of critical support functions, such as cooling and ventilation.

UPS not only provides protection against prolonged power outages, but also protects the system against slight fluctuations in power. These more subtle, split second failures can have an equally devastating effect on an information processing system's reliability. For example, industry studies have shown that 98 percent of the power outages causing a computer to break down are those lasting less than half a second. Also, almost any power outage will cause a disk storage device to be electronically interrupted or disconnected from the computer. This can result in loss or alteration of data being transferred to or from storage.

We examined NORAD's records regarding the power system from February 1977 through February 1978 and found that power fluctuations of less than 1 minute were not recorded although they do occur. We analyzed the recorded information and its effect on critical processing functions and found that the reliability of the power system was less than that prescribed for the 427M system.

At our closeout conference on May 10, 1978, NORAD/ADCOM officials generally agreed that UPS would be a desirable addition for the reasons stipulated in our report. However, they indicated that they were concerned about the problems of engineering 1/ such a system into the NCOC facility.

PROGRAM COST OVERRUNS EXCEED $100 MILLION

In June 1969, Headquarters, United States Air Force (USAF) issued a System Management Directive to implement the Joint Chiefs of Staff direction that USAF provide engineering and procurement support necessary to meet operational requirements of NCOC and SCC. AFSC was directed to budget for funds required to support the 427M program.

In April 1971, USAF issued a second System Management Directive instructing that

--WWMCCS computer equipment be used and

--an economic analysis of program requirements be prepared.

Responding to this direction, USAF issued Program Management Directive Number 1 which officially approved funding for the 427M improvement program in April 1972. Although the cost of the program was estimated at $100.8 million, approved funding amounted to $90.6 million. From April 1972 to January 1974, USAF issued revised Program Management Directives adding funds for increased program requirements and also deleting funds for management reserves and reports. Approved funding as of January 15, 1974, was $96.3 million.

As system development progressed into calendar year 1974, the Air Force became aware that the two WWMCCS computers would not adequately meet system availability criteria. The need for a third computer became more of a reality. Also, in late 1973, the ESD program office had begun to predict cost overruns on its development contracts.

1/These problems include physical space, heat removal, and electromagnetic pulse protection.

In April 1974, the Commander, AFSC, directed a Joint Operational and Technical Review of the 427M program. The reviewers reported that a program cost growth of $22.7 million had resulted from contractor cost overruns in

--the Space Computational Center software area,

--Communications System Segment software and integration tasks, and

--software changes and integration tasks required for the third WWMCCS computer system.

In September 1974, USAF increased approved funding to $122.2 million to provide for this growth in program cost. Major milestones were slipped from those previously listed in chapter 2 of this report.

Problems continued, and by March 1975, serious cost overruns were again recognized and the program was redefined to a "design-to-available dollar concept." ESD and ADCOM would have to assume increased responsibilities to include

--early operation and maintenance funding for certain 427M equipment,

--procurement of equipment, and

--development of software for NCS.

Automated test equipment in support of spare equipment verification and system maintenance, plus application software procurement, were added to the 427M program in early 1977. Approved funding was increased to $125.1 million.

In May 1977, ESD notified FACC that the contractor's revised program schedule presented an approximate 10-month slip in delivery of one segment and a 1-month slip in delivery of a second segment. The major cost growth associated with the delays was beyond the approved program funding. Contractor delays, plus required hardware and software changes, resulted in further increased costs.

ADCOM and AFSC agreed, in June 1977, that AFSC/ESD would budget for the current ESD baseline tasks and ADCOM would budget for all requirements beyond the ESD baseline. Headquarters, USAF, in a July 1977 Program Management Directive increased the ESD-approved program funding to $132.6 million.

ADCOM was also directed to concurrently accomplish a parallel effort to provide additional operational capability.

AFSC/ESD has calculated their 427M program approved funding cost as:

Program element	AFSC/ESD approved funding
	(millions)
Procurement	$ 64.6
Development	34.4
Operations and maintenance	12.8
Construction	20.8
Total	$132.6

NORAD/ADCOM obligations and expenditures

In addition to the AFSC/ESD reported program development costs, we found that NORAD/ADCOM has been financially involved in 427M development since 1968 when assigned personnel began software development activities. We calculated that NORAD/ADCOM actual program costs through fiscal year 1978 will be between $58.4 to $71.9 million. The development costs listed below were obtained from ADCOM furnished documents.

