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Report to Congressional Committees

April 2013

SATELLITE CONTROL

Long-Term Planning and Adoption of Commercial Practices Could Improve DOD's Operations

GAO-13-315

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GAO Accountability * Integrity * Reliability

Highlights

Highlights of GAO-13-315, a report to congressional committees

Why GAO Did This Study

DOD manages the nation's defense satellites, which are worth at least $13.7 billion, via ground stations located around the world. These ground stations and supporting infrastructure perform three primary functions: monitoring the health of the satellite; ensuring it stays in its proper orbit; (activities collectively known as satellite control operations), and planning, monitoring, and controlling the execution of the overall mission of the satellite. Based on the House Armed Services Committee Report and discussions with defense committee staff, GAO (1) reviewed the Air Force's satellite control operations to assess the potential for fragmentation or duplication, (2) assessed the status of modernization efforts, (3) identified any commercial practices that could improve the Air Force's satellite control operations, and (4) identified any barriers to implementing them. GAO reviewed modernization funding documents, related studies and interviewed DOD and 7 commercial satellite companies, from a nongeneralizable sample selected in part because of their companies' satellite capabilities.

What GAO Recommends

GAO recommends that the Secretary of Defense direct future DOD satellite acquisition programs to determine a business case for proceeding with either a dedicated or shared network for that program's satellite control operations and develop a department-wide long-term plan for modernizing its AFSCN and any future shared networks and implementing commercial practices to improve DOD satellite control networks. DOD concurred with our recommendations.

View GAO-13-315. For more information, contact Cristina Chaplain, (202) 512-4841, chaplainc@gao.gov.

What GAO Found

The Department of Defense (DOD) satellite control networks are fragmented and potentially duplicative. Over the past decade, DOD has increasingly deployed standalone satellite control operations networks, which are designed to operate a single satellite system, as opposed to shared systems that can operate multiple kinds of satellites. Dedicated networks can offer many benefits to programs, including possible lower risks and customization for a particular program's needs. However, they can also be more costly and have led to a fragmented, and potentially duplicative, approach which requires more infrastructure and personnel than shared operations. For example, one Air Force base has 10 satellite programs operated by 8 separate control centers. According to Air Force officials, DOD continues to acquire standalone networks and has not worked to move its current standalone operations towards a shared satellite control network, which could better leverage DOD investments.

The Air Force Satellite Control Network (AFSCN), DOD's primary shared satellite control network, is undergoing modernization efforts, but these will not increase the network's capabilities. The Air Force budgeted about $400 million over the next 5 years for these efforts. However, these efforts primarily focus on sustaining the network at its current level of capability and do not apply a decade of research recommending more significant improvements to the AFSCN that would increase its capabilities.

Commercial practices have the potential to increase the efficiency and decrease costs of DOD satellite control operations. These practices include: interoperability between satellite control operations networks; automation of routine satellite control operations functions; use of commercial off-the-shelf products instead of custom ones; and a "hybrid" network approach which allows a satellite operator to augment its network through another operator's complementary network. Both the Air Force and commercial officials GAO spoke to agree that there are opportunities for the Air Force to increase efficiencies and lower costs through these practices. Numerous studies by DOD and other government groups have recommended implementing or considering these practices, the Air Force has generally not incorporated them into Air Force satellite control operations networks.

DOD faces four barriers that complicate its ability to make improvements to its satellite control networks and adopt commercial practices. First, DOD has no long-term plan for satellite control operations. Second, the agency lacks reliable data on the costs of its current control networks and is unable to isolate satellite control costs from other expenses. Third, there is no requirement for satellite programs to establish a business case for their chosen satellite control operations approach. And fourth, even if program managers wanted to make satellite control operations improvements, they do not have the autonomy to implement changes at the program level. Until DOD begins addressing these barriers by implementing a long-term plan for future satellite control network investments that can capture estimates of satellite control costs as well as authorities that can be given to program managers and incorporates commercial practices, the department's ability to achieve significant improvements in satellite control operations capabilities will be hindered.

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Congressional Committees

The Department of Defense (DOD) uses ground stations located around the world to manage the nation's defense satellites—satellites worth at least $13.7 billion. These ground stations and supporting infrastructure perform three primary functions: (1) monitoring the health of a satellite; (2) ensuring the satellite stays in its proper orbit; (activities collectively known as satellite control), and (3) planning, monitoring, and controlling the execution of the overall mission of a satellite. Some of DOD's ground stations are linked together to form networks. The Air Force operates the largest of these networks, the Air Force Satellite Control Network (AFSCN), which is also the primary network for supporting the placement of satellites into their proper orbit. Established in 1959, the AFSCN is also the nation's primary network for the emergency recovery of tumbling or lost satellites.

Over the past two decades, the Air Force has replaced various outdated computer and communications equipment to sustain the AFSCN.[1] Today, efforts continue to update the AFSCN satellite operations centers and remote tracking stations by replacing outdated software and equipment that, in some cases, have been in place over 40 years. According to the Air Force, the AFSCN, as it currently stands, without planned upgrades and modernizations, is not sustainable beyond 2020. At some point in the near future, the Air Force will be confronted with making investment decisions regarding the AFSCN to determine whether to continue to support it or to pursue other options for satellite control operations. With increasingly tighter budgets, these decisions will require accurate information on all aspects of the Air Force's satellite control operations to make the best decisions for DOD. In the House Armed Services Committee Report accompanying the fiscal year 2012 National Defense Authorization Act, the committee raised questions as to whether satellite control operations centers require more resources than their commercial system counterparts. The committee also raised questions as to whether the Air Force was fully leveraging commercial practices to achieve greater

[1] Sustainment involves design and planning for replacement, or continuous supply, of parts needed to prolong a system's ability to perform its mission.

efficiencies, though it recognized that some DOD-unique requirements may preclude the adoption of certain commercial practices.

Based on the House Armed Services Committee Report's requirement for our review and discussions with defense committee staff, GAO (1) reviewed the Air Force's satellite control operations to assess the potential for fragmentation or duplication, (2) assessed the status of modernization efforts, (3) identified any commercial industry satellite control practices that could improve the Air Force's satellite control operations, and (4) identified any barriers to implementing improvements to satellite control operations.[2]

To address these objectives, we reviewed various satellite control upgrades, sustainment efforts, and modernization efforts by the Air Force, Navy, and Army. To identify the potential for fragmentation or duplication, we assessed satellite control plans, requirements, programs, budgets, and studies associated with current and future capabilities. For the purposes of our analysis, we considered "duplication" to occur when two or more agencies or programs are engaged in the same activities or provide the same services to the same beneficiaries. We used the term "fragmentation" to refer to those circumstances in which more than one federal agency (or more than one organization within an agency) is involved in the same broad area of national need, and opportunities may exist to improve how the government delivers these services. We analyzed documentation such as reports and studies on satellite control operations by government and industry groups, and interviewed officials from various offices of the Secretary of Defense, Air Force, Navy, and Army, and the National Reconnaissance Office. We also determined the extent to which various aspects of the modernization efforts were duplicative by reviewing DOD planning documents and discussing these topics with DOD officials. Our review focused on the ground systems used at command and control centers to perform satellite control operations. To determine the costs associated with current and planned upgrades, sustainment, and modernization efforts for the AFSCN and

[2] House of Representatives Armed Services Committee Report No. 112-78, at 117 (2011), accompanying H.R. 1540, the bill for the National Defense Authorization Act for Fiscal Year 2012 (Pub. L. No. 112-81 (2011)) directed GAO to assess DOD satellite operations modernization efforts and identify potential best practices and efficiencies. To fulfill this mandate, we delivered an oral briefing to the House and Senate Armed Services committees on February 6, 2012.

other military services' satellite control efforts, we reviewed the DOD's satellite operations funding documents for fiscal years 2011 through 2017. To determine which commercial practices could benefit the Air Force's satellite control operations, we asked 13 companies to provide information on how they develop, conduct, and manage their satellite control activities. From this nongeneralizable sample, seven companies met with us and provided information. We conducted internet searches and attended conferences on the related subject matter to identify potential companies, and selected participants based on their companies' satellites' constellation size, orbit, and capabilities. We interviewed key personnel and reviewed company data to identify potential practices that could potentially be employed by the Air Force to improve its satellite operations. To identify any potential barriers to DOD of implementing these commercial practices, we analyzed documentation such as DOD and other government studies on the organization of satellite control operations, and interviewed DOD officials. We used the information to assess any barriers impacting the funding, cost, schedule, and performance of satellite control operations.

