United States Government Accountability Office

GAO

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

October 2009

DEFENSE ACQUISITIONS

Challenges in Aligning Space System Components

GAO Accountability * Integrity * Reliability

GAO-10-55

Report Documentation Page

Report Documentation Page						*Form Approved* *OMB No. 0704-0188*
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.						
1. REPORT DATE **OCT 2009**		2. REPORT TYPE			3. DATES COVERED **00-00-2009 to 00-00-2009**	
4. TITLE AND SUBTITLE **Defense Acquisitions. Challenges in Aligning Space System Components**					5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)					5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Government Accountability Office,441 G Street NW,Washington,DC,20548**					8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)					10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT						
15. SUBJECT TERMS						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**43**		

October 2009

DEFENSE ACQUISITIONS

Challenges in Aligning Space System Components

GAO Accountability•Integrity•Reliability

Highlights

Highlights of GAO-10-55, a report to the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives

Why GAO Did This Study

The Department of Defense (DOD) expects to spend more than $50 billion to develop and procure eight major space systems. Typically, the systems have two main components: satellites and ground control systems. Some also have a third component—user terminals—that can allow access from remote locations. If the delivery of these three components is not synchronized, there can be delays in providing full capabilities to the warfighter, and satellites on orbit can remain underutilized for years. Given preliminary indication of uncoordinated deployment, GAO was asked to examine (1) the extent to which satellite, ground control, and user terminal deployments are aligned; (2) the reasons deployments have not always been well coordinated; (3) actions being taken to enhance coordination; and (4) whether enhancements to ground systems could optimize the government's investment. To accomplish this, GAO analyzed plans for all major DOD satellite acquisitions and interviewed key officials.

What GAO Recommends

GAO recommends that the Secretary of Defense take a variety of actions to help ensure that DOD space systems provide more capability to the warfighter through better alignment and increased commonality, and to provide increased insight into ground asset costs. DOD generally agreed with these recommendations. Previous GAO recommendations have focused on improving acquisition problems.

View GAO-10-55 or key components.
For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

What GAO Found

Satellites, ground control systems, and user terminals in most of DOD's major space system acquisitions are not optimally aligned, leading to underutilized satellites and limited capability provided to the warfighter. Of the eight major space system acquisitions we studied, three systems anticipated that their satellites will be launched well before their associated ground control systems are fully capable of operating on-orbit capabilities. Furthermore, for five of the eight major space systems GAO reviewed, user terminals were to become operational after their associated satellites reach initial capability—in some cases, years after. When the deployments of satellites, ground control systems, and user terminals are not well synchronized, problems arise that can affect both the warfighter and the space systems themselves. When capabilities are delayed because of lack of alignment between satellite and ground control systems or user terminals, the warfighter may develop short-term solutions, often at diminished capability and added cost. In addition, according to DOD testing officials, when the deployment of space system components is not properly timed, components may be ready for system testing at different times. This means that the space system may not be tested as a whole, connected system.

DOD has inherent challenges in aligning its satellite and ground control systems. However, long-standing acquisition problems, a tendency to shift funds from ground control system development to satellite development when satellite development problems arise and the underestimation of software complexity on several major space systems have exacerbated the problem. The primary cause for user terminals not being well synchronized with their associated space systems is that user terminal development programs are typically managed by different military acquisition organizations than those managing the satellites and ground control systems.

DOD does have several efforts in place to help achieve better synchronization. The Air Force has also made some attempts to improve acquisition management and increase oversight of contractors by separating the acquisition of satellites and their ground control systems. However, the outcomes of these efforts are still pending. Moreover, there is a lack of guidance needed to help plan for and coordinate the development of satellite and ground systems and a lack of transparency into costs for ground control systems and user terminals.

DOD representatives in the satellite acquisition community agree that opportunities exist for DOD to transition to a more common type of architecture for satellite ground control systems in order to achieve additional efficiencies, capabilities, and a higher degree of information sharing among space systems, ultimately resulting in increased capability to the warfighter. All of the officials GAO spoke with agreed that ground control systems can be developed to provide data and information to other systems, and expect the same in return, to potentially enhance the flow and timeliness of information and better exploit satellite capabilities.

Contents

Figure

Abbreviations

AEHF	Advanced Extremely High Frequency Satellite
AEP	Architecture Evolution Plan
CENTCOM	Central Command
CNPS	Consolidated Network Planning Software
DOD	Department of Defense
DOT&E	Director of Operational Test and Evaluation
FAB-T	Family of Advanced Beyond Line-of-Sight Terminals
GEO	geosynchronous earth orbit satellite
GPS	Global Positioning System
JROC	Joint Requirements Oversight Council
JTEO	Joint Terminal Engineering Office
JTRS	Joint Tactical Radio System
M-code	modernized military signal
MDA	Missile Defense Agency
MILSATCOM	Military Satellite Communications
MUOS	Mobile User Objective System
NASA	National Aeronautics and Space Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NRO	National Reconnaissance Office
NSA	National Security Agency
OSD	Office of Secretary of Defense
SAR	Selected Acquisition Reports
SBIRS	Space Based Infrared System High
SBSS	Space-Based Space Surveillance
SMC	United States Air Force Space and Missile Systems Center
SOCOM	Special Operations Command
STRATCOM	United States Strategic Command
STSS	Space Tracking and Surveillance System

TT&C	Tracking, telemetry, and commanding
WGS	Wideband Global SATCOM
WIN-T	Warfighter Information Network – Tactical

GAO

Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

October 29, 2009

The Honorable John P. Murtha
Chairman
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

The Department of Defense (DOD) expects to spend over $50 billion to develop and procure eight major space systems. These systems are intended to provide military communications, global positioning and navigation information, weather monitoring data, and missile warning information. Typically, space system acquisitions consist of two main components: satellites and ground control systems. Satellites use sensors to collect data or provide communications capabilities, while ground control systems receive and often process and transmit data from the satellites. Space systems often include a third component, user terminals, which allow the combatant commands,[1] also known as the warfighters, to use the space systems' capabilities in the field. While the costs associated with the ground control systems and user terminals can be much less than the costs of the satellites, space systems often require all three components—satellites, ground control systems, and user terminals—to work together to be fully utilized.

The majority of major space acquisition programs in DOD's space portfolio, however, have experienced problems during the past two decades that have delayed deployment and driven up cost. Many programs are experiencing significant schedule delays—as much as 7 years—resulting in potential capability gaps in areas such as positioning, navigation, and timing; missile warning; communications; and weather monitoring. We recently estimated that costs for major space acquisition programs have increased by about $11.0 billion from initial estimates of $11.4 billion for fiscal years 2008 through 2013. This investment risk is compounded because the development of satellite ground systems and

[1] There are 10 unified combatant commands. Six combatant commands have geographic responsibilities to plan and execute military operations in their respective regions. Four combatant commands have functional responsibilities, for example, providing transportation services.

user terminals sometimes lags considerably behind the development of satellites, even when the satellite development has faced considerable delay. This means that mission-capable satellites may be in orbit for months or years, but warfighters and others would be unable to use the full complement of the satellites' capabilities. The extent to which this problem is likely to occur is not well known. Satellite development problems typically represent a greater risk to the program and may therefore receive more attention. Ground system development problems may not be as visible as those facing satellite developments partially because the oversight and management of these development efforts is often intertwined. Moreover, while many DOD, congressional, and GAO studies have focused on the causes of satellite development delays and cost increases, few have focused on the delivery of ground control systems and user terminals, which are just as critical to optimizing the investment in space.

For these reasons, you asked us to determine (1) the extent to which the deployment of satellite, ground control systems, and user terminals is aligned, or "synchronized," so that the delivery of these assets optimizes investments in space; (2) the reasons satellites, ground control systems, and user terminals are not always aligned; (3) actions being taken to enhance coordination in the development of these assets; and (4) whether opportunities exist to enhance ground systems to better optimize the government's investment in space, given recent trends in information technology and networking.

To assess the coordination of satellite and ground system deployment, we analyzed current and future testing and fielding plans for corresponding satellite and ground assets (control systems and user terminals) of all major DOD space system acquisitions: the Advanced Extremely High Frequency Satellite (AEHF), NAVSTAR Global Positioning System (GPS), Mobile User Objective System (MUOS), National Polar-orbiting Operational Environmental Satellite System (NPOESS), Space Based Infrared System (SBIRS), Space-Based Space Surveillance (SBSS), Space Tracking and Surveillance System (STSS), and Wideband Global SATCOM[2] (WGS). In making determinations about whether space system acquisition programs had synchronization issues, we compared the fielding dates of satellites, ground systems, and user terminals to determine whether there were gaps in the delivery of capabilities associated with these three

[2] SATCOM stands for satellite communications.

components. We assessed user terminals to be not synchronized if a small percentage of terminals were scheduled to be delivered at the time of satellite and ground system delivery. Programs without gaps between fielding dates of satellites and ground system capabilities, and that had higher percentages of user terminals scheduled to be fielded, were determined to be synchronized. We also examined four of these programs in greater detail to better understand the causes of less-than-optimal synchronization. Further, we discussed ground control system and user terminal development with combatant commanders (warfighters) to help determine the effect(s) that synchronization issues have on the users of the space system capabilities. We also interviewed various space officials within DOD, including program management officials of the satellite programs we reviewed. To determine whether enhancements can be made to ground systems to increase utility of satellite capabilities, we interviewed high-level DOD representatives of various offices in the satellite acquisition community, officials in the intelligence community, and staff at ground control system facilities.