	(thousands)
WWMCCS computer maintenance, rental, and systems analysts	$ 2,701
Contractor software development, system integration, testing, and training	12,723
In-house software development	a/41,239
Contractor technical writing	1,241
Equipment rental to support technical writing	76
FACC operation and maintenance	6,201
Civil Engineer construction	4,377
U-1106 Core Memory	164
ADCOM 427M Program Office	1,729
NORAD Computer Program Division	369
Future 427M Civil Engineer construction	1,050
Total	$71,870

a/The cost figure provided by ADCOM 427M software development operating location was based on total military and civilian personnel authorizations by year and a $26,000 annual salary. We verified personnel authorizations from July 1974 through 1978. Personnel costs were computed for fiscal years 1976 through 1978 based on actual annual rates as listed in Air Force Regulation 173-10. Department of Defense pay deflators using fiscal year 1978 as the base year were used to compute personnel costs for 1968 through 1975. We calculated in-house software development costs of $27.8 million. Using our calculations, ADCOM total development costs through fiscal year 1978 are $58.4 million.

As discussed in chapter 4, FACC performance on the ADCOM software enhancement contract has generated strong concern regarding contractor ability to achieve milestones identified in the ADCOM contract schedule.

Based on the program development history of about 3 years slippage and current software development problems, we believe the system will not achieve operational status in December 1978, as currently scheduled.

ADCOM has prepared fiscal year 1979 funding requirements of $19.4 million for the 427M. We have therefore calculated that total program development costs will be at least $210.4 million to develop equivalent operational capability 1/ for the system.

The following schedule shows 427M development costs through fiscal year 1979 based on military documentation and our estimates.

	Military documentation	Our estimate
	(millions)	
AFSC/ESD (through FY-79)	$132.6	$132.6
NORAD/ADCOM (through FY-78)	71.8	58.4
NORAD/ADCOM (FY-79)	19.4	19.4
Total	$223.8	$210.4

NORAD/ADCOM officials, at our closeout conference, took issue with our calculation of a $100 million program cost overrun. They agreed that there have been additional costs of over $100 million; however, they believed that the cost overrun should only total about $62 million and the difference was normal cost growth based on system development changes. They stated that the cost overruns should include only the NORAD/ADCOM costs attributable to the 3-year schedule slip which they estimated to be $30 million plus the AFSC/ESD cost growth of $32 million ($132.6 - $100.8 = $31.8). We explained that we viewed program cost overruns as the additional costs incurred from the approved program funding in 1972 of $90.6 million to date; therefore, we still believed that the cost over run exceeds $100 million.

1/Equivalent operational capability was coined by the Air Force Independent Review Group in April 1977 to indicate that the 427M system would have the same capability as the 425L/496L systems.

CONCLUSIONS

NCS and SCC, the mission performing information processing systems of NCOC, will not be fully capable of performing their intended functions. Due to hardware problems, certain satellite orbit calculations will not be possible in SCC. Those calculations that are done will be of less than originally specified accuracy and timeliness. In NCS, mission-essential functions, such as automating global weather messages, have been postponed indefinitely. Furthermore, recent tests show throughput processing time, under certain conditions, will not meet specifications. What can be said for the NCS and SCC software and hardware is that, given a solution to the communications processing problems, they could be used on an interim basis and provide NORAD some capabilities for a few years until replaced. The current Philco 212s are old and inadequate.

CSS has experienced problems since its beginning. Catastrophic failure of CSS would drastically degrade NORAD capabilities.

The CSS software, which must be completed prior to operational testing of other segments of the 427M, has been an effective roadblock to completion for the past 3 years. A changing baseline of requirements and the contractor's inability to produce a working system leaves grave doubts as to when, if ever, CSS will be completed. Viable replacements for CSS offer capabilities that could enhance communications processing for NCOC and should be pursued.

The reliability of the 427M is directly dependent upon the power system that supplies it. The current system in NCCC cannot provide reliable enough power to let the 427M hardware meet system specifications for critical information processing functions. The addition of a UPS would greatly enhance this reliability and ensure that minute fluctuations in power will not cause catastrophic damage to data files vital to NORAD's mission performance.

Cost escalation in the 427M program has exceeded $100 million. We believe the primary factor responsible for this overrun was the attempt to develop software fixes to permit the Honeywell computers to operate in a real-time, on-line environment. However, a lack of centralized program management and inadequate control over implementing contracts also contributed to the escalating cost. The last two matters are discussed in the following chapter.