We conducted this performance audit from June 2012 to April 2013 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. Additional details on our scope and methodology are provided in appendix I.

Background

Every satellite has a bus and payload. The bus is the body of the satellite. It carries the payload and is composed of a number of subsystems, like the power supply, antennas, telemetry and tracking command, and mechanical and thermal control subsystems. The bus also provides electrical power, stability, and propulsion for the entire satellite. The payload—carried by the bus—includes all the devices a satellite needs to perform its mission, which differs for every type of satellite. For example, the payload for a weather satellite could include cameras to take pictures of cloud formations, while the payload for a communications satellite may include transponders to relay data such as television or telephone signals. Monitoring and commanding of the satellite payload is done to collect data or provide a capability to the warfighter. Satellite control operations are used to manage the bus and are the focus of this report.

Satellite control operations essentially consist of (1) tracking—determining the satellite's location based on position and range measurements to receive commands from the ground, (2) telemetry—collecting health and status reports which are transmitted from the satellite to the ground, and (3) commanding—transmitting signals from the ground to the satellite to control satellite subsystems. Tracking, telemetry, and commanding (TT&C) are accomplished by a network of ground stations, ground antennas, and communication links between the centers, antennas, and satellites, strategically located around the world. TT&C is essentially the same for any given satellite, based on its orbit, regardless of its mission. Payload control involves operation and control of the payload on the satellite, or managing the operations of a satellite's mission equipment.

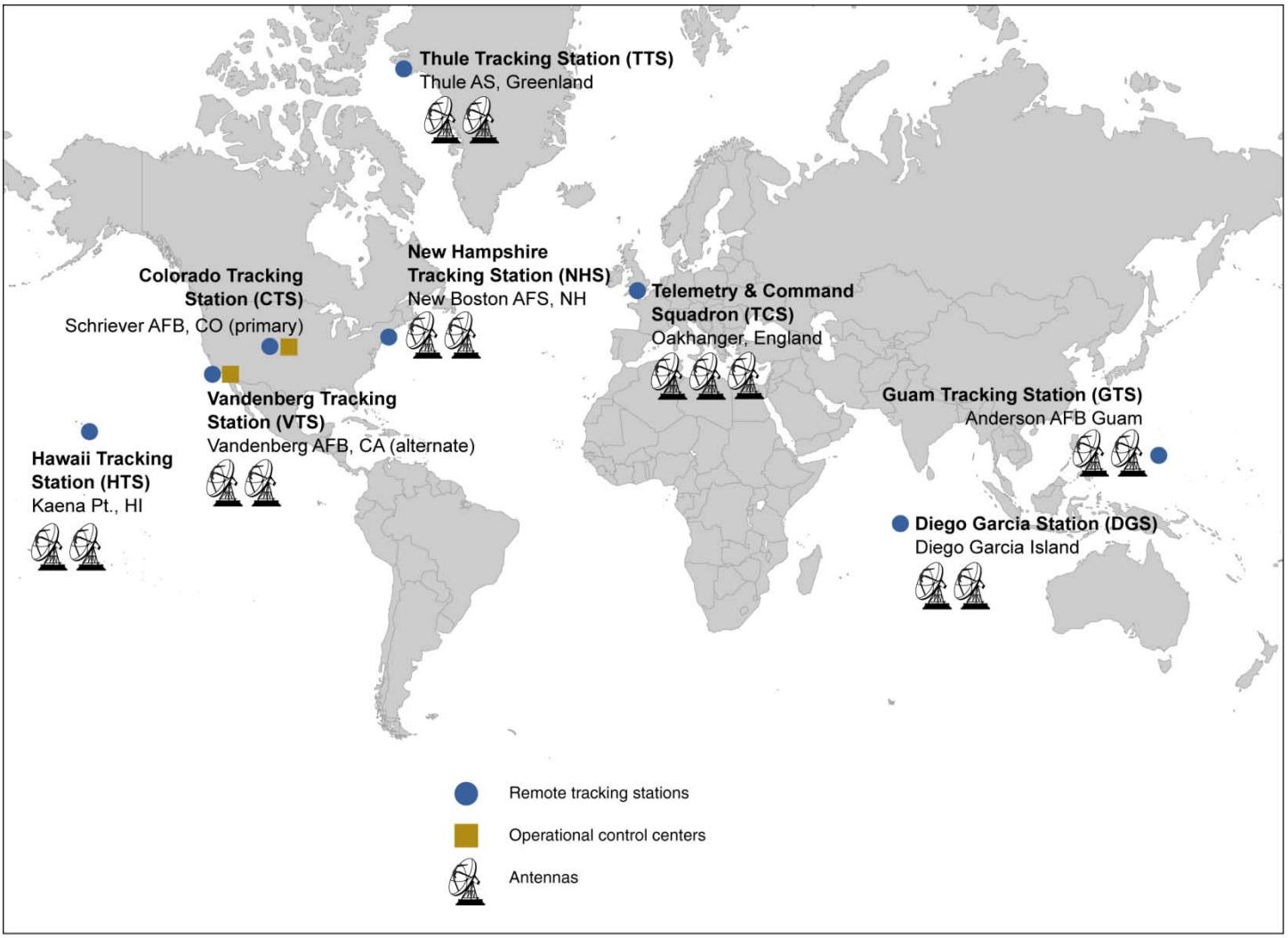
The ground segment of satellite control is made up of various ground control centers, ground stations, and user elements. There are two kinds of satellite ground stations: control stations and tracking stations. Satellite control ground stations perform the TT&C functions to ensure that satellites remain in the proper orbit and are performing as designed, and are the stations that manage the bus. The tracking stations enable contact with the satellites through communication uplinks and downlinks.

Ground stations can be tied together and can form two types of networks —shared and dedicated. A shared network can support several satellite systems, and is able to share its antennas and software among many different kinds of satellites. While not considering the payload, a shared network is primarily used for bus control and for controlling satellites that are only contacted intermittently using relatively low data rates. However, a shared network can also support functions such as launch and early orbit tracking of satellites, and telemetry and commanding of satellites that are experiencing anomalies.[3] Examples of DOD satellite systems that are controlled by a shared network include the Defense Satellite Communications System and Ultra High Frequency Follow-On system, also a communications satellite.

[3] Satellite anomalies are malfunctions on the satellite. In most cases, these malfunctions do not affect operations or services, but occasionally can have serious consequences leading to interruptions in services, component failure, or in extreme events, total loss of the satellite.

The AFSCN is DOD's largest shared network. It supports national security (defense and intelligence) satellites during launch and early orbit periods, and is used to analyze anomalies affecting orbiting satellites. It also acts as a backup control system for national security satellites, even for satellites that are not routinely controlled by the AFSCN. AFSCN is comprised of three interrelated segments: (1) operational control centers that provide satellite TT&C support from launch preparation through on-orbit operations, (2) remote tracking stations that provide the space-ground link between satellites on-orbit and the AFSCN, and (3) an interconnected network of space and ground assets with communication links that provides interfaces for external users to access network data. The AFSCN has two operational control centers: a primary center located at Schriever Air Force Base, Colorado; and a secondary control node (backup center) at Vandenberg Air Force Base, California. The AFSCN also has antennas and tracking stations dispersed throughout the world. Figure 1 outlines the AFSCN and related centers, stations, and antennas.

Figure 1: Air Force Satellite Control Network



Source: GAO analysis of DOD data; Map Resources (map); ArtExplosion (image).

The Navy and Army also operate smaller shared satellite control networks with satellite control operations centers, antennas, and tracking stations that support several satellite programs, including:

- The Naval Satellite Control Network, which operates, manages, and maintains five missions through one operational control center and four remote sites.

- The Naval Research Laboratory satellite control network, which supports multiple classified and scientific satellite missions through one operational control center.
- The Army conducts payload control, transmission control, and backup platform control for two missions through five operations centers located throughout the world.

In addition to the shared network, the Air Force operates a number of dedicated satellite control networks. A dedicated network operates a single satellite system, and its assets are generally not shared with other satellite systems. Dedicated networks are usually customized or tailored to their associated satellite and therefore unsupportable on the shared networks. In addition, unlike a shared network, a dedicated network often performs both bus and payload control through the same antenna. Examples of Air Force satellite systems controlled by a dedicated network include the Space Based Infrared System (SBIRS), a missile warning satellite system, and the Global Positioning System (GPS), a constellation of satellites that provides positioning, navigation, and timing data to users worldwide. These dedicated networks have 23 antennas at 10 locations around the world. Figure 2 shows the number of antennas at various sites around the world for the AFSCN, a shared network, and for several dedicated networks, such as those used by SBIRS and GPS.