We conducted this performance audit from November 2008 to September 2009 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. For more information on our scope and methodology, see appendix I.

Background

DOD's major space system acquisition programs are intended to perform a wide variety of functions, including communications, missile warning, navigation, tracking space objects, and even providing weather information. Communication satellites provide DOD the ability to communicate along narrowband, wideband, and secure and protected bandwidths. Narrowband communications use lower (slower) rates to process data and give the warfighter the ability to communicate better while on the move, and also work better in disadvantaged environments, such as in forests, where conventional frequencies might be less effective. Wideband communications use higher data rates and work better for stationary locations in addition to allowing more warfighters to use this type of bandwidth. Secure and protected bandwidths allow warfighters to communicate when other satellites are disabled because of enemy jamming measures and allow a wider use of terminals deployed on backpacks, submarines, airborne assets, and other means. Missile detection satellites allow DOD to identify launches and initially track ballistic missiles and provide early warnings to warfighters. Positioning and navigation satellites give DOD the ability to pinpoint a location, enabling soldiers to call for precise air support and lowering the risk of accidents. Satellites that track space objects and debris help keep satellites safe in space. Finally, weather satellites allow the warfighter to directly receive weather and climate information for more effective military operations. The satellites DOD is developing have finite useful lives that range from about 5 to15 years. Some space systems under development, such as AEHF, are intended to replace older legacy systems with upgraded and more robust capabilities—such as increasing the volume of data transmitted per second. Table 1 shows the various missions of current and planned DOD satellite programs.

Table 1: Current and Planned DOD Space Systems by Mission and Associated Cost

Fiscal year 2009 dollars in millions

Mission	Total mission costs (RDT&E and procurement)	Space systems
Communications	$19,012.4	Advanced Extremely High Frequency Satellite Mobile User Objective System Wideband Global SATCOM
Missile warning and tracking	12,554.4	Space Based Infrared System Space Tracking and Surveillance System
Positioning, navigation, and timing	9,423.5	NAVSTAR Global Positioning System[a]
Space object tracking	514.1	Space-Based Space Surveillance
Terrestrial and near-space weather	11,068.9	National Polar-orbiting Operational Environmental Satellite System

Source: GAO presentation of DOD data.

Legend: RDT&E = research, development, test, and evaluation.

[a]Includes Block IIR/IIR-M, Block IIF, Operational Control Segment, and military user equipment

Most space systems consist of satellites, ground control systems, and user terminals, though some space systems only require ground control systems to provide capability to users. Ground control systems are generally used to (1) download and process data from satellite sensors and disseminate this information to warfighters and other users and (2) maintain the health and status of the satellites, including steering the satellites and ensuring that they stay in assigned orbits.

User terminals, typically procured by the military services and managed separately from associated satellites and ground control systems, can range from equipment hosted on backpacks to terminals mounted on Humvees, airborne assets, or ships. Terminals can be used to help the warfighter determine longitude, latitude, and altitude via GPS satellites, or securely communicate with others via AEHF satellites. Some user terminals are not solely dedicated to delivering capability from a specific satellite system. For example, the Joint Tactical Radio System (JTRS) is the primary user terminal associated with the MUOS program, but the system is also designed to be the next generation of tactical radios, allowing extensive ground-to-ground communication as well.

Most Major Space Systems Are Not Aligned with Delivery of Ground Assets, User Assets, or Both

For six of DOD's eight major space system acquisitions, DOD has not been able to align delivery of space assets with ground assets, user assets, or both. Of the eight major space system acquisitions, five ground control system efforts are optimally aligned to deliver capability with their companion satellites, while three are not optimally aligned. For the five space systems requiring user terminals, none were aligned. In some cases, capability gaps resulting from delays in the fielding of ground control systems or user terminals are 4 or more years. When space system acquisitions are not aligned, satellite capability is available but underutilized, though in some cases, work-around efforts can help compensate for the loss or delay of capability. Moreover, when ground systems, user terminals, or both are not aligned with satellites, there are significant limitations in the extent to which the system as a whole can be independently tested and verified. Table 2 provides a summary of alignment between space systems and corresponding ground control systems or user terminals.

Table 2: Alignment of Space System Acquisitions

Space system	Gap exists between delivery of satellites and full ground control capabilities, user terminal capabilities, or both	Gap between delivery of satellites and full ground control system capabilities	Gap between delivery of satellites and fully fielded user terminals
AEHF	Yes	No[a]	Yes
GPS	Yes	Yes	Yes
MUOS	Yes	No	Yes
NPOESS	Yes	No	Yes
SBIRS	Yes	Yes	N/A[b]
SBSS	No	No	N/A[b]
STSS	No	No	N/A[b]
WGS	Yes	Yes	Yes

Source: GAO analysis based on DOD data.

[a]According to program officials, recent unplanned delays in the launch dates of AEHF satellites have allowed the program to become better synchronized with ground control system capabilities.

[b]This indicates that the space system does not include user terminals; capability is exacted through the ground system.

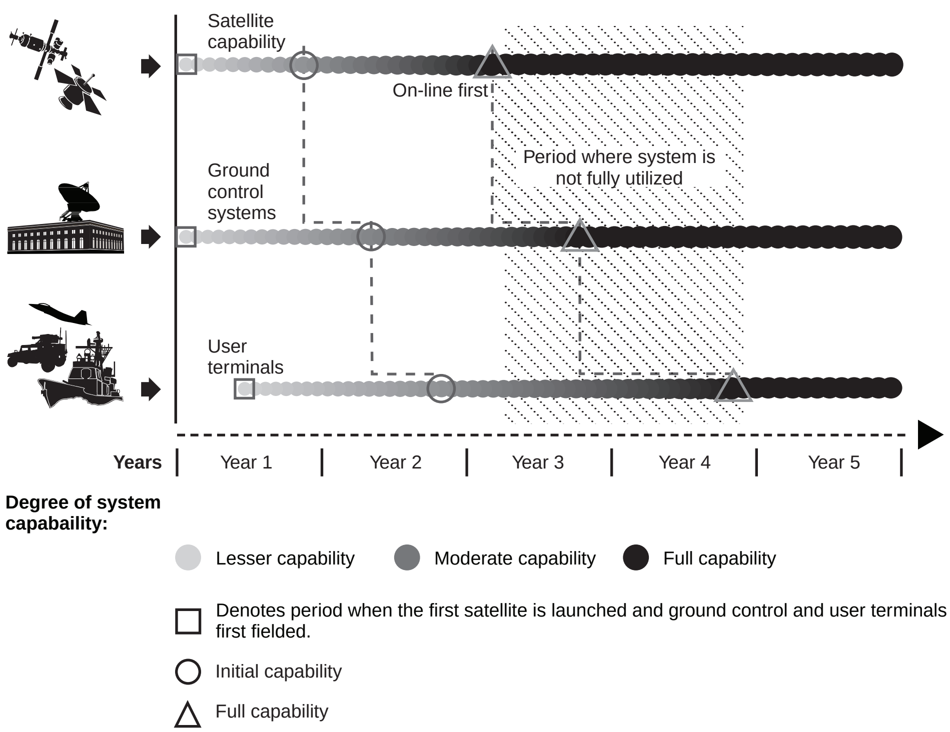
In making determinations about whether space system acquisitions were aligned, we examined whether there were gaps between fielding dates of satellite capabilities compared to ground control system capabilities and whether lower percentages of user terminal types were planned to be fielded by the space system acquisitions' planned initial capability. We generally only considered aspects of a space acquisition unaligned if there was a gap of years, rather than months, between the fielding dates of significant capabilities. Regarding user terminals, we only considered these unaligned compared to satellite capabilities when user terminals did not meet DOD's measure of synchronization for military satellite communications space acquisitions. This measure, established by U.S. Strategic Command (STRATCOM), a primary user of DOD space systems, asserts that 20 percent of any type of user terminal should be fielded by a space system acquisition's initial capability date and 85 percent should be fielded by its full capability date.[3]

Notwithstanding the fact that alignment gaps are undesirable, several factors provide insight into the inherent challenges associated with managing alignment. First, alignment may be relatively easier to achieve in some programs than in others. For example, some space systems may require only a ground system or few user terminals and may even manage these acquisitions within one organization. By contrast, other programs may require literally tens of thousands of terminals that must be installed on a wide span of weapon systems, including ships, planes, vehicles, and even other space systems—which are owned and controlled by various military services. Second, an inherent difficulty in aligning satellite launches with ground and user terminal programs is the lead time needed to schedule satellite launches—about 2 years—which makes it difficult to hold back satellite deployment if a ground or user terminal is experiencing a considerable delay. Nevertheless, there is a consensus that investments in space are not optimized when satellites are in orbit and user terminals or ground systems are many months or years away from being delivered.