CHAPTER

WHAT IS WRONG WITH PROGRAM MANAGEMENT?

The design and development efforts required for a complex, integrated data processing system, such as the 427M, are costly, constrained by time, and affected by changing technology and management. Moreover, there is a significant impact on functional users affecting the efficiency and effectiveness of their operations.

In chapter 3, we discussed the major problems associated with development of the system around a predetermined type of automatic data processing hardware and software, namely the WWMCCS standard hardware and related software. Although we believe that this was the primary factor inhibiting the effective development of this system, we found that this development was also hampered by a lack of centralized management and inadequate contract control.

LACK OF CENTRALIZED MANAGEMENT

The successful development of any system depends on well organized and disciplined management control of needed data processing resources. However, our experience in auditing such large integrated systems, as the 427M, indicates that it is usually the lack of a central manager that contributes to prolonged system development cycles, sizable cost overruns, and user dissatisfaction with untimely and unreliable system products.

We found that the 427M program was no exception. For example, in September 1969, a 427M program office was established within ESD at Hanscom Air Base, Massachusetts. The NORAD Commander requested, on three occasions, that the program office or program manager be located in Colorado Springs, Colordo; however, the AFSC Commander did not concur. In September 1972, a single point of contact in ADCOM was designated for the ADCOM 427M program activities, but this was still ineffective.

Further efforts to tighten up program management came about in March 1975 when ESD/ADCOM held a joint meeting and agreed to realign the system program office. As a result, program management was subsequently located in Colorado Springs while contract management was conducted at ESD in Massachusetts. Each office was headed by a Deputy System Program Director and, to keep the program within current funding, NORAD/ADCOM assumed funding responsibility for certain 427M equipment.

Problems continued to surface and, in February 1977, the NORAD Commander requested an independent review of the program and centralized ADCOM's efforts under a single full-time manager.

Independent review points out management weaknesses

In April 1977, an Air Force Independent Review Group (IRG) reported that the management organization for the overall 427M program had been severely fragmented since its restructuring in early 1975. Methods provided to tie the segments into a system were inadequate. The ADCOM manager did not represent all ADCOM participants and the ESD program office was divided into 2 parts separated by some 2,000 miles. IRG stated that the ultimate effect of the 1975 restructuring divided the 427M into two separate programs tied together only by contractor developed, ADCOM approved, interface control documents which have remained virtually static.

In addition, IRG stated that the prior management organization was a single point of contact in name only. Various directorates and organizations were responsible for work in their areas of concern. Without a single manager, disagreements, misunderstandings, and uncoordinated unilateral actions affecting other activities were inevitable.

Specifically regarding ESD, the report stated that the separation of ESD program office elements greatly reduced the time available to discuss problems. The fragmented management structure required the field office to work business management problems for ESD headquarters personnel at the expense of time lost in engineering activity. By the same token, telephone input of engineering management problems and advice to business management personnel did not allow the extensive communication required to arrive at optimum management decisions. Accordingly, it is difficult to understand the many issues of a problem without personal exchanges and necessary documentation.

The program director has been severely hampered by being separated from either group. He required regular and timely advice from engineering and test personnel, as well as business management personnel. This separation problem was compounded by the fact that both the user for the system, ADCOM, as well as the contractor, FACC, were located in Colorado Springs. The considerable pressure on the field office indicated a need for the presence of the program director and many members of his management staff more frequently than 2 or 3 days per month.

The report summarized its findings regarding management as follows:

--System level management and engineering are lacking. This has created a severe development vacuum.

--System management responsibility is fragmented between the two commands. One has financial and development for a major part, the other is managing resources and development for another segment as well as shepherding the operational performance responsibility in a constantly changing environment. Resource performance trade-offs are not addressed in a structureed fashion, and comprehensive illumination of system level problems generally occurs only after reaching crisis proportions.

IRG concluded that the joint management of 427M has hindered the program's progress. ESD's integration role was very narrow and inadequate from a systems' viewpoint. ADCOM was without a systems engineering resource. The lack of a systems engineering or integrating capability to bring the program segments into a single system was a major shortcoming and hindrance to effective joint management. Also, joint program management has not achieved orderly progress toward program objectives. The divergent interests and the difficulties encoutered indicate that total management responsibility for the 427M program should be vested in a single agency.