Figure 2: Numbers of Selected Shared and Dedicated Antennas at Locations Around the World

Source: GAO analysis of DOD data; Map Resources (map).

Although some satellites using dedicated networks require continuous contact with their ground antennas, thereby precluding those antennas

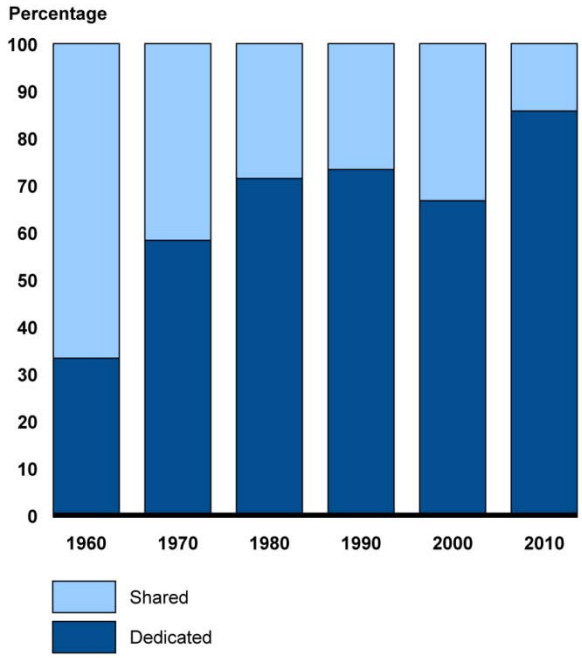
from being shared with other satellite systems, other satellites need only be in contact with their ground antennas on an intermittent basis, thus being potentially compatible with a shared network.

DOD's Satellite Control Networks are Fragmented, Resulting in Inefficiencies Across Satellite Programs

Over the past 50 years, and especially in the last decade, DOD has increasingly deployed dedicated satellite control networks in lieu of integrating them into a larger shared satellite control network. DOD is currently operating at least a dozen dedicated satellite control networks, which typically do not share assets or personnel with other dedicated or shared networks, resulting in fragmented and potentially duplicative operations and inefficiencies across its satellite control operations. While dedicated networks offer a handful of advantages to the specific satellite systems they serve, shared networks offer potential advantages DOD-wide in leveraging hardware, software, and personnel. As of February 2013, Air Force officials stated that the Air Force had not worked to move its current dedicated operations to a shared satellite control network, which could better leverage investments.

Since 1992, DOD has described its largest shared network, the AFSCN, as among other things, fragmented and lacking standardization and interoperability. In addition, Air Force Space Command officials also stated that consolidation of functions and capabilities, reduction of potential duplication and improvement in interoperability at all levels, is needed. DOD's share of satellite programs using dedicated networks has increased since 1960, as shown in figure 3.

Figure 3: Proportion of DOD Satellite Programs Using Shared or Dedicated Infrastructure by Decade Since 1960



Source: GAO analysis of DOD study.

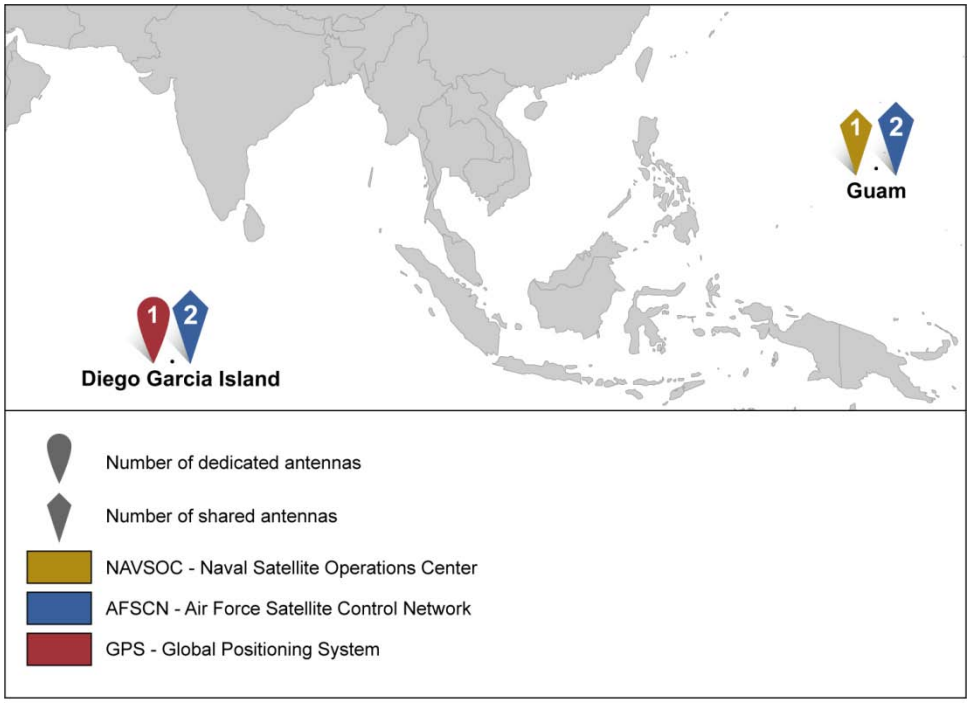
Long-standing systems, such as the Defense Support Program and Defense Satellite Communication System, were developed with their own control centers and antenna sites because existing shared networks could not accommodate them, or because the programs were determined to be better served by combining payload and satellite control operations into a single, dedicated network. As a result of these types of decisions, DOD now uses multiple dedicated networks built specifically for individual satellite programs. Some of these networks include:

- GPS, which is comprised of two control centers and four antenna sites
- SBIRS, which is comprised of three control centers and four sites which each have up to five antennas.

In recent years, the Air Force has acquired and launched the Space Based Space Surveillance satellite that has its own dedicated system. In addition, plans for other future satellite acquisitions indicate likely additional dedicated networks. While these networks enable satellite control operations, they were not designed to be interoperable. As a result, they require dedicated and unshared control centers and

antennas, even when sites are co-located. Figure 4 below illustrates the co-location of several antennas in the Indian and Pacific Oceans operated by the Air Force and Navy (a smaller network), but are not interoperable.

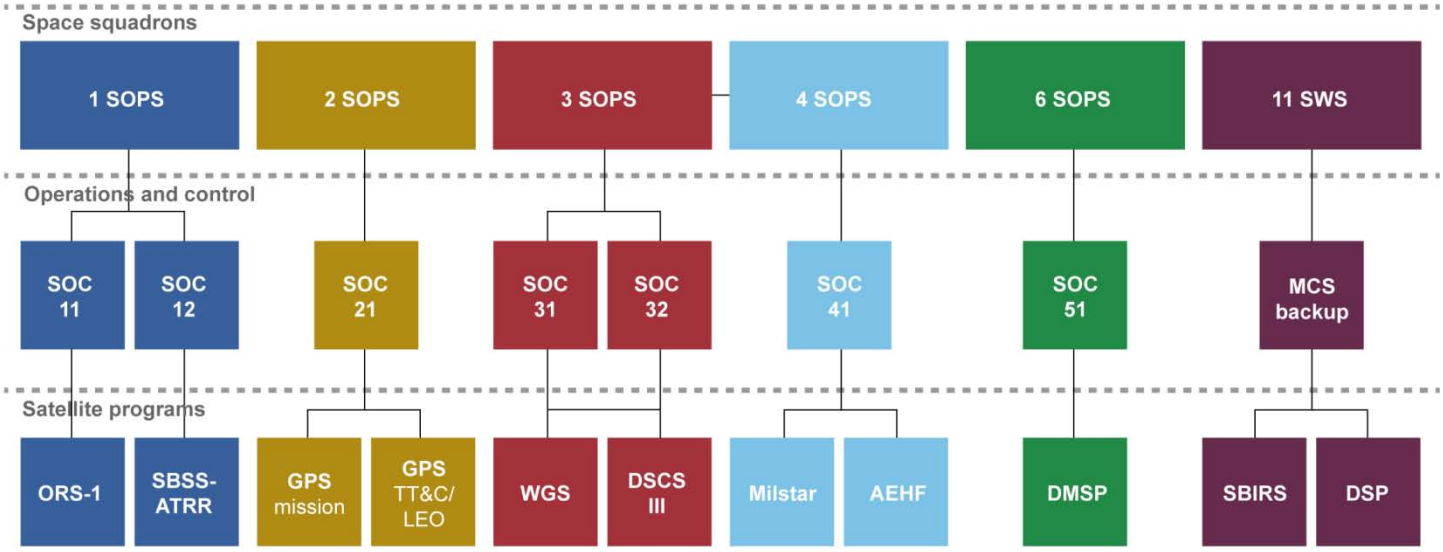
Figure 4: Numbers of Co-located Antennas at Selected Sites



Source: GAO analysis of DOD data; Map Resources (map).