[3] It should be noted that while there are criteria for communications satellites, there are no criteria available in DOD that determine the optimum alignment or synchronization for the broader portfolio of satellite programs. This is principally because of inherent differences in satellite missions and their associated ground and user assets, according to officials involved in space system development as well as acquisition oversight.

Third, it is difficult to measure the extent to which warfighters and other users are being affected by delayed capability or even the extent to which capability is delayed. As figure 1 depicts, satellites themselves only offer initial capabilities until enough satellites have been launched to provide the coverage needed to achieve full capability. This process alone can take years and will vary system to system as the number of satellites required to achieve full operational capability depends on mission requirements and coverage offered by satellites, among other factors. At the same time, ground control systems can be delivered in phases, the first of which may focus solely on controlling and maintaining the health of the satellite, with subsequent phases delivering software that can collect and process sensor data. User terminals can take years to install as they can span a broad spectrum of weapon systems and their installation is usually done along side other upgrades.

Figure 1: Notional Representation of Space System Components (Satellites, Ground Control Systems, and User Terminals) That Are Not Well Synchronized



Source: GAO analysis and Art Explosion (clip art).

Alignment of Ground Control Systems and Satellites

Ground systems deployment for three of DOD's major space system acquisitions is lagging behind delivery of satellites. This means that satellites either already are in space or will be in space, but are or will be unable to deliver all of their planned capabilities. In one case, the development of the ground system was completed in time, but the system has not worked properly. In contrast, five major space system acquisitions have largely aligned their satellites and associated ground control systems acquisitions so that capabilities on satellites are fielded at approximately the same time as on the ground. In some of these instances, schedule slips in satellite development allowed more time for ground control system development. Had the satellites been delivered on their original schedules, the ground control systems might not have aligned with satellite delivery. The three instances where we identified gaps are described below.

- GPS achieved full operational capability in 1995 and currently is a constellation of 31 active satellites of various generations used extensively by the military for multiple applications worldwide. The current GPS ground control system consists of the Operational Control Segment and an upgrade under way called the Architecture Evolution Plan. However, the plan and the capabilities it is being designed to provide have been delayed and are significantly over budget. As a result, some new capabilities are not now available to the warfighter because the ground control system features needed to command and operate the capabilities have not been completely delivered. For example, updated user equipment possessing a capability to prevent spoofing[4] of navigation information started being delivered to the warfighter in 2004. However, the Architecture Evolution Plan, representing the current ground control system, is not capable of providing two important aspects of this capability and is not expected to do so until early fiscal year 2010.

- The first SBIRS satellite[5] will carry scanning and staring sensors designed to provide early missile warning capabilities. However, DOD will not be able to fully utilize the data collected from the staring sensor when this first satellite launches, currently planned for September 2010, because the ground control software that is to process the sensor's data is not planned to be fully functional until at least 2014. This means that complete, usable

---

[4] Spoofing is a process where an entity gains unauthorized access to a system to disrupt the normal flow of information.

[5] That is, the first geosynchronous earth orbiting satellite to be delivered by the SBIRS program, rather than a previously deployed missile warning sensor that is now in orbit on two highly elliptical orbiting satellites.

data from the staring sensor will not be available until about 4 years after the satellite is on orbit.

- The first WGS satellite launched in October 2007, but its associated ground mission planning software—the Consolidated Network Planning Software—does not work properly. This planning software was designed to compute required bandwidth for all users simultaneously accessing WGS satellites. It would then disseminate that information to various satellite operation and support stations located globally so that all stations had a real-time view of the availability of WGS satellite capabilities. However, because the development of the mission planning software has had problems and is not well coordinated with WGS satellite capability, the dissemination of information does not occur as designed, and the information has to go through a time-consuming and labor-intensive work-around through a single ground station before it reaches the warfighter.

Alignment of User Terminals

Five of the eight major space systems we reviewed had user terminals scheduled to be delivered and become operational after, and in some cases long after, their associated space systems achieved initial capability. The other three space systems did not require user terminals. It should be noted that in some cases—for example, AEHF, GPS, and NPOESS—there is more than one type of terminal that will serve a similar purpose. However, when we examined these programs we also identified gaps across the programs. For AEHF specifically, the most prominent gap existed in the terminal that will have the widest use—Family of Advanced Beyond Line-of-Sight Terminals (FAB-T). Three instances where we identified gaps are described below. Appendix III contains more details.

- *FAB-T*. The Air Force's FAB-T program is designed to provide antijam and protected communications for nuclear and conventional forces as well as many airborne assets and ground command posts. As one of the primary user terminal programs associated with AEHF, FAB-T has recently experienced numerous problems and is not currently aligned with the AEHF satellite program. Specifically, contractor performance problems, which caused design teams to be restructured to improve performance and efficiency, caused a delay in the start of initial production from fiscal year 2007 to fiscal year 2010. In addition, design changes and contract cost growth have more than tripled development costs since the contract was first awarded. While AEHF will be able to provide capability through other user terminals, current estimates show that FAB-T will only have 2 percent of its terminals fielded when AEHF is scheduled to reach its initial operating capability in 2011. Further, estimates are that FAB-T will not have all of its terminals fielded until fiscal year 2019.

- *JTRS*. JTRS is a family of interoperable, digital, modular, and software-defined radios that is planned to provide the capability to receive, transmit, and relay voice, data, and video. In the past, tactical military radios could not work well with each other. The JTRS radio is also being designed as the primary user terminal for the new MUOS satellite capability to help the warfighter achieve information superiority. Although MUOS will be able to provide capability through other, legacy user terminals, DOD estimates that less than 20 percent of JTRS terminals will be available to access the MUOS satellite when it achieves operational on-orbit capability in December 2011. In 2014, when MUOS is expected to reach full operational capability, 32 percent of JTRS terminals are expected to be available to the warfighter. DOD expects to field all the needed JTRS terminals by 2021—about 7 years after MUOS is expected to be fully operational. In the past, we have expressed concerns about the JTRS program because of problems with requirements, technology development, and program management.[6] A recent DOD independent program assessment concluded that the interface between MUOS and the JTRS radios and satellite contained unwarranted risk.[7]

- *Military GPS user equipment*. DOD also plans to field extensive—both in quantity and type—GPS user equipment and terminals to assist with positioning and navigation on a variety of air, ground, and sea platforms to utilize a modernized military signal (M-code), designed to be secure and jam resistant. This signal is planned to reach its initial operating capability on the GPS satellites and ground control system by 2014. While user terminals will start to receive and process the signal in 2014 as they are being fielded leading up to 2025, the user equipment and terminals are not expected to be fully fielded and operational until 2025. As a result, the military services' ability to achieve a joint navigation capability, an essential element of conducting future military operations, may not be fully realized until 2025. In a 2007 memo from United States Strategic Command (STRATCOM)[8] to the Vice Chairman of the Joint Chiefs of Staff, the combatant command expressed concern that new GPS capabilities will

[6] GAO, *Defense Acquisitions: Department of Defense Needs Framework for Balancing Investments in Tactical Radios*, GAO-08-877 (Washington, D.C.: Aug. 15, 2008).

[7] Mobile User Objective System Independent Program Assessment Build Approval, February 2008.

[8] STRATCOM is a combatant command with the functional responsibility for space and information operations; missile defense; global command and control, intelligence, surveillance, and reconnaissance; strategic deterrence; and integration and synchronization of DOD's departmentwide efforts in combating weapons of mass destruction.

not be realized in a timely manner because of the lack of alignment between the major GPS components.

Implications on Warfighters and the Testing Community

When space capabilities are not delivered in a coordinated manner or are partially delivered, the warfighter will either not have certain capabilities available when expected or may have to develop short-term solutions while waiting for the expected capability. Officials from one warfighting command (users of the capability) told us that because of the 2-year gap between when all MUOS satellites reach on-orbit capability and when the MUOS-capable user terminals (JTRS) first become available, the MUOS satellites will have spent a portion of their expected lifespan less than fully utilized. This issue concerns the combatant command because MUOS is replacing the aging Ultra High Frequency Follow-On space system, which currently serves more military customers than it was originally designed to handle. While waiting for the JTRS capability, the command will likely have to lease commercial satellite capability and user terminals to increase bandwidth capacity and improve the speed and effectiveness of information and communication transfers.

The testing community is also significantly affected when satellite delivery is not aligned with ground control systems and user terminals, according to officials from the Office of the Director of Operational Test and Evaluation (DOT&E).[9] If all three space system components—satellites, ground control systems, and user terminals—are not working together, they essentially do not represent actual system capability, thus requiring nonrepresentative equipment to be used in testing and possibly yielding results that are not characteristic of the actual system. Overall, DOT&E officials identified alignment issues as the most significant obstacle to their obtaining credible and useful test results. However, these officials also noted that there have been recent efforts by some space system programs to better synchronize satellite capabilities with their ground systems. For example, MUOS will have production-representative satellite and ground control systems available for testing, which will facilitate optimal operational testing.