Agency actions to resolve management difficulties

As a result of the IRG report, NORAD/ADCOM and AFSC Commanders agreed, in June 1977, to modify the existing program management structure, and ADCOM assumed the system management responsibility. Total responsibility, however, was not given to one agency as recommended by IRG.

The joint NORAD/AFSC agreement provided that:

--ADCOM would assume responsibility for system engineering, integration, and test effort. ADCOM would budget and contract for all additional requirements beyond the ESD baseline.

--MITRE Corporation would perform as the 427M System Engineer for the ADCOM System Manager, chair a System Engineering Management Panel, and provide engineering support to ESD.

--AFSC/ESD would continue to be responsible for the ESD contract with FACC until ESD baseline segments are transferred to ADCOM.

To maintain maximum visibility in FACC efforts on the 427M program, the ADCOM procurement office was asked to provide copies of 427M correspondence to the MITRE Corporation's System Engineer, the ESD Field Manager and ESD contract administration agent, and the Denver-Defense Contract Administration Services Management Area so that these agencies would be kept informed in the "minutest detail" of all contractual direction.

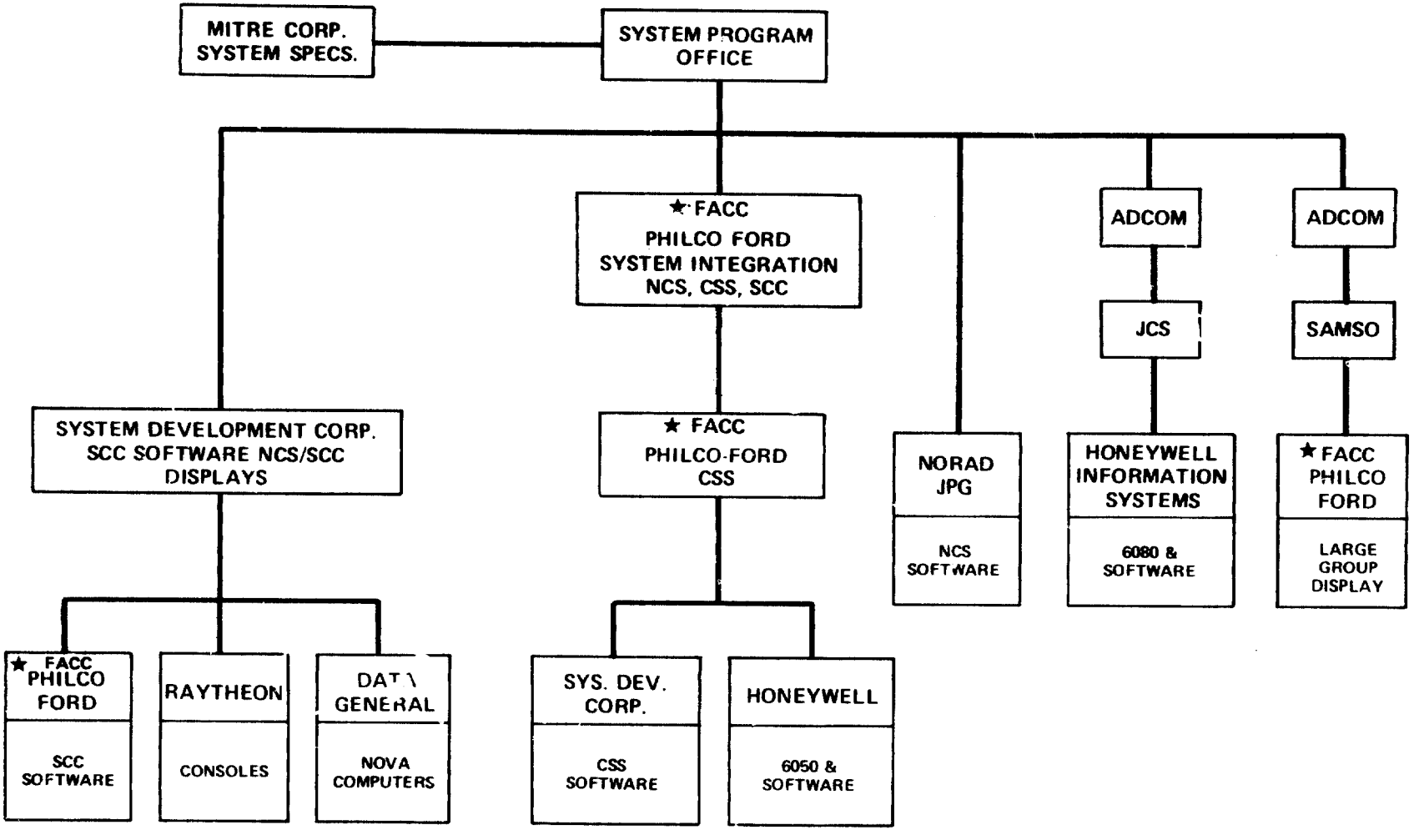
INADEQUATE CONTRACT CONTROL

As development of the 427M program grew, the complexity of the contracting structure also grew. Maintaining adequate control over contracts was complicated by the management restructuring discussed earlier in this chapter. Consequently, contracting problems arose which contributed to the overall system development problems. Although we did not perform a complete contract audit, the following problems surfaced as a result of our management review.

Contract development

In October 1972, ESD awarded a cost-plus-incentive fee contract to FACC for development of the 427M system. The incentive feature was intended to encourage the contractor to control costs so that he could realize an increased fee for costs incurred below a target cost or a depletion of fee for costs above target. FACC was also given specific responsibility for producing the semiautomated technical control and communications processor segments. The System Development Corporation was to produce software for the Space Computational Center and displays for both the SCC and NORAD computer systems. As an in-house effort, NORAD was to provide mission processing software for NCS. This arrangement was complicated by the fact that FACC subcontracted the communications processor software to SDC, and SDC, in turn, subcontracted the astrodynamic (space) software to FACC. Also, SDC subcontracted display consoles to the Raytheon Corporation and to Data General Corporation for NOVA minicomputers to drive the displays. Furthermore, Honeywell Corporation became the WWMCCS contractor in 1971, with responsibility for providing the computers to be used in the SCC and NCS segments. The chart on page 34, shows the 427M contract structure as of March 1974. In 1975, ESD assumed responsibility for system integration, removing that task from FACC. ADCOM assumed responsibility for an additional software effort and the SDC contracts were

1974-427M CONTRACT STRUCTURE



★Ford Aerospace and Communications Corp. formerly Philco-Ford Corp.

redirected to a level of effort because of the firm's inability to produce a satisfactory product.