Even when control centers are co-located, the configuration of the various networks as well as the organizational structure of the Air Force centers is often fragmented. For example, at Schriever Air Force Base in Colorado, 10 satellite programs are operated by eight separate satellite operations centers under the command of six separate space squadrons, or units, as shown in figure 5.

Figure 5: Satellite Program Organizational Structure at Schriever Air Force Base



SOPS	Space Operations Squadron
SWS	Space Warning Squadron
SOC	Satellite Operations Center
MCS	Mission Control Station
ORS-1	Operationally Responsive Space
SBSS-ATRR	Space Tracking and Surveillance System Advanced Technology Risk Reduction
GPS	Global Positioning System
WGS	Wideband Global Satellite Communications Satellite
DSCS III	Defense Satellite Communications System
Milstar	Military Strategic Tactical, and Relay
AEHF	Advanced Extremely High Frequency
DMSP	Defense Meteorological Satellite Program
SBIRS	Space-Based Infrared System
DSP	Defense Support Program

Source: GAO analysis of Air Force data.

Note: The numbers in the figure are designations given to the space squadrons, operations and control centers, or satellite programs. 3SOPS and 4 SOPS are connected by an integrated operations environment, which better enables information sharing between the two squadrons.

DOD's reliance on dedicated satellite control operations networks is continuing with its newest satellite system acquisitions, as well as with updates for established systems. Despite being required to conduct a cost analysis and other analyses, DOD officials managing acquisitions of new satellite systems are not required to develop a business case when deciding whether to acquire a dedicated network or to use an existing shared network. Air Force officials stated that in some cases, satellite programs are required to make their dedicated networks compatible with

a potential future standard, but many programs receive waivers from that requirement. Furthermore, because dedicated networks effectively meet mission needs, the status quo is upheld without regard for cost or department-wide strategic planning for satellite control operations. New satellites in the early stages of development are already being designed to operate on dedicated networks rather than being designed with the interoperability needed for shared networks. For example, the Precision Tracking Space System, which will be part of the Missile Defense Agency's Ballistic Missile Defense System, has been designed with a dedicated satellite control operations network. In addition, updates of existing systems, such as the third generation of GPS satellites, are also continuing with the dedicated network approach.

Although dedicated networks support the unique needs of some satellite programs, not all satellite control networks need to be dedicated. According to Air Force officials, the increase in dedicated networks reflects more of a preference by satellite program managers than a need. Officials stated that program managers would rather have the large, individual budget for completing its mission, to include a satellite control operations network, and have other programs become compatible with their satellite control operations network, if necessary. By customizing satellite control operations for each satellite, program managers do not have to modify their plans to fit within a larger organizational structure, or negotiate with any other programs over the satellite control operations system, which they may need to do if they used a shared network. However, development of a dedicated network can also result in higher costs due to the unique development required, as well as for follow-on support, since the original contractor is typically the only one able to provide this proprietary or specialized support. At the same time, while shared networks offer efficiencies and lower costs, they can have other limitations, like not being able to support unique data rates and continuous contact needs. Some potential pros and cons of the two types of networks, based on our analysis, are outlined in table 1.

Table 1: Pros and Cons of Using Dedicated Versus Shared Satellite Control Networks

Dedicated Network		Shared Network	
Pros	**Cons**	**Pros**	**Cons**
Available to the satellite immediately and for any duration	Separate control centers and remote tracking hardware, which adds expense	Supports multiple satellite systems	Network cannot be available to all satellites at all times
Allows for special radio frequencies or high data rates	Unique software and hardware (proprietary) can be more costly	Hardware and software, to include ground antennas and core data processing capabilities, are shared among satellites	Potential delays in gaining access due to prioritization of satellites using shared network
Allows for added security and resiliency	Costs to carry out similar functions, like TT&C, reoccur for every dedicated system	Costs for carrying out similar functions, like TT&C, are shared and consolidated for satellite systems	Entire system must be modified, tested and implemented to every program for any change required by a single program
	Each dedicated system requires personnel that must be trained on the specifics of that system	Less personnel is needed to carry out similar shared functions	Difficult to meet the needs of a large variety of systems within one network
	Difficult to make interoperable and standardized	Greater flexibility to make interoperable and standardized	
	Less likely to use commercial off-the-shelf products	Greater opportunity to use commercial off-the-shelf products	
		Optimizes DOD's investment by more fully/continuously using the hardware and staff	

Source: GAO analysis of DOD documents and interviews.

While each dedicated network optimizes its individual operations, our analysis indicates that multiple dedicated systems are inefficient, because they increase fragmentation and the potential for duplication across DOD satellite control operations, and they are ultimately more expensive for DOD to acquire and operate. This fragmented approach requires more infrastructure and personnel than shared networks, because the dedicated networks often require unique software, separate and possibly unique hardware, and specialized training. As such, dedicated networks that require global access to their satellites will each have to install at least one control center and several ground stations, whereas a shared network could accommodate multiple programs with one control center and a set of global ground sites. Dedicated networks typically require individualized training for their operators, and therefore personnel tend to be specialized to one system, leading to potentially higher overall costs. Satellite operators learn how to use unique software that is not transferable across satellite programs, as well as unique protocols for the various dedicated networks, since they are built by several companies

with no common standards. The current practice is that satellite control operators specialize in functional areas for a specific satellite program. The narrowly focused training associated with this specialization limits satellite and ground system technical knowledge, resulting in heavy reliance on "back room engineering" or experts to diagnose problems. Training people on each of these programs requires time and personnel investment. Thus, a satellite operator who transfers from one satellite program to another will likely have to be retrained because even though the tasks are similar, satellite control operations are conducted differently. Networks established to operate under common standards, or with a common control interface, would likely not need special training.

Air Force's Modernization Efforts May do Little to Improve the Air Force Satellite Control Network

The Air Force has budgeted about $400 million to modernize the AFSCN over the next five years, but the planned upgrades will do little to increase the network's capability.[4] These efforts are mainly focused on sustaining the network at its current level of capability, and ignore more than a decade of research recommending more significant improvements to the AFSCN.

Air Force Spending to Modernize the Air Force Satellite Control Network will do Little to Increase the Network's Capability

The Air Force's approximately $400 million investment in modernizing the AFSCN over the next five years is to extend its life by replacing unsupportable equipment. According to Air Force Space Command officials, these efforts will provide minor capability upgrades that will maintain the aging system, but will not provide material improvements in service.

Specifically, this modernization funding is being spent mainly on two efforts:

- The Electronic Schedule Disseminator (ESD) system, which schedules activities on the network, is to be upgraded from ESD 2.7 to ESD version 3.0. Version 2.7 has been the operational baseline

[4] Modernization means the alteration or replacement of facilities solely to implement new or higher standards, to accommodate new functions, or to replace building components that typically last more than 50 years (such as the framework or foundation), as defined in DOD's *Financial Management Regulation, 7000.14R,* Vol. 2B, Chap. 8, (Dec. 2010).

since 1991 and operates on 1980s computer technology. The ESD upgrade will run on a Microsoft Windows operating system and commercial off the shelf (COTS) hardware. This upgrade is currently underway with a planned completion in mid-2015.

- The Remote Tracking Station Block Change effort is to upgrade existing electronics on the network's ground control computers and antennas to more modern versions on a Microsoft Windows operating system. This upgrade is currently underway and the Air Force plans to have all of its stations upgraded by 2019. The AFSCN is currently using 1980s-era hardware based on the disk operating system.