[9] DOT&E is DOD's primary office responsible for the testing of weapons, equipment, or munitions under operational, or realistic, conditions for the purpose of determining their effectiveness and suitability for use.

DOT&E officials identified GPS as a specific example of where delays in delivery of ground assets have hampered testing. The GPS program office has not yet fully developed the ground control software designed to prevent spoofing of navigation information. The unavailability of this software has delayed both the testing and the use of the antispoofing capability by the warfighter. Had the needed ground system component been fielded as scheduled, this capability could have been tested shortly after user equipment started being delivered to the warfighter in 2004. As it stands now, by the time testing of these functionalities is conducted, the entire constellation of satellites will have been launched. DOT&E officials told us that recently the GPS program has undertaken efforts to align schedules to achieve a higher degree of overall synchronization, which should facilitate more effective testing.

Another example involved JTRS user terminals, which are 2 years behind MUOS. While the MUOS satellite and ground control systems are ready for testing with production-representative equipment, representative user terminals are not. Because operational testing relies on production-representative components, DOT&E officials will not be able to test the overall system. For more examples of how less-than-optimal synchronization issues can affect testing, see appendix II.

Acquisition and Other Problems Contribute to a Lack of Space System Component Alignment

Though there are inherent difficulties in aligning delivery of satellites, ground control systems, and user terminals, the lack of synchronization between segments of space acquisition programs is largely the result of the same core issues that hamper acquisition in general—requirements instability, funding instability, insufficient technology maturity, underestimation of complexity, and poor contractor oversight, among other issues. Previous GAO reports on DOD acquisitions have consistently linked such problems to significant cost increases and schedule delays. In addition, user terminals are not optimally aligned because of a lack of coordination and effective oversight over the many military organizations that either develop user terminals or have some hand in development.

Acquisition Problems

The satellite, ground system, and user terminal programs we studied have had execution problems that have caused substantial delays in schedule that in turn have made it more difficult to align delivery of all three space system components. Most prominent are requirements changes, technical problems resulting from underestimation of complexity, and poor contractor oversight. The first satellite delivery of SBIRS, for instance, has been delayed at least 7 years in part because of poor oversight, technical complexities, and rework. The first satellite delivery for NPOESS is over 4 years late. AEHF has experienced delays of about 3 years for these reasons along with requirements changes that occurred earlier in the program and difficulties meeting information assurance requirements for its satellite. The GPS IIF system has also had about a 3-year delay because of technical and workmanship problems and requirements changes. Ground systems and user terminals have experienced similar problems. JTRS, for example, has experienced significant delays because of problems in maturing critical technologies, and as noted earlier, FAB-T delays have occurred because of contractor performance problems. Also, as noted earlier, the WGS ground system has experienced technical problems that have prevented it from working properly with WGS satellites now in orbit.

We have previously reported that space acquisition problems are leading to potential gaps in the delivery of critical capabilities, and that with too many programs in its portfolio, DOD is forced to continually shift funds to and from programs. Additionally, DOD has preferred to make fewer but more complex satellites, which has stretched technology challenges beyond current capabilities in some cases, and vastly increased the complexities related to software. Also, there is no way to accurately estimate how long the design, development, and construction of a satellite system will take when critical technologies planned for that system are still in relatively early stages of discovery and invention. These factors and more can contribute to the inherent challenges in aligning delivery of space system components.

Underestimating software complexity has also been a problem. The complexity of software on any system, including space systems, is often denoted by the amount of software, or number of lines of software code. Generally, the greater the number of lines of code, the more complicated the software system development, and ground control systems typically require significantly more software than the satellites. This means that software development for ground control systems is oftentimes the higher risk. In some cases, unanticipated software complexity can lead to lack of synchronization between the satellite and ground systems of space system acquisitions. For example, on the AEHF space system, the prime contractor has experienced quality control problems with the software for the mission planning element of the ground control system. In testing so far, the government has identified numerous significant software deficiencies and continues to find deficiencies as testing continues. Ground control system fielding will be delayed until the deficiencies are corrected. Also, our past work has shown that the MUOS ground control software represented one of the greatest risks to the program because of the size and complexity of the design. On SBIRS, the total estimated lines of code on the ground control system software grew from approximately 1.55 million in August 2004 to approximately 1.88 million in December 2008.

In at least one case, delays being experienced as a result of program execution development difficulties in satellite programs may actually offer a ground control or user terminal program some schedule relief. For example, when the AEHF space system was forced to delay the launch of its first two satellites because of issues that arose during vacuum testing, the unplanned delay allowed time for ground control system and user terminal capabilities to catch up to the revised satellite launch dates so that they are now planned to be fielded closer together. At the same time, however, these difficulties may ultimately require changes in requirements or designs that can create disruptive changes to ground control and user terminal programs.

We have made numerous recommendations over the past decade aimed at reducing execution problems experienced in weapon system and space system programs, many of which inherently make it more difficult to align delivery of space system components and achieve better synchronization. Generally, we have recommended that DOD separate technology discovery from acquisition, follow an incremental path toward meeting user needs, match resources and requirements at program start, and use quantifiable data and demonstrable knowledge to make decisions to move to next phases. We have also identified practices related to cost estimating, program manager tenure, quality assurance, technology transition, and an array of other aspects of acquisition program management that space systems could benefit from.

Funding Shifts

Space system acquisition programs sometimes shift funds from the development of ground control systems to their associated satellite development efforts to meet unexpected obstacles—an action that can create new problems. For example, when the GPS IIF satellite program encountered development problems, the program shifted funds set aside for the GPS ground control system to address the satellite problems, causing a delay in the delivery of some ground control capabilities. Similarly, SBIRS officials reallocated funding from the ground control system to address satellite software issues, which may have contributed to the system's initial inability to utilize the staring sensor data from the first geosynchronous earth orbit satellite. Program officials told us that they like the flexibility of being able to move funds from ground control systems to the satellites if priorities warrant. However, as we indicated above, this can put the development of ground control systems at a disadvantage compared to development of the satellites for space systems, for example, GPS and SBIRS.

Lack of Coordinated Planning among Organizations Involved in Development

DOD program office officials told us the primary reason that user terminals are not optimally synchronized is a lack of coordination and effective oversight over the many military organizations that either develop user terminals or have some hand in the development. For some systems, user terminal development could involve several different organizations and a complex sequencing of events. For example, in the case of GPS, the Air Force must first develop prototype electronic modules and production-ready receiver hardware for selected platforms within the space, air, ground, and maritime environments—a process that can take several years. After this is done, each of the military services will still need to procure the new user equipment and install it on a range of other platforms. Given the breadth of equipment that the terminals must be installed on and the need to coordinate installations with existing maintenance schedules, the process of realizing capability could take 10 or more years. Thus, user terminal programs need to have timely funding and be well-coordinated.

In the case of GPS, this advance planning did not take place, and it is likely that the installation of user equipment that can take advantage of the satellites' modernized military signal (M-code), designed to be secure and jam resistant, will not be completed until 2025. We reported[10] earlier this year that there was a lack of coordination with GPS and that no single authority was responsible for synchronizing GPS satellites and ground

[10] GAO, *Global Positioning System: Significant Challenges in Sustaining and Upgrading Widely Used Capabilities*, GAO-09-325 (Washington, D.C.: Apr. 30, 2009).

systems and user terminals. Both the Defense Science Board[11] and the U.S. Space Commission identified the same problem in earlier reports. A January 2001 study by DOD's U.S. Space Commission[12] noted that when satellites and ground control systems are funded in one budget and user terminals in another, the result can be a lack of synchronization in the acquisition of satellites and their associated user terminals because of this decentralized arrangement.

In another example, the responsibility for developing and acquiring the MUOS satellite and associated ground control systems falls under the Space and Naval Warfare Systems Command, but responsibility for developing and acquiring JTRS user equipment and terminals associated with MUOS falls under a joint program office with multiple services involved. Under this structure, there is no single office or group responsible for the coordination of these two interdependent program offices to help achieve better synchronization. However, MUOS program officials told us that in 2004 they began to recognize that their program's success was tied to the JTRS program and there was a need to coordinate and address synchronization and other issues. As a result, a formal group was established to address systems engineering coordination issues under both programs. While this group does not constitute a single authority responsible for synchronizing MUOS and JTRS, program officials stated that it has helped resolve coordination issues.

Officials from a third program, AEHF, agreed that space system synchronization challenges often result from the way the military services are organized to manage the various space system components. Officials told us that satellites and associated user terminals are often not well synchronized because they are frequently managed by different military services with different development contracts and funding accounts. They said that they would like for all of the terminals to be fielded at the same time, but because of the independent nature of these programs and their complexity, they are unable to synchronize them to a greater extent. These officials acknowledged that it would help if there was one person or organization that could oversee all the components of a satellite system, both within a service and among services, to help ensure that satellites and

[11] Defense Science Board Task Force, *The Future of the Global Positioning System*, (Washington, D.C., Oct. 28, 2005).

[12] Report of the Commission to Assess United States National Security Space Management and Organization, January 2001.

their user terminals are better synchronized. We recently reported[13] that DOD's acquisition process is not well designed to manage across programs in part because the military services have traditionally focused on developing and acquiring systems to meet their own specific missions and have placed relatively less emphasis on developing and acquiring the types of interoperable systems needed to meet the demands of joint operations.