According to contractor documentation, studies made parallel with the 427M development effort identified the need for additional equipment. Also, constraints were levied on the 427M program by the WWMCCS computer program. Implementation of the additional equipment and being responsive to the WWMCCS constraints were recognized as being beyond the scope of the original program; therefore, in September 1975, the FACC contract was revised to provide for completion of the communications and display segments. In addition, ESD, in February 1978, finalized a major addendum to its FACC contract for additions to the 427M which will add 1-1/2 years to the time required to complete the contract.

ADCOM, as a result of assuming responsibility for system engineering, integration, and test efforts in June 1977, signed a letter contract with FACC in August 1977 for software enhancement and testing support. The ADCOM Director of Communications, Electronics and Computer resources, in justifying a sole source procurement from FACC stated:

> "For numerous reasons, * * *, slippage in achieving the planned operational capability has been experienced. * * * this is the first command, control and communications system in which so many computers and automated features are merged into a single system linking the NORAD Cheyenne Mountain Operations Center with the real time sensors of the missile warning systems, and the National Command Authority. The unique features of the CSS indicate that the training and experience necessary for any other contractor to accomplish these tasks would result in significant delay in the completion of the identified tasks."

Therefore, ADCOM and ESD awarded software development/enhancement contracts to FACC which duplicated the work to be done. For example, both contracts require computer program configuration changes related to the 427M interface with certain missile warning sensor systems. Also, message management tests required by the contracts would be made simultaneously.

Objections to this type of contracting procedure and concern about the possible manipulation of charges between contracts prompted the Defense Contract Administration Service to express its concern.

Objections raised to contracting procedure

Objections have been raised regarding this dual contracting concept. The Defense Contract Administration Service Management Area (Denver), Administrative Contracting Officer, in July 1977, advised the ESD Commander that:

> "* * * it becomes increasingly evident that the contractual arrangement being proposed for the continuation and expansion of the 427M program places this office in a position that approaches being untenable. * * * The most obvious of the objections to (the) dual contract concept is the possibility of the contractor being able to manipulate charges between contracts to enhance his fee position, particularly if the incentive provisions of the two contracts are not identical. This will completely undermine the initial purpose of the incentives. Obviously, if the contractor finds himself in an overrun situation on one or the other contracts, he will be free to divert costs to the other contract or even the O & M contract, which we understand is fixed price. If the incentive provisions of one contract are more favorable than the other, the subterfuge can be more subtle, even more effective, and much more difficult to detect."