While not fully funded, the Air Force plans to modify the AFSCN so that it is able to operate on an additional communication frequency, or band. This upgrade is to allow the network to perform data uplinks on both the L-Band and the S-Band, to add greater flexibility and avoid potential sources of interference.[5]

While these modernization efforts are intended to improve the aging system, according to Air Force officials, these measures sustain the system at the current level of performance and do not offer a material improvement in capability. For example, some of the equipment the Air Force is replacing was so outdated that program officials had to search on an online auction site for replacement parts, because they were no longer being sold by manufacturers. Air Force officials said that one reason the new upgrades were not undertaken to provide more capability is that the requirements for the network have not changed, and the Air Force does not want to pay for capabilities above and beyond the established requirements. For example, Air Force officials cited one case where the program acquired a new piece of hardware to replace an outdated piece. The new hardware provided additional capabilities beyond what was called for in the requirements document. However, the added capabilities are being turned off so that the Air Force does not have to pay to maintain them when they are not required. Though it is prudent for programs to only pay for capabilities called for by program requirements, the overall approach of making minor changes to keep the

[5] Bands are groups of radio frequencies that have similar characteristics, such as L-band and S-band. L-band operates at the approximate wavelength range of 30-15 cm (wavelength in centimeters) and approximate frequency of 1-2 GHz (gigahertz), while S-band operates at the approximate wavelength range of 15-7.5 cm and approximate frequency of 2-4 GHz.

system operating with its current capabilities may not be the best use of Air Force funds in the long-term.

The Air Force's actions are somewhat contrary to more than 15 years of government and space industry reports that recommended that the Air Force incorporate newer and more efficient technologies into the AFSCN to improve its capability. As long ago as 1994, Air Force Space Command identified the need for improved satellite control operations capabilities. It cited, among other things, aging equipment and technological opportunities as reasons for needed network upgrades. In 1999, GAO reported[6] that DOD had made minimal progress in integrating and improving its satellite control operations capabilities in accordance with the then 1996 national space policy.[7] More recently, in 2008, the Commander of Air Force Space Command issued a memo describing the need for increased satellite control operations efficiencies, improved interoperability, and consolidated functions. Despite these recommendations having been made over the course of almost two decades, no guidance currently exists directing the Air Force to increase the efficiency or capacity of the AFSCN. Thus, modernization efforts have continued to focus on sustaining systems at current levels of performance. A long-term plan for modernizing the network and any future shared satellite control operations networks could assist DOD in making more informed decisions about investments and whether and to what extent expand satellite control operations capabilities.

[6] GAO, *Satellite Control Systems: Opportunity for DOD to Implement Space Policy and Integrate Capabilities,* GAO/NSIAD-99-81 (Washington, D.C.: May 17, 1999).

[7] *National Space Policy,* Presidential Decision Directive-National Security Council-49/National Science and Technology Council-8 (Sept. 14, 1996). The current policy (*National Space Policy of the United States of America* (June 28, 2010)) does not specifically direct DOD to integrate and improve its satellite control operations.

Commercial Practices Have the Potential to Increase DOD's Satellite Control Operations Efficiencies

Commercial satellite companies that we spoke with incorporate varying degrees of interoperability, automation, and other practices into their satellite control operations networks to decrease programs costs and increase efficiencies. According to Air Force officials, commercial practices could offer the Air Force similar benefits for routine functions. Satellite control operations officials at commercial companies also agree that there is potential for improvement if the Air Force adopts some commercial practices. Furthermore, for over 10 years, government and space industry reports have asserted that commercial practices for satellite control operations may increase the efficiency and effectiveness of government satellite control operations. Although there is ample evidence that these leading commercial practices could generate cost savings and improve efficiency, the Air Force has generally not implemented these practices.

Commercial Satellite Companies have Taken Steps to Lower Costs and Increase Satellite Control Operations Efficiencies

Officials from the seven commercial satellite companies that we spoke with leverage practices such as interoperability and automation to realize cost efficiencies and increase the accuracy of their satellite control operations. Because this industry is extremely competitive, these companies have been reluctant to publicize or share with us specific program costs, though they noted that since their companies are profit-oriented, they would not undertake the various commercial practices if they did not reduce costs and increase efficiency. Specifically, officials from all seven of the commercial companies we spoke with have found some or all of the practices below to be beneficial:

- **Interoperability:** Interoperable satellite control operations networks allow a single operator to control multiple satellites from one terminal, with one software interface, regardless of the satellite's age or manufacturer. For example, one company that we spoke with develops satellite control operations software for multiple companies. One of their software programs is being used to control four satellites, each of which was made by a different contractor, and all four are of different ages.

- **Automation:** All but one of the commercial companies we spoke with use automation of routine functions, such as downloading telemetry data, which allows these companies to reduce the number of operators they need, and can reduce the risk of human errors. One commercial company we spoke with wrote software that allows its customer to leverage automation to operate a fleet of communication satellites with nearly "lights out" operations—needing only one

operator at a time to control 15 satellites.

- **Commercial-off-the-shelf (COTS) products:** All but one of the commercial companies we spoke with agreed that COTS products are less expensive than custom ones and can be modified to meet each company's needs. A number of companies we spoke with take advantage of COTS products, which are also easier to replace when needed. For example, one of the COTS satellite control operations software systems that is used by many commercial satellite operators allows a satellite to be controlled by any company that uses the same software. This can be beneficial when companies buy and sell satellites, or when a company leases out control of its satellite to another company.

- **Hybrid network:** A hybrid network arrangement allows a company to augment its ground network of antennas and control stations by leasing antenna time on another company's network.[8] One company we spoke with has found that using pre-existing physical assets from other providers can be less costly than building and maintaining all of the ground assets they use.

Commercial Practices are Applicable to DOD Satellite Control Operations

While commercial satellites and Air Force satellites can greatly differ in their missions, and to some extent may differ in their need for information security, basic satellite control operations functions of most of these satellites are generally the same, allowing trusted practices from the commercial sector to be applicable to many Air Force satellite programs. Air Force satellite control officials have stated that there are opportunities for increasing efficiencies and reducing costs in Air Force satellite control operations by using these commercial practices. Officials at three of the commercial satellite operations companies we spoke with that have knowledge or experience with DOD satellite control networks, agreed with these statements. The practices mentioned above are trusted and proven in the commercial sector, and incorporating some or all of them may result in improved Air Force satellite control operations. For example:

- **Interoperability:** While implementing an interoperable infrastructure for software and hardware could have a dramatic impact on program costs, many Air Force satellites currently rely on separate interface

[8] At this point, the Universal Space Network (USN) is the only U.S. company that operates a satellite control network as a leased, pay-as-you-go arrangement to customers.

software and hardware to control each kind of satellite. For example, when looking at basic control functions, the control interface for a communications satellite is significantly different from a positioning, navigation, and timing satellite, and even two positioning, navigation, and timing satellites may have different control interfaces, depending on when they were built and what company built them. Making future Air Force satellite programs' satellite control operations interoperable would allow one operator to use a single terminal to control numerous satellites, similar to commercial practices. This could reduce costs associated with purchasing multiple types of software and training the operators on each system, as well as potentially reduce the number of staff required, since one person could operate multiple satellites more easily. One example put forward by an industry group study estimated that increasing interoperability and automation could allow one Air Force satellite control operations group to reduce its operations personnel by 45 percent[9]. Retrofitting existing satellite programs to use common software would likely be cost-prohibitive, but it would be possible for programs under development to be designed and built utilizing standard satellite control operations software programs, allowing for greater flexibility in the future.

- **Automation:** While commercial companies use computer programs to perform routine tasks, the Air Force typically uses human operators. Increasing automation for routine control functions could reduce Air Force personnel costs, and the potential for human errors. According to satellite control operations officials at Air Force Space Command, the use of automation in Air Force satellite control network is discouraged by the risk averse culture of the service.

- **COTS products:** Basic satellite control operations software programs exist on the market that could be modified to meet the Air Force's needs, but the Air Force continues to purchase custom software solutions. Specialized software systems are usually expensive and often take longer to develop than planned. Not only are customized systems expensive to acquire, they are also proprietary to the company that developed them, requiring the Air Force to use the original contractor for any follow-up modifications to the software.

[9] National Defense Industrial Association, *2007 Summer Study – AFSPC Satellite Operations Enterprise Assessment.* December 19, 2007.