Finally, another factor contributing to user terminal delays is the difficulties some programs have in anticipating security requirements and gaining approval from the National Security Agency (NSA), which is responsible for certifying a satellite system's information security. In the past, we have reported on delays in obtaining NSA's certification associated with the AEHF and MUOS space systems. In addition, the risk of this potential delay is not always fully known at program inception. For example, in the AEHF program, the changing nature of security requirements placed stress on an already tight schedule by adding a high level of complexity to the program's user terminal efforts. In the case of MUOS, which is associated with the JTRS user terminal, NSA determined that the user terminal's existing security architecture was not adequate, and as a result, NSA declined to certify the system until changes were made to its architecture.

[13] GAO, *Defense Acquisitions: DOD Management Approach and Processes Not Well-Suited to Support Development of Global Information Grid*, GAO-06-211 (Washington, D.C.: Jan. 30, 2006).

Efforts Are Being Made to Achieve Better Alignment of Satellite, Ground Control System, and User Terminal Deliveries, but They Are Limited by Lack of Guidance and Cost Data

There are efforts in place focused specifically at better aligning delivery of satellite, ground system, and user terminals as well as reducing the kinds of acquisition problems that contribute to delays that make alignment difficult. However, it remains to be seen how effective these will be. Moreover, improvements are likely to be hampered by a lack of guidance to help plan for and coordinate the development of satellite and ground systems and a lack of transparency into the costs of ground control systems and user terminals.

In 2005, DOD's Joint Terminal Engineering Office (JTEO) began monitoring the alignment of military satellite communication space systems, including satellites, ground control systems, and user terminals.[14] JTEO analyzes program plans, schedules, and budgets; identifies interdependent systems that are not aligned; and analyzes the impact of systems that are not aligned and shares the results of its analysis with a wide variety of organizations involved with military communications satellites. JTEO uses guidance established by STRATCOM to define basic and optimal synchronization to assess the level of synchronization of military satellite communications space systems. However, officials from both JTEO and STRATCOM acknowledged that these definitions are somewhat arbitrary and do not really measure what is most important—capability provided to the warfighter via a certain level of synchronization related to a space system's components. Further, JTEO only tracks synchronization of military satellite communications space systems, not the space systems involved with other space missions.

Also, the Under Secretary of Defense, Acquisition, Technology and Logistics, has recently been utilizing an advisory body called the Narrowband SATCOM Systems Engineering Group to focus specifically on the alignment of MUOS and JTRS given the extent of schedule gaps and the importance of JTRS to MUOS. The advisory body seeks to anticipate and identify the technical challenges between MUOS and JTRS and any other interdependent systems.

In addition, the Air Force is attempting to mitigate some of the contributing factors that create synchronization issues by separating the acquisition of satellites and their ground control systems, intending to ensure that ground systems receive increased oversight. Specifically, the

[14] JTEO is an Air Force office that provides a DOD-wide view of MILSATCOM synchronization.

GPS program recently split the acquisition and funding of the GPS IIIA satellites from its ground control system. While both acquisitions remain under the same GPS program management, GPS officials told us that they expect the funding separation to yield greater government oversight of the contractor and increased control over programmatic decisions. For example, if a satellite encounters a problem during development, a contractor may be tempted to make changes to the satellite's operating software. Such changes, which could add time and rework to the ground control system's software development effort, might not receive attention from the government. By acquiring the satellites and ground system separately, GPS program officials believe that acquisition changes will have to be approved through program management, and that more generally, the ground programs would receive more focused oversight than they receive now. Officials also indicated that when programs use the same contractor to develop both the satellite and ground control systems, the government can be beholden to the single contractor to deliver some capability, even if contractor performance falls below expectations.

Other actions have been taken to improve program execution within space and other weapon programs that have the potential to improve DOD's ability to align delivery of satellites with ground and user terminals. For example, the Air Force is planning to conduct a review in November 2009 with the Office of the Secretary of Defense to enable better management of GPS as an enterprise instead of as many individual programs. Further, within the space community, the Air Force has been emphasizing the use of an incremental development approach where it will gradually meet the needs of its users, and it is requiring space programs to make independent technology readiness assessments at particular points in the acquisition process. For some newer space programs, such as GPS III, the Air Force has taken actions to ensure that requirements remain stable and to hold contractors more accountable for their performance. The Office of Networks Information and Integration within the Office of the Secretary of Defense has also developed tools to enable better coordination among interdependent programs, such as the Net-Centric[15] Integrated Master Schedule, an online software program designed to provide insight to program schedules, key events, and most importantly cross-program dependencies, to more effectively synchronize aspects of the net-centric

[15] Net-centric refers to the capability to discover, access, trust and use information within a complex community of people, devices, information and services interconnected by a communications network to achieve optimal benefit of resources.

portfolio, including space system acquisitions. Moreover, recently passed acquisition reform legislation also sets requirements for space and other programs to increase emphasis on systems engineering and developmental testing, preliminary design reviews, and technology readiness assessments.[16] We recently testified that actions that the Air Force and the Office of the Secretary of Defense have been taking to address problems related to technology development are good steps. However, there are still more significant changes to processes, policies, and support needed to ensure that reforms can take hold, including addressing the diffused leadership for space programs, which hampers the ability of DOD to synchronize delivery of space, ground, and user assets for space programs.

Limited Insight into Costs of Ground Systems and User Terminals Can Hamper Oversight

DOD's efforts to improve coordination of satellite, ground control system, and user terminal efforts may be hampered by a lack of transparency in the costs associated with ground control systems and user terminals. To identify the costs associated with the poor synchronization of space system components, we attempted to determine development and procurement costs associated with ground control systems. However, several of DOD's space system acquisitions do not break out these costs through their standard reporting measures,[17] reporting instead combined satellite and ground system costs. We asked the program offices to provide separate costs for their ground control systems, and while most programs were able to provide some information, officials with two programs—AEHF and GPS—told us that they did not officially track cost information in this manner. The next-generation GPS ground control system is being acquired under a separate contract than the satellites which could allow the program to separate cost information. Without better cost information on ground control systems, congressional decision makers and appropriators have limited insight into costs, and the possibility of cost overruns, for ground control systems of major space systems.

Table 3 shows the six space systems that were able to provide cost information that distinguished the development and procurement costs of their satellites from the development and procurement costs of their

[16] Weapon Systems Acquisition Reform Act of 2009, Public Law 111-23, May 22, 2009.

[17] Selected Acquisition Reports, primary sources for cost information on all major DOD acquisition programs (including space systems), for example, do not show costs associated with the ground control systems, but instead show the combined total costs of satellites and ground control systems.

ground control systems. It also shows the two space systems, AEHF and GPS, that were not able to officially break out and distinguish development and procurement costs between satellites and their ground control systems.

Table 3: Space System Program Costs Showing Separate Costs for Satellites and Ground Control Systems

Fiscal year 2009 dollars in millions

	RDT&E			Procurement			
Program	**Satellite**	**Ground**	**Total**	**Satellite**	**Ground**	**Total**	**Total RDT&E and procurement**
AEHF[a,b]	Not available[a]	Not available[a]	**$7,267.3**	Not available[a]	Not available[a]	**$3,150.1**	**$10,417.4**
NAVSTAR GPS[a,b]	Not available[a]	Not available[a]	**$4,485.9**	Not available[a]	Not available[a]	**$4,937.6**	**$9,423.5**
MUOS[b]	$2,065.8	$1,741.9	**$3,807.7**	$2,536.3	$135.1	**$2,671.4**	**$6,479.1**
NPOESS[b]	6,661.3	1,464.2	**$8,125.5**	2,943.4	0.0	**$2,943.4**	**$11,068.9**
SBIRS[c]	5,615.1	2,109.6	**$7,724.7**	2,522.7	133.0	**$2,655.7**	**$10,380.4**
SBSS[c]	469.1	45.0	**$514.1**	N/A[e]	N/A[e]	**N/A[e]**	**$514.1**
STSS[d]	1,886.1	287.9	**$2,174.0**	N/A[d]	N/A[d]	**N/A[d]**	**$2,174.0**
WGS[c]	377.9	N/A	**$377.9**	1,706.7	31.3	**$1,738.0**	**$2,115.9**
Total	**$17,075.3**	**$5,648.6**	**$34,477.1**	**$9,709.1**	**$299.4**	**$18,096.2**	**$52,573.3**

Source: GAO presentation of DOD and Missile Defense Agency data.

Legend: RDT&E = research, development, test, and evaluation; N/A = not applicable.

[a]The program office was not able to officially provide separate satellite and ground control system costs.

[b]The program office provided cost data for the RDT&E and procurement phases.

[c]The program office provided cost data through fiscal year 2013 or 2014.

[d]This program is a demonstration effort and DOD does not currently have plans for a procurement phase.

[e]The original SBSS selected acquisition report did not include procurement funding.