He went on to say:

> "The second, and potentially more serious, of the dangers of the proposed concept is the ability of the contractor to play both ends against the middle. There are almost unlimited opportunities for the contractor to cite directions received from one agency on its contract as the basis for a claim against the other agency and its contract. Likewise, problems or slippages on one contract will almost automatically cause problems or slippages on the other, whether real or invented. Finger pointing is almost certain to become a major issue, and the contrator is in the enviable position of being able to point in both directions.

"There are many other administrative problems and headaches which are inherent in the proposed arrangement both for this office and for the administration office of the ADCOM contract. Some of these problems surfaced earlier in the program as a result of ADCOM personnel meeting and talking directly with the contractor, instead of through the Program Office and the Contracting Officer.

"It is our firm belief that the best protection against problems, claims, finger pointing and even intentional fraud would be to combine the remaining tasks and contemplated new work into one contract, preferably the existing contract. This is the optimum arrangement from the standpoint of administrative feasibility."

The Electronic Systems Division replied to the Defense Contract Administration Services Management Area that:

"Management considerations plus alignment of roles and responsibilities between AFSC and ADCOM, however, preclude the use of the single contract approach, even though, on the surface that might appear to be the best business strategy."

To further complicate matters, in November 1977, the ADCOM Administrative Contracting Officer advised ESD that:

"* * * the contractor was playing ADCOM against ESD * * *. With two CPIF 1/contracts, each for similar and, in some cases, identical requirements, the contractor was in a position so that any delays on one contract could be attributed to the impact of the other contract, and that any costs not collected from one could be charged against the other."

Although the possibility of terminating the ADCOM contract and transferring funds to ESD's contract was suggested, ESD did not believe it could be done without extreme difficulty.

1/Cost-plus-incentive fee.

There appears to be some justification in the concerns expressed above because on January 25, 1978, the ADCOM Administrative Contracting Officer corresponded with FACC expressing the Air Force's concern as to the contractor's ability to achieve milestones identified in the contracting schedule. He also stated that the Government was concerned that FACC lacked sufficient technical resources to prosecute the tasks on the ADCOM and ESD contracts in an independent and timely manner. He further stated that the apparent inability to attain the level of expenditure which FACC has twice proposed and stated as being necessary to complete this contract as required can only lead to further schedule slips.

An ADCOM official had previously described the ADCOM and ESD contracts as being pursued by the same FACC personnel, working part time on each task due to the lack of sufficient technical personnel. This was indicated in the FACC invoices which showed less man-hours applied to software development than was forecasted in its cost proposal. The underrunning of FACC man-hours applied has resulted in its not achieving software development milestones and delayed delivery of required cost performance reports to ADCOM.

Again in February 1978, this ADCOM official reported that FACC was showing a continuing negative trend of work being done and that contractor explanations had not been satisfactory.

Apparently ADCOM officials believed FACC was not satisfactorily accomplishing the tasks required on the ADCOM software letter contract. However, during the week of March 13 to 17, 1978, ADCOM and FACC negotiated a definitized formal contract to supersede the sole source letter contract. Delivery of the FACC final off-line software development package to ADCOM was extended to August 1979. ADCOM also requested additional funding to cover the increased cost of the FACC efforts.

The ADCOM software enhancement contract provides for additional, unplanned capabilities required to bring the 427M system to an operational status equivalent to the currently operating systems. The requirements were not anticipated when the ESD contract was awarded.

As mentioned previously, ADCOM agreed to early funding for operation and maintenance of certain 427M equipment. In justifying the award of a sole source operation and maintenance contract to FACC, ADCOM stated:

"The primary reason is the lack of a 427M Systems Manual. This manual will be the only document that will technically describe the multitude of interfaces that exist in the system and is the critical document that ties together the many equipment maintenance technical orders required for system maintenance. The manual is being developed by Ford and will not be available until 1, January 1978. Without this manual, the only contractor with the system knowledge to maintain the 427M program is the development contractor, * * * Ford * * *."

The General Services Administration, in April 1976, granted ADCOM delegation of procurement authority for the sole source acquisition of maintenance services.