- **Hybrid networks:** Although the Air Force has selectively and sparingly used commercial networks for some satellite control operations, it has no future plans to regularly use any commercial antennas or control centers for its satellite control operations. The Air Force by necessity has very high standards for security and reliability, and Air Force officials have said that these security standards are higher than those of private sector space systems. However, officials from the commercial companies we spoke with that have used this practice told us that they have similarly high security standards to the Air Force, and have been able to effectively use hybrid networks. Both large defense contractors and space agencies in other countries use second party providers for some of their satellite control operations. Also, the National Aeronautics and Space Administration (NASA) has embraced a hybrid system for its Near Earth Network, and although it owns and operates some control stations, NASA has seen benefits from contracting out its service in other locations. According to NASA officials, there were cost avoidances associated with not building satellite tracking stations in geographical areas where mission requirements were minimal. In this case, a commercial network was able to provide the necessary capabilities to augment NASA's network with a lower cost alternative. According to NASA officials, obtaining geographically diverse support from commercial providers enables NASA to avoid some infrastructure costs. Although NASA was unable to quantify the exact cost savings from using hybrid networks, one commercial company who provides services to NASA estimated the use of commercial networks reduced NASA's operations and maintenance cost by about 30 percent with very low mission risk. According to Air Force Space Command satellite control operations officials, the Air Force has not yet explored this possibility. Air Force officials acknowledged that they may be missing out on an inexpensive way to improve their satellite control operations at a low cost, though said that security issues, such as handling of classified data, would have to be addressed to the Air Force's satisfaction to make this a possibility.

Over a Decade of Government and Industry Research Supports Applying Commercial Practices to DOD's Satellite Control Operations

Government and space industry reports for over 10 years have reported that commercial practices for satellite interoperability may increase the efficiency and effectiveness of government satellite control operations, and many of these studies have recommended that DOD adopt these practices. Since 1996, a number of reports by government and industry groups have described opportunities for Air Force satellite control operations to improve their efficiency through methods such as interoperability between satellite control networks and the adoption of

commercial practices. These reports generally concluded that there are numerous opportunities for improvement in Air Force satellite control operations in the near- and long-term as indicated in figure 6.

Figure 6: Past Government and Industry Studies on Opportunities to Improve Satellite Control Operations

Year	Report	Automation	Interoperability	Use of commercial practices/ products
1996	GAO Report, "Satellite Control Capabilities: National Policy Could Help Consolidation and Cost Savings"		●	●
1998	Air Force Science Advisory Board Report, "A Space Roadmap for the 21st Century Aerospace Force"	●	●	●
1999	GAO Report, "Satellite Control Systems: Opportunity for DOD to Implement Space Policy and Integrate Capabilities"		●	●
1999	National Security Space Architect Satellite Operations Study	●	●	●
2003	American Institute of Aeronautics and Astronautics, "Satellite Mission Operations Best Practices"	●	●	●
2007	National Defense Industrial Association Summer Study-AFSPC Satellite Operations Enterprise Assessment	●	●	●
2009	Air Force Satellite Command and Control Compatibility Study		●	●

Source: GAO analysis of a sample of government and industry reports since 1996.

DOD has Generally Not Implemented Commercial Practices

Though Air Force officials, management at commercial companies, and a decade of government research agree that there are opportunities to use commercial practices in Air Force satellite control operations, the Air Force has generally not implemented these practices. Efforts to implement commercial practices have been discussed, and in some cases initial steps to initiate changes have been taken, but the Air Force has not followed through with their implementation. For example, the Air Force participates in the annual Ground Systems Architecture Workshop, where experts in the field gather to discuss ground system issues and

collaborate on solutions, but according to Air Force officials, few if any of the solutions discussed have been implemented. In addition, DOD initiated the SATOPS (satellite operations) Enterprise Transformation effort in 2011 to reduce duplication, improve interoperability, enable consolidation, and move to more efficient satellite control operations. However, one of the new technologies that was planned as part of this effort, a new type of antenna, has not been proven to be cost effective, and progress appears to be stalled overall on the proposed improvements, resulting in no change to the way the Air Force conducts its satellite control operations.

DOD Faces Barriers to Making Improvements to its Satellite Control Networks and Adopting Commercial Practices

While opportunities exist to improve DOD satellite control operations, there are also barriers that hinder DOD's ability to make these improvements. These barriers exist at both at the program level and at higher management levels within DOD, and include: the lack of a long-term plan for satellite control; limited insight into satellite control operations spending; no existing requirement to establish a business case for a program's satellite control operations approach; and lack of autonomy at the program level to implement satellite control operations improvements. In particular:

- **DOD does not have a long-term plan for satellite control operations.** Several DOD officials we spoke with stated that although they believe there are efficiencies to be gained from alternative ways of performing satellite control, there is nothing prompting them do things differently. Furthermore, they stated that there is no DOD-wide guidance or long-term plan that directs or supports the implementation of alternative methods for performing satellite control operations. In addition, DOD does not have plans to transition its dedicated networks to shared networks. Instead, the agency plans to continue deploying dedicated networks, in part because it is not required to justify whether a shared or dedicated network best meets overall requirements. However, we found that there have been some plans to evolve future satellite operations centers to be more integrated and interoperable. For example, in an Air Force briefing from June 2007, plans were depicted to evolve stove-piped centers—where each satellite program procures its own TT&C system—to centers where compatible systems share TT&C services. In addition, in December 2008, the Air Force Space Command Commander issued a memorandum on its intent for an Air Force Satellite Operations Enterprise Architecture Transformation. The Commander cited fiscal realities, operational efficiencies and emerging threats as reasons for

reevaluating how satellite operations, to include satellite control, are conducted for on-orbit systems. However, Air Force officials told us that other than the current, limited AFSCN modernization efforts, there are no other current plans in place to update or modernize the capabilities of the network, and at this time, according to Air Force documents, there is no end-of-life or follow-on projected for the network, either.

- **DOD is unable to quantify all spending on satellite ground control operations across DOD programs.** DOD is unable to identify all funding for satellite control operations across all DOD satellite programs. Programs have not needed to keep track of budgets by dividing satellite control operations funding out from other satellite mission funding since the focus has been on dedicated ground control networks. However, without knowing how much it spends on basic satellite control operations for all of its satellites, DOD cannot calculate the potential savings or perform a cost/benefit analysis of any future changes to satellite control operations. Each of the individual satellite programs with a dedicated ground system manages and reports that program's satellite control operations budget separately from AFSCN funding. These budget reports do not separate the satellite control operations funding from other program funds, such as those expended on mission data. Furthermore, the way that programs are budgeted and organized makes it onerous for them to determine how much of their budget is spent on satellite control operations. It can be particularly challenging when programs use the same communication paths and staff for satellite control operations and mission data transfers, or when a satellite ground control center controls multiple systems, because program costs are accounted for as a whole for these functions. For example, the Navy's Mobile User Objective System (MUOS) program office officials said that MUOS uses the same communications paths for both the satellite control operations and the mission data commands. As a result, determining how much of the communication time is spent on satellite control operations versus mission data would be hard to do accurately. In addition, three satellite constellations are controlled from the same Navy satellite operations center using the same people and same equipment. To determine how much time spent on each piece of equipment by each person in order to divide the funding between the three systems would be difficult to do with any degree of reliability. Similarly, the Defense Meteorological Satellite Program sends communications for both satellite control operations and mission data simultaneously over the same routes. The program utilizes commercial circuits for this, and pays for these connections

under the same invoice, with no way to determine how much would be allocated to satellite control operations and to mission data. However, it may be possible to track costs associated with satellite control operations through the program's individual work breakdown structure which is the cornerstone of every program because it defines in detail the work necessary to accomplish a program's objectives. Establishing a work breakdown structure to track weapon system acquisition costs is a best practice because it allows a program to track cost and schedule by defined deliverables.[10]

- **Satellite programs are not required to present a business case when choosing to develop a dedicated network**. Air Force satellite program officials are currently free to choose the satellite control network type that best suits their program without needing to justify that choice. Without the requirement to weight potential compromises in performance with potential reductions in cost, most new programs are choosing to build a dedicated network. For some satellite programs, having a dedicated satellite control operations network might still be the most efficient choice, due to unique mission requirements. However, programs are not required to conduct an analysis to determine a business case for proceeding with a dedicated or shared network, or to validate their network's requirements[11]. Currently, the lack of cost data means that DOD cannot perform a cost-benefit analysis to determine whether the potential benefits of individual programs using dedicated networks outweighs the potential drawbacks of continued and even increased systemic fragmentation and inefficiency. Without a cost-benefit analysis, DOD has a less compelling business case for its current approach for acquiring satellite control networks and cannot strategically determine if its

[10] GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (Supersedes* GAO-07-1134SP*),* GAO-09-3SP (Washington D.C.: Mar 2, 2009).