Although six programs were able to provide some information that distinguished costs between satellites and ground control systems, the programs did not report this information separately in their Selected Acquisition Reports (SAR).[18] DOD officials at one program office told us that they do not break out these costs because they have a combined contract for development of the satellites and ground control systems.

[18] These comprehensive, summary status reports on major defense acquisition programs are required for periodic submission to the Congress.

Officials at another program explained that when a program uses one contractor for satellite and ground control system development, it has flexibility to move funds between satellite and ground control system development, as necessary. As a result, it can be difficult to identify, track, and report separate cost information for satellites and ground control systems. However, the Air Force initiative to separate the acquisition of satellites and their ground control systems might make it easier to track and report separate cost information. In addition, the overall acquisition costs associated with user terminal programs are also difficult to determine because different DOD organizations often manage these acquisitions. Even though user terminals are what allow for the day-to-day use of a typical space system's capabilities by military services in the field, the costs of user terminal programs are not usually reported along with, or as part of, the total space system. This can result in a lack of transparency regarding the total costs of all components of a space system.

Opportunities Exist to Enhance the Capabilities of Satellite Ground Systems

DOD has typically developed and operated its ground systems in a stovepiped manner. Specifically, each ground system's development is dedicated to a particular satellite system for a specific mission area, such as communications, missile warning, navigation, space object tracking, or weather monitoring. As a result, ground systems generally only receive and process data from the satellites for which they were developed. They generally do not control and operate more than one type of satellite and they generally do not share their data with other ground systems. More important, there are few ground systems that are capable of fusing data from multiple space systems to enhance military and intelligence planning and operations.

In recent years, however, information technology has migrated toward common architectures and systems that enabled systems that were traditionally stovepiped to share or even fuse data to maximize their value. There is a consensus among officials we spoke with—including individuals from the Office of the Under Secretary of Defense, Acquisition, Technology and Logistics; the Joint Requirements Oversight Council; National Reconnaissance Office; Office of the Secretary of the Air Force; Air Force Space Command; and Lincoln Laboratory (a federally funded research and development center)—that investments in ground systems can be optimized in two ways. First, common ground systems can be built to operate and control multiple satellite systems rather than just one. Second, ground systems or other types of information technology can be used to combine or fuse data from multiple space assets to optimize planning and execution of military operations. Several of the officials we spoke with in fact believe that including air-, land-, and sea-based sensor data in addition to satellite data in such systems or architectures could ultimately reduce the current level of capability needed in space. We have also reported in the past that designing systems with common subsystems and components and using an open systems[19] design approach can reduce production and life cycle costs.[20]

Several of these officials, however, also identified obstacles to such commonality. These obstacles include getting agreement on a common design, meaning whether it will be based primarily on the warfighter's needs or cost savings, and overcoming the resistance of different DOD organizations to sharing their data and trusting that the data will not be misused.

Moreover, progress on building common ground systems or technology that can fuse data from a variety of sensors in the military has been limited. One satellite control facility operated by the Navy, known as Blossom Point,[21] does operate a ground system that can control a variety of national security satellites. The facility uses a common approach (architecture) to command and control the satellites as well as receive and analyze data and information transmitted from the satellites. The common approach allows the facility to reuse a large percentage of the existing software across multiple satellites. Typically, 80 percent of the software required on the ground to operate the satellites can be reused and only about 20 percent is unique and has to be created for that new system. However, the facility primarily operates nonmilitary space systems and according to Blossom Point officials, no major Navy or Air Force space system uses the facility even though the capacity and capability exists. The Air Force has no similar facility, opting instead to primarily develop unique ground control systems for each satellite system.[22] In addition, there are efforts currently being planned at the Air Force's Space and Missile Systems Center that will fuse early missile warning information from SBIRS and information from the next generation of infrared missile

[19] Open systems allow the use of commercially available products from multiple vendors, rather than developing unique components.

[20] GAO, *Ballistic Missile Defense: More Common Systems and Components Could Result in Cost Savings*, GAO/NSIAD-99-101 (Washington, D.C.: May 21, 1999).

[21] The Blossom Point Tracking Facility is located in Maryland near Washington, D.C.

[22] The Air Force does have a similar capability specifically for communications satellite constellations, but no capability to allow for control of multiple space systems with different missions.

detection satellites. These efforts are aimed at eliminating the need for the Air Force to develop separate dedicated ground control systems. However, these efforts are in the planning stages.

In 2004, DOD established policy[23] directing that data collected by various means, including space systems, be made visible and accessible to any potential user in DOD by making them available in shared spaces, but again, according to the individuals we interviewed, this has not made progress because of resistance to sharing data as well as system design, development, and operation. Confirming these views, in 2009, DOD's Defense Science Board[24] reported that while DOD has initiated some efforts to achieve interoperability, it is a long way from achieving the desired level of interoperability in several areas, including satellite communication.[25]

Conclusions

DOD's space systems continue to offer opportunities to enhance and transform how the military conducts its operations. But such opportunities are being limited or delayed because of problems in synchronizing the delivery of space, ground, and user assets. While synchronization is inherently difficult for space systems and complete synchronization is practically unattainable, there are relatively straightforward actions that can be taken to allow for better synchronization. These include better coordination among the many players involved with development and more transparency into and awareness of program complexity, costs, consequences of delays, and criteria to help planning and oversight. DOD has appropriately started taking some of these actions, but expanding this effort could increase cost transparency. Moreover, in response to previous recommendations, DOD has taken actions to address long-standing acquisition problems and ensure that development of the three space system components is knowledge based. Without doing so, synchronization will not be achieved even if coordination and guidance are strengthened. Because acquisition improvements are still relatively recent, the success of these efforts will

[23] DOD Directive 8320.02, December 2, 2004.

[24] The Defense Science Board is an advisory board within DOD that provides independent advice to the Secretary of Defense.

[25] Defense Science Board Task Force, *Creating an Assured Joint DOD and Interagency Interoperable Net-Centric Enterprise*, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (Washington, D.C., March 2009).

not be known for some time. Lastly, there are opportunities to increase the quality and usefulness of data collected from satellites that DOD has been slow to take advantage of. In this case, technical obstacles seem to be easier to overcome than cultural obstacles. DOD has already issued policies to adopt approaches that would facilitate data sharing and senior leaders have been encouraging such approaches, but they have not been implemented. Resistance and lack of coordination among the individual organizations that develop and use space systems are seen by some as key factors. As such, it may be in DOD's best interest to support small-scale demonstrations of new architectures and technologies, such as DOD planned efforts to fuse missile warning information, and find ways to incentivize programs to participate in these demonstrations.

Recommendations for Executive Action

To help DOD space systems provide more capability to the warfighter through better synchronization and increased commonality, and to provide increased insight into the costs associated with ground assets, we are making five recommendations to the Secretary of Defense.

- Define a basic level of expected synchronization during the development of each space system acquisition based on delivering a capability to the warfighter.
- Assess the value of designating an office with responsibility for overseeing the relative progress of satellite, ground, and user terminal programs with the aim of ensuring that problems that could affect the ability to synchronize a space system are known and addressed.
- Formulate guidance to better align space system components so that all components are available to facilitate optimal operational testing.
- Develop DOD-wide guidance, specific to space systems, to allow for the integration and consolidation, to the extent feasible, of DOD's current and future satellite ground control systems via common ground architecture or by other similar means.
- Provide annual documentation to Congress (in SARs or in other documents) that specifically delineates the cost, and cost performance, associated with (1) the satellites, (2) the ground control systems, and (3) associated user terminals, and as a result, provides the total cost of all planned components of each space system acquisition.

Agency Comments and Our Evaluation

DOD provided us with written comments on a draft of this report. DOD concurred with four of our recommendations and partially concurred with a fifth recommendation and identified actions it has taken or plans to take to address them. The comments are reprinted in appendix IV.

In partially concurring with our recommendation to formulate guidance to align space system components to better facilitate optimal operational testing, the department noted that it had taken some steps to better align space system oversight and noted that it did not want to significantly delay providing the warfighter with needed space system capabilities to optimize operational testing. We agree that any efforts to optimize space system operational testing should not result in significant delays in providing the warfighter with needed capabilities. However, the purpose of operational testing is to ensure a system's effectiveness and suitability for use by the warfighter. Not being able to conduct operational testing with production-representative equipment can yield results that are not characteristic of the actual system. This can also negatively affect the warfighter. Our recommendation seeks to achieve a more pragmatic balance. It seems reasonable and even beneficial to the warfighter to have guidance that endorses operational testing that includes all of a space system's components, or at least as many components as can be feasibly tested before delivery to the warfighter.

In concurring with our other recommendations, DOD identified actions it has already taken that it believes will address our concerns. However, we considered these actions in formulating our recommendations and found that they did not go far enough to address the problems we identified. For example, DOD cited a newly created Space and Intelligence Office within the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics as a means of enhancing oversight for space programs. However, the office does not have oversight authority over all user terminals. DOD also stated that total cost information on each space system is provided to the Congress in SARs. However, these reports do not currently capture satellite, ground system, and related user terminal costs in a single document, which we found was needed to provide more accessible and transparent data on total costs for space programs. To improve synchronization and commonality of space systems, we believe that DOD needs to go beyond what it is already doing. This is the intent of our recommendations.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and other interested parties. The report also is available at no charge on the GAO Web site at http://www.gao.gov.