In March 1978, ADCOM advised Headquarters, USAF, that the fiscal year 1979 427M operation and maintenance contract must again be obtained via sole source from FACC and that the documentation necessary for competitive bidding would be turned over to ADCOM when equivalent operational capability is achieved, now expected (by ADCOM) to be December 1978. Document delivery is presently scheduled about 1 year later than anticipated when the first sole-source contact was awarded to FACC.

FACC has not delivered a systems manual and other documentation on schedule, thereby, preventing ADCOM from obtaining competitive bids for the operation and maintenance effort.

CONCLUSIONS

The 427M improvement program demonstrates the need for well organized and effective management control over development of large, complex, integrated information processing systems, particularly those that stress huge computer capabilities and new software technology.

In our opinion, the lack of centralized management and contract control were significant contributors to the many development problems encountered with this system. This resulted in a prolonged system development cycle and the sizeable cost overrun discussed in chapter 3.

Further, we believe that an already complex contract structure was further complicated by the separation of the FACC contract between ESD and ADCOM. In this regard, we

agree with the opinion of the Defense Contract Administration Service that the FACC contracts should be consolidated under a single manager to avoid more unnecessary problems in completing the remaining tasks to be accomplished in the program.

CHAPTER 5

WHAT CAN BE DONE?

RECOMMENDATIONS

The role of the North American Air Defense Command is vital to our national defense and that of the North American Continent. Due to the hardware and software limitations of the WWMCCS standard equipment, the 427M system does not represent the improvement deemed necessary in NORAD warning and assessment capabilities. The magnitude of the problems related to the WWMCCS standard equipment could seriously inhibit NORAD's effective operation; therefore, we recommend that either the Secretary of Defense or his designee, the Secretary of the Air Force, take immediate action to:

--Consolidate remaining CSS contractual efforts under ADCOM.

--Replace CSS with available state-of-the-art computer message switching equipment.

--Accept and use, on an interim basis, the Space Computational Center and NORAD Computer System hardware and software augmented by the Mission Essential Back Up computer.

--Start a redesign effort to replace the SCC and NORAD Computer System WWMCCS hardware and software with available state-of-the-art systems. This would require developing functional specifications and obtaining equipment best suited to achieve critical requirements.

--Initiate acquisition of an Uninterruptable Power Supply in NCOC to protect the critical information processing equipment.

--Establish a steering committee to assess problems with current and future system developments and monitor corrective actions taken. This committee should be accountable for the proper execution of the redesign effort mentioned above.

--Direct the Chairman of JCS to exempt NORAD from using future WWMCCS computers. However, NORAD

should implement a computer system that can compatibly interface with other command and control systems--JCS or its designee should develop standard specifications for exchanging information between various command and control systems.

CHAPTER 6

SCOPE OF REVIEW

Our review of the NORAD/ADCOM 427M improvement program was self initiated as part of our continuing effort to provide the Congress adequate visibility of programs to improve the Department of Defense capabilities to meet military communications and information processing needs.

We made our review primarily at the headquarters, North American Air Defense Command and the Aerospace Defense Command at Colorado Springs, Colorado.

The basic objective was to identify mission essential information requirements at the NORAD Combat Operations Center and the equipment capabilities necessary to process them.

In meeting this objective, we reviewed and evaluated policies, objectives, plans, principles, and procedures governing the existing system and the 427M improvement program.

We interviewed various officials, staff members, and contractor representatives who were responsible for designing, developing, and implementing the 427M system. We also reviewed pertinent planning documents, memorandums, internal reports, and cost data related to the improvement program.

We did not solicit written comments from the Secretary of Defense. However, the matters discussed in this report have been presented to various Defense Department personnel, including representatives of the Assistant Secretary, Command, Control, Communications and Intelligence; the Joint Chiefs of Staff; the North American Air Defense Command; and the Aerospace Defense Command. Their comments have been considered in the report.

Aerospace Defense Command officials, after reviewing this report, stated that it contained no classified material.

APPENDIX I

HEADQUARTERS
NORTH AMERICAN AIR DEFENSE COMMAND
ENT AIR FORCE BASE, COLORADO 80912

12 August 1970

General John D. Ryan
Chief of Staff
United States Air Force
Washington, DC 20330

Dear Chief,

Reference Maj Gen Cody's letter, Subject: WWMCCS Scientific Benchmark Adequacy, 7 August 1970 (Attachment 1).