[11] While business case analyses are required for milestone B certification of major defense acquisition programs, which is approval to enter system development, there is not a specific requirement or policy to analyze whether or not to use a shared satellite control operations network. 10 U.S.C. §2366b (a); DOD Instruction 5000.02, Encl. 2, §6 (c) (5) (Dec. 8, 2008). DOD Directive Type Memorandum (DTM) 09-027, "Implementation of Weapon Systems Acquisition Reform Act of 2009," (Dec. 4, 2009, incorporating Change 4, Jan. 11, 2013). Major defense acquisition programs are those estimated by DOD to require an eventual total expenditure for research, development, test, and evaluation of more than $365 million, or for procurement of more than $2.19 billion, including all planned increments or spirals, in fiscal year 2000 constant dollars.

current options of shared and dedicated networks are the best option or whether other options, such as hybrid networks, might be better suited to meet its satellite control operational needs.

GAO's Cost Estimating and Assessment Guide states that a business case analysis or a cost-benefit analysis seeks to find the best value solution by linking each alternative to how it satisfies a strategic objective. This linkage is achieved by developing business cases that present facts and supporting details among competing alternatives, including the life cycle costs and quantifiable and non-quantifiable benefits. Specifically, each alternative should identify: (1) relative life cycle costs and benefits; (2) methods and rationale for quantifying the life cycle costs and benefits; (3) effect and value of cost, schedule, and performance trade-offs; (4) sensitivity to changes in assumptions; and (5) risk factors.[12] DOD guidance regarding economic analysis similarly encourages the use of sensitivity analysis, a tool that can be used to determine the extent to which costs and benefits change or are sensitive to changes in key factors; this analysis can produce a range of costs and benefits that may provide a better guide or indicator than a single estimate.[13] While historical trends show a move away from shared networks to dedicated networks, AFSCN, the largest shared network, is currently undergoing expensive efforts to sustain the networks capabilities. This is happening at the same time that DOD is planning on building new dedicated networks for upcoming satellite programs. These are large investments for DOD, and approaching them without a thorough analysis of the options for satellite control operations may lead to wasted money and missed opportunities to reduce fragmentation and increase satellite control operations efficiencies.

- **Satellite programs do not have the autonomy to implement improvements to satellite control operations.** It is difficult to implement improvements to satellite control operations practices, because changes must be initiated at a level higher than at the individual program-level. According to Air Force officials, even if an

[12] GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (Supersedes* GAO-07-1134SP*),* GAO-09-3SP (Washington D.C.: Mar 2, 2009).

[13] See Department of Defense Instruction No. 7041.3, *Economic Analysis for Decisionmaking*, E3.A1, (Nov. 7, 1995).

individual satellite program's managers wanted to begin to incorporate commercial practices, they have limited flexibility to do so. We reported above that DOD allows programs to begin without establishing a business case resulting in program managers not being well-positioned to successfully execute a weapon acquisition. Program officials are required to adhere to established program requirements, and many such requirements do not allow for these improvements. For example, Air Force officials cited one case where the program acquired a new piece of hardware to replace an outdated piece. The new hardware provided additional capabilities beyond what was called for in the requirements document. However, the added capabilities are being turned off so that the Air Force does not have to pay to maintain them when they are not required. In addition, according to Air Force Space Command officials, some DOD satellite program managers prefer to have satellite control networks that are optimized for their specific mission needs and are wary of introducing alternative ways of doing business, such as automation and interoperability into satellite systems. Officials explained that concerns about information security, automation errors, and a lack of desire to change the status quo, keep programs from implementing changes that they feel might threaten their missions. Information security in particular is of concern for the Air Force. According to Air Force officials, satellite control operations are highly dependent on accurate and precise information, and security threats such as introduction of malicious code to the system or interception of sensitive data could pose significant risks to the satellite's mission. The perception that a large upfront investment would be needed to implement new satellite operation practices likely make the status quo of dedicated networks the preferred acquisition approach going forward. In addition, the time that would be needed to develop a shared system with increased automation, for example, also likely makes the status quo more appealing.

Conclusions

DOD's current array of satellite control networks favor dedicated systems that have been largely shaped by past practices. Dedicated networks are the default option because they offer custom solutions for each satellite system. For this reason, there have been and will continue to be good reasons for having dedicated networks. However, opting for dedicated systems does not form a clear approach for acquiring satellite control networks that are a result of analysis, not a presumption. Given the prevalence of dedicated networks, DOD has had long-standing difficulty in effectively implementing improvements across its varied satellite control operations which has hindered its ability to achieve significant

results in this area. At the moment, DOD lacks the incentive to change its current practices, in part, because it does not know the total cost associated with its satellite control operations, though it is currently spending millions on modernization efforts. Numerous studies, commercial practices, and fiscal constraints all offer compelling reasons for DOD to take a fresh look in how it designs and invests in control networks. But several barriers have maintained the status quo, to include the lack of a long-term plan, an aversion to risk, and no cost visibility. Thus, by developing a plan for modernizing its shared satellite control operations networks, DOD could be better positioned to address barriers, reduce fragmentation, and increase efficiencies.

Recommendations for Executive Action

To better facilitate the conduct of satellite control operations and accountability for the estimated millions of dollars in satellite control investments, and to reduce fragmentation, we recommend that the Secretary of Defense take the following two actions:

1. Conduct an analysis at the beginning of a new satellite acquisition to determine a business case for proceeding with either a shared or dedicated satellite control system, to include its associated ground antenna network. The analysis should include a comparison of total dedicated network costs to the incremental cost of integrating onto a shared network to determine applicable cost savings and efficiencies.

2. Develop a department-wide long-term plan for modernizing its Air Force Satellite Control Network and any future shared satellite control services and capabilities. This plan should identify methods that can capture or estimate satellite control costs as well as authorities that can be given to the program managers to give them the flexibility needed to ensure ground systems are built to a common network when the business case analysis shows it to be beneficial. This plan should also identify which commercial practices, if any, can improve DOD satellite control operations in the near- and long-term, and as appropriate, develop a plan of action for implementing them.

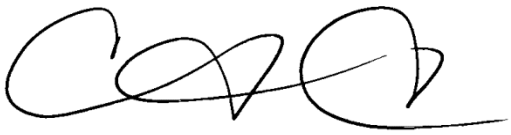
Agency Comments

We provided a draft of this report to DOD for comment. In its written comments, DOD concurred with our two recommendations. The comments are reprinted in appendix II. DOD also provided technical comments which were incorporated as appropriate.

In concurring with our recommendations, DOD agreed that efficiencies can be gained from investing in shared satellite control operations networks, with a goal of reducing duplication and improving interoperability among networks. DOD also agreed that developing a long-term, department-wide plan for modernizing satellite control operations is needed. DOD noted that both of GAO's recommendations are similar to concepts endorsed by the Air Force, Army, and Navy, and DOD plans to initiate a comprehensive Satellite Operations Enterprise Architectural Analysis to serve as a foundation to define requirements for planning new satellite program acquisitions.

We are sending copies of this report to the appropriate congressional committees; the Secretary of Defense; the Secretaries of the Air Force, Navy, and Army; and other interested parties. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff 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. GAO staff who made key contributions to this report are listed in appendix III.



Cristina Chaplain
Director
Acquisition and Sourcing Management

List of Committees

The Honorable Carl Levin
Chairman
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United States Senate

The Honorable Dick Durbin
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House of Representatives

The Honorable C.W. Bill Young
Chairman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Scope and Methodology

Our review focused on the ground networks used to perform satellite control operations. As such, we reviewed relevant satellite control upgrades, and sustainment and modernization efforts for the Air Force, Navy and Army to determine the potential for fragmentation or duplication. We reviewed satellite control plans, requirements, budgets, and studies associated with current and future capabilities. We developed an inventory of key satellite programs to enable a comparison of satellite control operations types, attributes, and funding. To identify any potential for fragmentation and duplication, we assessed military service investments in satellite control operations, acquisitions, and capabilities, and reviewed prior GAO work for relevant criteria.[1] We also used the information associated with various aspects of the modernization efforts, and actual or planned satellite control operations capabilities, to assess whether any of the efforts were potentially duplicative. We analyzed documentation and interviewed officials from various offices of the Secretary of Defense, to include the Office of the Deputy Assistant Secretary of Defense for Communications, Command and Control and Cyber, Air Force, Navy, Army, and National Reconnaissance Office (NRO). We did not, however, review NRO systems, budgets, or requirements, but did obtain perspectives on satellite operations from the NRO, which could not be incorporated due to their classification. We also determined the extent to which various aspects of the modernization efforts were duplicative by reviewing briefings on satellite control operations and obtaining status updates from Air Force, Navy, and Army officials.