If you have any questions about this report, please contact me at (202) 512-4841 or chaplainc@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are provided in appendix V.

Sincerely yours,

Cristina T. Chaplain
Director
Acquisition and Sourcing Management

Appendix I: Scope and Methodology

To determine the extent to which the Department of Defense (DOD) manages the synchronization of capabilities between satellite and ground components of satellite programs, we assessed eight DOD satellite programs: the Advanced Extremely High Frequency Satellite (AEHF), NAVSTAR Global Positioning System (GPS), Mobile User Objective System (MUOS), National Polar-orbiting Operational Environmental Satellite System (NPOESS), Space-Based Infrared System (SBIRS), Space-Based Space Surveillance (SBSS), Space Tracking and Surveillance System (STSS), and Wideband Global SATCOM (WGS). We developed and sent data requests to the respective program offices, and examined planned deployment dates for satellites, ground systems, and user terminals to determine if capabilities will be synchronized. In making determinations about whether space system acquisitions had synchronization issues, we examined whether there were gaps between fielding dates of satellite capabilities compared to ground system capabilities and whether lower percentages of user terminal types were planned to be fielded by the space system acquisitions' planned initial capability. Programs without gaps between fielding dates of satellite capabilities and ground system capabilities and that had plans for higher percentages of user terminal types to be fielded by their associated space system's initial capability, were determined to be synchronized. While there is no DOD standard by which to measure lack of synchronization between satellite capabilities and ground system capabilities, we generally only considered aspects of a space acquisition unsynchronized if there was a gap of years, rather than months, between the fielding dates of significant capabilities. Regarding user terminals, we only considered these unsynchronized compared to satellite capabilities when user terminals did not meet DOD's measure of synchronization for military satellite communications space acquisitions.[1] This DOD measure of basic synchronization, established by U.S. Strategic Command (STRATCOM) says that 20 percent of any type of user terminal should be fielded by a space system acquisition's initial capability date and 85 percent should be fielded by its full capability date.[2] Although DOD officials acknowledged that these definitions are somewhat arbitrary and do not really measure what is most important—capability provided to the

[1] DOD does not have a measure of synchronization for space acquisitions with missions other than military satellite communications.

[2] U.S. Strategic Command, *SATCOM Mission Area Initial Capabilities Document*, August 2004. DOD also has a definition for optimal military satellite communications user terminal synchronization of 50 percent of a type of user terminal fielded by a space acquisition's initial capability date and 95 percent by its' full capability date.

warfighter via a certain level of synchronization—this is the only DOD measure of space system synchronization.

We analyzed four programs (AEHF, GPS, MUOS, and SBIRS) in greater detail to better understand the causes of less-than-optimal synchronization. We also reviewed various reports and analyses that identified factors contributing to a lack of synchronization. To determine the effect(s) of space systems that are not synchronized, we interviewed combatant commanders (in STRATCOM, Omaha, Nebraska; U.S. Special Operations Command, Tampa, Florida; and U.S. Central Command, Tampa, Florida) and testing personnel from the Office of the Director of Operational Testing and Evaluation, Washington, D.C., to determine if programs are optimally synchronized for testing and the consequences if they are not. We also analyzed cost data for the various programs to determine how much money was allocated to the satellites versus the ground control systems.

To determine whether enhancements could be made to ground control systems and what challenges must be overcome to better utilize space systems, we interviewed DOD and government personnel at the Joint Requirements Oversight Council, Washington, D.C.; Office of the Under Secretary of Defense, Acquisition, Technology and Logistics, Washington, D.C.; National Reconnaissance Office, Chantilly, Virginia; Office of the Secretary of the Air Force, Washington, D.C.; United States Air Force Space and Missile Systems Center, Los Angeles, California; the Navy's Blossom Point Tracking Facility, Maryland; and RAND Corporation, Los Angeles, California.

We conducted this performance audit from November 2008 to September 2009 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Summary of Synchronization Issues Affecting Testing

Satellite system and description	Synchronization issues and how testing is affected
AEHF. A communications satellite intended to provide global, secure, jam-resistant communications capability for strategic and tactical warfighters.	• The prime contractor has experienced significant software development problems (issuing numerous deficiency reports) with an aspect of the ground control system that controls mission planning. Ground control system fielding will be delayed until the deficiencies are corrected and verified by the government testers. • The Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) command post terminal for command and control (ability to "fly") of AEHF will be delayed. As a result, an interim, non-production-representative command and control terminal will have to be relied upon for testing and initial support of AEHF. In order to determine that a space system is operationally effective and suitable, production-representative equipment for all components must be in place for operational testing.
MOUS. A communications satellite designed to provide a worldwide, multiservice population of mobile and fixed terminal users with narrow-band line of sight satellite communications capability. MUOS will be capable of operating in adverse weather conditions.	• Delays in the Joint Tactical Radio System (JTRS) terminals mean that these are not well synchronized with MUOS. As a result, there may be no production-representative JTRS available for MUOS operational testing scheduled for fiscal year 2010, which will affect the ability to test several aspects of MUOS. • Because of development delays, the majority of MUOS testing will be conducted in a laboratory instead of an operational platform environment. This will limit the capability to assess operational effectiveness and suitability issues associated with satellites' payload performance in their intended environment.
GPS. A navigation satellite with a space-based radio-positioning system providing navigation and timing data to military and civilian users worldwide.	• The development delays of a ground control system capable of commanding several significant satellite capabilities, which are designed to ensure that military GPS signals are secure, has delayed both testing and operational use of the capabilities. These capabilities could have been tested in 2005 if there had been no delays, but now they most likely will not be tested until 2010. As a result, by the time operational testing can be conducted for these significant capabilities, the entire GPS constellation (Block IIR-M and IIF satellites) will have already been launched, eliminating the opportunity for operational testing to influence the development of those satellites before they launch. Therefore, the overall lack of GPS program synchronization limits the utility of operational testing.
SBIRS. A missile warning satellite designed to meet requirements in the missile warning, missile defense, technical intelligence, and battlespace characterization missions.	• The hardware for an important sensor capability was placed on the first increment of SBIRS satellites, but because of problems, the associated software to enable full utilization of the sensor data will not be available. As a result, this sensor's data will be available years before it can be fully utilized. From a testing standpoint, this means that initial satellite capabilities cannot be tested in time to affect the subsequent increment of satellites. • There has also been instability in the plan for the ground control system architecture because system requirements have continued to change. These requirements changes have led to ground software development delays and, from a test perspective, difficulties in developing an efficient test strategy.
WGS. A communications satellite designed to provide essential communications services to U.S. warfighters, allies, and coalition partners during almost all levels of conflict.	• The mission planning system does not work as intended. It was acquired separately from the satellite, and its shortcomings affect the ability of the Wideband Satellite Operations Center to perform its missions. This affects the ability of testers to validate user operations.

Source: GAO analysis of DOD data.

Appendix III: Synchronization Issues between Satellites and User Terminals

DOD program		User terminal synchronization issues
Advanced Extremely High Frequency Satellite System	**AEHF** -Initial operational capability (IOC) 2011[a] (two satellites fielded) -Full operational capability (FOC) date not specified by program[a]	**Air Force terminals:** **FAB-T Increment 1** Function: Provide voice and data military satellite communications for nuclear and conventional forces as well as airborne and ground command posts. Synchronization issue: Two percent fielded by AEHF IOC (2011). **Ground Element Minimum Essential Emergency Communication Network** Function: Fixed and deployable communication for alerting aircrew of emergencies on bombers, tankers, and reconnaissance aircraft. Synchronization issue: Sixty-four percent fielded by AEHF IOC (2011). **Minuteman Minimum Essential Emergency Communication Network Program –-Upgrade** Function: Provides 24/7 survivable, redundant communication links for the reception of emergency action messages and command and control of ICBM force. Synchronization issue: Fifty-two percent fielded by AEHF IOC (2011). **Secure Mobile Anti-Jam Reliable Tactical Terminal** Function: Provide worldwide, low probability of intercept/detection, jam-resistant, survivable multichannel communications and robust operations. Synchronization issue: Fifty-eight percent fielded by AEHF IOC (2011). **Navy terminal:** **Navy Multiband Terminal** Function: Next generation of maritime satellite communication designed to enhance protected and survivable satellite communications to naval forces. Synchronization issue: Only 14 percent fielded by AEHF IOC (2011)
NAVSTAR Global Positioning System	**NAVSTAR GPS**	**Military GPS user equipment:** DOD plans to field extensive GPS user equipment and terminals to assist with positioning and navigation on a variety of air, ground, and sea platforms. While we did not evaluate plans to field the many types of GPS user equipment, we did examine when user equipment would be able to utilize a modernized military signal (M-code), designed to be secure and jam resistant. Synchronization issue: The M-code signal is planned to reach its IOC on the GPS satellites and ground control system by 2014. While user terminals will start to receive and process the signal as they begin to be fielded leading up to 2025, the user equipment and terminals are not expected to be fully fielded and operational until that year.