In his letter, General Cody expresses concern that the electronic data processing equipment (EDPE) to be identified in the WWMCCS update program will not satisfy the anticipated processing requirements of the 427M Program for updating the NCMC. I, too, am concerned that the specifications for equipments to satisfy my operational requirements do not adequately represent those requirements.

My technical staff has repeatedly expressed their dissatisfaction with the WWMCCS update program, especially regarding the inadequacies of the benchmarks. Their 8 July 1968 analysis of the force control workload resulted in an upgrade of the force control benchmark. Further analyses were not conducted until recent decisions made it apparent that the WWMCCS update program was not merely selecting a vendor but rather a computer main frame for each user included in the procurement. Upon learning of this change in philosophy, an analysis was done (see Attachment 1, Appendix 2) on the scientific benchmark and the results were presented to ESD. The benchmark was found to be grossly inadequate as a representation of the Space Computational Center (SCC) workload.

In addition to the SCC benchmark problem, the current WWMCCS implementation philosophy presents several other problem areas of concern to me, relative to the efficient implementation of the 427M Program. Of vital concern is the inability of a computer configuration under WWMCCS to meet my availabilitv requirement. Also, the phasing of computers into the Cheyenne Mountain Complex is made increasingly difficult and costly if computers of different characteristics are provided for the SCC and the NCS. The providing of different computers also complicates the production and testing of software for the NORAD Computer System (NCS), as well as the SCC. These areas are discussed in more detail in Attachment 2.

APPENDIX I

As outlined above, the present WWMCCS RFP will not provide a computer system capable of performing the CINCNORAD mission. I concur with General Cody's recommendations and strongly urge their implementation. I further recommend that every attempt be made to procure identical CPU's for the SCC and the NCS to alleviate the computer programming problem and that sufficient redundancy be provided to meet my availability requirements. I recognize, along with General Cody and General McGehee, that this could substantially delay the WWMCCS procurement. It is my understanding that it is planned to release the RFP to industry during the week 17 through 21 August 1970. However, I feel the WWMCCS RFP should not be released to industry until it meets my operational requirements. In view of the urgency of the situation, your personal assistance in having the WWMCCS RFP amended and the scientific benchmarks upgraded is urgently requested.

Sincerely,

SETH J. McKEE
General, USAF
Commander-in-Chief

2 Atch
1. LTr, ESD, 7Aug70, Subj: WWMCCS Scientific Benchmark Adequacy w/2 Atch (Atch 1 Secret)
2. Additional WWMCCS Problems

NOT ATCH

[illegible] contents are withheld, the classification of correspondence will be downgraded, in accordance with [illegible] not declassified, in accordance with [illegible] 18, AFR 205-1.

APPENDIX II

DEPARTMENT OF THE AIR FORCE
OFFICE OF THE CHIEF OF STAFF
UNITED STATES AIR FORCE
WASHINGTON, D.C. 20330

31 AUG 1970

General Seth J. McKee
Commander in Chief
North American Air Defense Command
Ent AFB, Colorado 80912

Dear Seth

I appreciate the concern voiced by you in your letter of 12 August 1970 and that of Tom McGehee in his 131539Z Aug 70 message over the computer configuration you are presently scheduled to receive under the WWMCCS buy. The DEPSECDEF decision on 4 June 1970, which reduced the scope of WWMCCS, and the GSA insistence on a firm fixed price bid created the problem areas you identified. Let me assure you there is no intention to acquire equipments that will not meet requirements. Therefore, some satisfactory resolution for the shortcomings must be found. The fix, however, should stay within the WWMCCS framework. In this regard, it must insure minimum impact on other users and funding as well as be approved through JCS channels.

The DEPSECDEF has already put a hold on the release of the RFP due to possible impact of the Fitzhugh "Blue Ribbon Panel Report." His action will give at least a few days to explore possible alternatives.

One possible alternative is to change the scientific computer to a force control machine. This change would solve the commonality problem and may also adequately resolve the sizing and availability problems due to the multi-processor configuration of the force control machine. In addition, we would also propose to put another force control machine in the optional category of the WWMCCS buy to be procured later if experience and analyses substantiate the requirement. This course of action has been discussed informally with the JCS WWMCCS Program Manager who stated that he foresees no reason why this proposal would not be acceptable to the JCS.

Request your staff representatives work with the 427M SPO (ESD) and evaluate the technical feasibility of this alternative.

Sincerely

Cy to: AFSC
ADC

(941153)