To assess the status of modernization efforts and the costs associated with current and planned upgrades and sustainment efforts for the Air Force Satellite Control Network (AFSCN) and other services' satellite control efforts, we reviewed the military services' satellite operations budget documents for fiscal years 2011 through 2017. Specifically, we obtained budget documentation from the Office of the Under Secretary of Defense (Comptroller) for all 7 years. Based on our review of budget information we collected from agencies that we contacted as well as from

[1] For the purposes of our analysis, we considered "duplication" to occur when two or more agencies or programs are engaged in the same activities or provide the same services to the same beneficiaries. We considered "fragmentation" to occur when more than one federal agency (or more than one organization within an agency) is involved in the same broad area of national need and there may be opportunities to improve how the government delivers these services.

presidential budget estimates, we determined that the AFSCN was the largest satellite control operations network within DOD and that the Air Force was responsible for most satellite control programs. We interviewed AFSCN officials and asked for an explanation and description of each planned upgrade, sustainment and modernization effort. We reviewed documentation and interviewed officials on the status, technology, and actual or planned operational characteristics. We reviewed and analyzed the budget documents and program documentation to determine how the Air Force defined and was proceeding with its modernization efforts for the AFSCN and interviewed DOD officials. We also reviewed our prior reports on satellite control operations to gain a better understanding of the progress DOD has made on its satellite control operations.[2]

To determine which commercial practices could benefit the Air Force's satellite control operations, we conducted internet searches and attended conferences on the related subject matter to identify potential companies to participate. We then selected a nongeneralizable sample of 13 commercial companies that are known in the space community to operate satellites and have knowledge of satellite control operations and based on their satellite constellation size, orbit and capabilities. We asked the 13 companies to provide information on how they perform or build their satellite control operations and capabilities. Of the 13 companies we contacted, we received detailed information from 7. We interviewed officials from these commercial companies and reviewed documentation on their practices associated with satellite control operations and compared and contrasted them with Air Force practices. We interviewed key personnel and reviewed company data to compile a list of potential practices that could be employed by the Air Force to improve its satellite operations. Based on interviews and reviews of commercial documentation and DOD reports on satellite control operations, we determined that specific commercial practices—such as automation and commercial off- the-shelf products—may be beneficial to DOD satellite programs. It should be noted that the commercial practices used by the companies that we included in our review align with practices that other satellite industry companies, as well as DOD, have cited as beneficial for

[2] GAO, *Satellite Control Systems: Opportunity for DOD to Implement Space Policy and Integrate Capabilities*, GAO/NSIAD-99-81 (Washington D.C.: May 17, 1999). GAO, *Satellite Control Capabilities: National Policy Could Help Consolidation and Cost Savings,* GAO/NSIAD-96-77 (Washington D.C.: May 2, 1996).

improving the effectiveness of satellite control operations. Our assessment of the applicability of satellite control operations practices adopted by commercial companies is focused primarily on unclassified DOD satellite programs and may not be applicable to classified NRO systems.

To identify any potential barriers to the implementation of commercial practices, we reviewed reports and documentation, such as the National Defense Industrial Association (NDIA) 2007 Summer Study –AFSPC Satellite Operations Enterprise Assessment and briefings from the Ground Systems Architectures Workshop and interviewed officials from the organizations mentioned above. We interviewed commercial company officials with prior military service and Air Force officials, given that the Air Force Satellite Control Network is DOD's largest satellite control network. We reviewed our prior reports to compare and contrast previous DOD efforts to improve satellite control operations.[3] In doing so, we were able to identify if DOD had improved its operations, or if barriers persisted. We used the information to assess whether barriers had affected the funding, cost, schedule, and performance of satellite control operations.

[3] GAO, *Satellite Control Systems: Opportunity for DOD to Implement Space Policy and Integrate Capabilities*, GAO/NSIAD-99-81 (Washington D.C.: May 17, 1999). GAO, *Satellite Control Capabilities: National Policy Could Help Consolidation and Cost Savings,* GAO/NSIAD-96-77 (Washington D.C.: May 2, 1996).

Appendix II: Comments from the Department of Defense

ASSISTANT SECRETARY OF DEFENSE
30150 DEFENSE PENTAGON
WASHINGTON, DC 20301-3015

ACQUISITION

Ms. Cristina Chaplain
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G Street, N.W.
Washington, DC 20548

040813

Dear Ms. Chaplain:

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, GAO-13-315, "SATELLITE CONTROL: Long-Term Planning and Adoption of Commercial Practices Could Improve DOD's Operations," dated April 2013 (GAO Code 121074). Detailed comments on the report recommendations are enclosed.

Sincerely,

Katrina McFarland

Enclosure:
As stated

GAO DRAFT REPORT DATED APRIL 2013
GAO-13-315 (GAO CODE 121074)

"SATELLITE CONTROL: LONG-TERM PLANNING AND ADOPTION OF COMMERCIAL PRACTICES COULD IMPROVE DOD's OPERATIONS"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommends that the Secretary of Defense conduct an analysis at the beginning of a new satellite acquisition to determine a business case for proceeding with either a shared or dedicated satellite control operations network. The analysis should include a comparison of total dedicated network costs to the incremental cost of integrating onto a shared network to determine applicable cost savings and efficiencies.

DoD RESPONSE: CONCUR. The DoD concurs with conducting an analysis at the beginning of a new satellite acquisition to ensure ground systems development and operations are horizontally integrated when the business case analysis shows it to be beneficial.

The DoD acknowledges efficiencies can be gained from investing in shared satellite control operations networks, and concurs with the objective to reduce duplication, foster consolidation, improve interoperability and transform toward more efficient satellite operations (SATOPS). Recommendation 1 is consistent with concepts endorsed and employed by the Navy and Army, as well as Air Force Space Command's (AFSPC) enterprise transformation objectives.

Accordingly, the Office of the Secretary of Defense will work with the services to identify resources to initiate a comprehensive SATOPS Enterprise Architectural Analysis to provide a foundation define requirements for new satellite program acquisitions and ultimately satisfy this recommendation. Furthermore, analysis will enable the DoD to incorporate unique vulnerability analysis and risk assessments. While the GAO report does not specify security as a key SATOPS element, it is a critical issue to consider when building business case analysis for national security satellite acquisitions.

RECOMMENDATION 2: The GAO recommends that the Secretary of Defense develop a department-wide long-term plan for modernizing its Air Force Satellite Control Network (AFSCN) and any future shared satellite control operations networks. This plan should identify methods that can capture or estimate satellite control costs as well as authorities that can be given to the program managers to give them the flexibility needed to ensure ground systems are built to a common network when the business case analysis shows it to beneficial. This plan should also identify which commercial practices, if any, can improve DOD satellite control operations in the near- and long-term, and as appropriate develop a plan of action for implementing them.

DoD RESPONSE: CONCUR. The DoD concurs with this recommendation. A long-term, department-wide plan for modernizing its SATOPS enterprise, including the AFSCN and analogous satellite control functions within the DoD is needed.

Regarding the AFSCN, Recommendation 2 is consistent with concepts endorsed and employed by the Navy and Army, as well as Air Force Space Command's (AFSPC) enterprise transformation objectives. Additionally, the DoD supports modernization research and development and integrations efforts such as those currently underway at Air Force Space and Missile Systems Center and the Naval Satellite Operations Center, and will seek to capture the best practices from these efforts to include commercial practices.

Furthermore, the DoD recognizes that the paths to achieve both GAO recommendations are congruent, and asserts that the same foundational analysis will be required for each. As such, the DoD will leverage the aforementioned SATOPS Enterprise Architectural Analysis as a blueprint toward addressing the specific objectives of Recommendation 2.

Appendix III: GAO Contacts and Staff Acknowledgments

GAO Contact

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

Staff Acknowledgements

In addition to the contact named above, Arthur Gallegos, Assistant Director; Marie P. Ahearn; Maricela Cherveny; Danielle Greene; Laura Hook; Ioan Ifrim; Angela Pleasants; and Roxanna T. Sun made key contributions to this report.