DOD program		User terminal synchronization issues
National Polar-orbiting Operational Environmental Satellite System	**NPOESS** - IOC 2014 (one satellite fielded) - FOC 2017 (number of satellites not specified by program)	**Navy terminals:** **AN-SMQ-11 – Navy Field Terminal** Function: Fielded primarily shipboard, with some shore, depot, and training assets. It ingests, processes, stores, and displays environmental data records (EDR) from meteorology and oceanographic (METOC) satellite families. Synchronization issue: System is currently fielded, but program estimates that only 50 percent of population will be upgraded for NPOESS compatibility by NPOESS IOC (2014). **AN-FMQ-17 - Navy Field Terminal** Function: Fielded on shore only. It ingests, processes, stores, and displays EDRs from METOC satellite families. Synchronization issue: System is currently fielded, but program estimates that only 67 percent of population will be upgraded for NPOESS compatibility by NPOESS IOC (2014). **Marine terminal:** **Field Terminal Segment (FTS) Mobile** Function: Signal Processing Element (SPE), Data Processing Element (DPE), and Mission Applications Element (MAE). SPE receives, decrypts, and conducts basic RF processing. DPE provides the data analysis algorithms that transform the raw data into usable images and METOC data. MAE provides the graphical user interface for the system, conducts postprocessing analysis, and displays finished products. This capability is highly desired in the FTS for size and weight considerations. Synchronization issue: Twelve planned, but only 1 estimated to be available by NPOESS IOC. **Air Force terminals:** **MARK IVB and RSS terminals** Function: Both types of terminals designed to receive geostationary information. Synchronization issue: Systems are currently fielded and work with legacy systems. Plans and funding are in place to achieve NPOESS compatibility.
Mobile User Objective System	**MUOS** - IOC 2011 (one satellite fielded) - FOC 2014 (when all five satellites are fielded)	**Joint terminal:** **JTRS** Function: Software-defined radios that will interoperate and increase communication and networking capabilities. Synchronization issue: Less than 20 percent of MUOS-capable JTRS terminals available by MUOS IOC (on orbit capability) in late 2011.
Wideband Global SATCOM	**WGS** - IOC 2009 (one satellite fielded) - FOC 2013 (when all five satellites are fielded)	**Army, Navy, and Air Force - several airborne intelligence surveillance reconnaissance terminals** Synchronization issue: SADT for Predator/Reaper UAV, FAB-T Increment 2, and the Aerial Common Sensor—all zero percent fielded as of WGS IOC (2009).

Source: GAO analysis of DOD data.

Legend: IOC = Initial Operational Capability; FOC = Full Operational Capability.

[a] AEHF IOC (defined as two satellites fielded) is currently scheduled for 2011 and there is no specified FOC date. However, there is a new acquisition program baseline pending approval. If it is approved, IOC will be delayed until 2013, and FOC is projected for 2019 (defined as four satellites fielded) because of satellite development issues. If the IOC date becomes 2013, this will alleviate several of the terminal synchronization issues listed above. AEHF program management told us that the satellite delays have been fortuitous in that they have allowed the program to be more synchronized. Regardless, before this unplanned delay in IOC, the program was being managed with significantly less-than-optimal synchronization (as evidenced by the information above).

Appendix IV: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

Ms. Cristina Chaplain
Director, Acquisition and Sourcing
441 G Street, N.W.
Washington, D.C. 20548

Dear Ms. Chaplain:

This is the Department of Defense (DoD) response to the GAO draft report 10-55, "DEFENSE ACQUISITIONS: Challenges In Aligning Space System Components," dated September 9, 2009 (GAO Code 120787). Detailed comments on the report recommendations are enclosed.

The Department appreciates the opportunity to respond to your draft report and look forward to working with you to ensure alignment of Space System components.

Sincerely,

Gil Klinger
Director
Space and Intelligence

Enclosures:
As stated

GAO Draft Report Dated September 11, 2009
GAO-10-55 (GAO CODE 120787)

"DEFENSE ACQUISITIONS: CHALLENGES IN ALIGNING SPACE SYSTEM COMPONENTS"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommends that the Secretary of Defense define a basic level of expected synchronization during the development of each space system acquisition based on delivering a capability to the warfighter. (p. 24/GAO Draft Report)

DOD RESPONSE: Concur. The Department concurs that defining a basic level of expected synchronization during development of new space-based capabilities may better inform acquisition decision makers. As noted in the report, the Department, through the Commander of Strategic Command, has already established a synchronization measure for military satellite communications (MILSATCOM) capabilities and a bi-annual report is published on MILSATCOM synchronization based on Service MILSATCOM terminal fielding plans. These data are included in each Defense Acquisition Board MILSATCOM system review. In addition, as the Net-Centric Capability Portfolio Manager the OASD(NII) periodically reviews MILSATCOM capability fielding as a function of alignment between satellite and terminal fielding. A similar measure might be beneficially applied to other space systems. However, the delivery of capabilities to the warfighter is dependent on military deployments and the Combatant Commanders' need to respond swiftly to emerging situations. To more-specifically define a level of synchronization based on fielded warfighter capabilities would require tying dynamic operational deployment plans to capability measures and acquisition program schedules.

RECOMMENDATION 2: The GAO recommends that the Secretary of Defense assess the value of designating an office with responsibility for overseeing the relative progress of satellite, ground, and user terminal programs with the aim of ensuring that problems that could affect the ability to synchronize a space system are known and addressed. (p. 24/GAO Draft Report)

DOD RESPONSE: Concur. The Department has already taken actions to improve space system acquisition programs. In June 2008, to more effectively conduct oversight of the space and intelligence enterprise, the Under Secretary of Defense for Acquisition, Technology, and Logistics [USD(AT&L)] created the Space and Intelligence Office. Additionally in 2008 and 2009, the USD(AT&L) approved several recommendations from a Joint Analysis Team (JAT) that assessed the effectiveness of the Department's various acquisition oversight bodies. Two special boards were disestablished (Defense Space Acquisition Board and Joint Tactical Radio System Board Of Directors) and all space and intelligence programs were directed to be governed by the Defense Acquisition Board. Additional acquisition effectiveness may be

3

available by assessing the Overarching Integrated Product Team (OIPT) governance structure of space acquisition programs.

RECOMMENDATION 3: The GAO recommends that the Secretary of Defense formulate guidance to better align space system components so that all components are available to facilitate optimal operational testing. (p. 24/GAO Draft Report)

DOD RESPONSE: Partially Concur. The Department has already taken several steps to better align and consolidate space system oversight, as noted in the Department's response to recommendation 2. However, the Department should not significantly further delay providing the warfighter with needed space system capabilities in order to optimize operational testing if a space system component is significantly delayed. The Department in all cases will conduct adequate operational testing of space systems.

RECOMMENDATION 4: The GAO recommends that the Secretary of Defense develop DoD-wide guidance, specific to space systems, to allow for the integration and consolidation, to the extent feasible, of DoD's current and future satellite ground control systems via common ground architecture or by similar means. (p. 24/GAO Draft Report)

DOD RESPONSE: Concur. The Department agrees that the integration and consolidation of satellite ground control systems has many benefits. For example, since March 2002 the Department has been pursuing this capability with the Air Force's Command Control System – Consolidated (CCS-C). CCS-C has consolidated the satellite ground control systems for Defense Satellite Communication Systems (DSCS), Milstar, and Wideband Global SATCOM (WGS) Block I. By October, 2011, CCS-C will also be controlling the Advanced Extremely High Frequency (AEHF) System as well as WGS Block II. Although additional guidance may be needed, existing guidance allows for the integration and consolidation of satellite ground control systems as evidenced by as demonstrated by the CCS-C program.

RECOMMENDATION 5: The GAO recommends that the Secretary of Defense provide annual documentation to Congress that specifically delineates the cost, and cost performance, associated with (1) the satellites, (2) the ground control systems, and (3) associated user terminals, and as a result, provide the total cost of all planned components of each space system acquisition. (p. 24/GAO Draft Report)

DOD RESPONSE: Concur. The Department agrees that a report to Congress that highlights the cost and cost performance of satellites, ground control systems, and associated user equipment is valuable to informing Congressional oversight. The Department already provides these data via annual Select Acquisition Reports based on cost and cost performance metrics contained in Acquisition Program Baselines.

4

Appendix V: GAO Contacts and Staff Acknowledgments

GAO Contact

Cristina T. Chaplain (202) 512-4841 or chaplainc@gao.gov

Acknowledgments

In addition to the contact named above, key contributors to this report were Art Gallegos, Assistant Director; Michael Aiken; Greg Campbell; John Crawford; Claire Cyrnak; John Krump; and Don Springman.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday afternoon, GAO posts on its Web site newly released reports, testimony, and correspondence. To have GAO e-mail you a list of newly posted products, go to www.gao.gov and select "E-mail Updates."

Order by Phone

The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's Web site, http://www.gao.gov/ordering.htm.

Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537.

Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Ralph Dawn, Managing Director, dawnr@gao.gov, (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548