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May 2011

SPACE ACQUISITIONS

Development and Oversight Challenges in Delivering Improved Space Situational Awareness Capabilities

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Highlights

Highlights of GAO-11-545, a report to the subcommittee on Strategic Forces, Committee on Armed Services, House of Representatives

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SPACE ACQUISITIONS

Development and Oversight Challenges in Delivering Improved Space Situational Awareness Capabilities

Why GAO Did This Study

The United States' growing dependence on space systems makes them vulnerable to a range of threats. DOD has undertaken a variety of initiatives to provide space situational awareness (SSA)—the knowledge and characterization of space objects and the environment on which space operations depend. GAO was asked to (1) review key systems being planned and acquired to provide SSA, and their progress meeting cost, schedule, and performance goals; and (2) determine how much an integrated approach is being used to manage and oversee efforts to develop SSA capabilities. To achieve this, GAO analyzed documentation and interviewed key officials on major SSA development efforts and oversight and management of SSA. This report is an unclassified version of a classified report issued in February 2011.

What GAO Recommends

GAO recommends that DOD assure—in approving the Space Fence and JMS acquisition efforts to initiate product development—that all critical technologies are identified and matured, and that other key risks have been fully assessed. If DOD determines that the programs should move forward with less mature technologies, DOD should assess available backup technologies and additional resources required to meet performance objectives. DOD agreed with the first recommendation and partially agreed with the second. GAO continues to believe DOD should assess required resources earlier than its stated intent.

View GAO-11-545 or key components. For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

What GAO Found

DOD has significantly increased its investment and planned investment in SSA acquisition efforts in recent years to address growing SSA capability shortfalls. Most efforts designed to meet these shortfalls have struggled with cost, schedule, and performance challenges and are rooted in systemic problems that most space acquisition programs have encountered over the past decade. Consequently, in the past 5 fiscal years, DOD has not delivered significant new SSA capabilities as originally expected. To its credit, the Air Force recently launched a space-based sensor that is expected to appreciably enhance SSA. However, two critical acquisition efforts that are scheduled to begin development within the next 2 years—Space Fence and the Joint Space Operations Center Mission System (JMS)—face development challenges and risks, such as the use of immature technologies and planning to deliver all capabilities in a single, large increment, versus smaller and more manageable increments. It is essential that these acquisitions are placed on a solid footing at the start of development to help ensure their capabilities are delivered to the warfighter as and when promised. GAO has consistently recommended that reliable acquisition business cases be established, such as maturing technologies prior to development start, utilizing evolutionary development, and stabilizing requirements in order to reduce program risks. For efforts that move forward with less mature technologies, assessments of the cost, schedule, and performance implications of utilizing backup technologies, if they exist, could provide the knowledge needed to determine whether the efforts are worth pursuing or the investment trade-offs that may need to be made. DOD plans to begin delivering other new capabilities in the coming 5 years, but it is too early to determine the extent to which these additions will address capability shortfalls.

There are significant inherent challenges to executing and overseeing the SSA mission, largely due to the sheer number of governmentwide organizations and assets involved in the mission. Additionally, while the recently issued National Space Policy assigns SSA responsibility to the Secretary of Defense, the Secretary does not necessarily have the corresponding *authority* to execute this responsibility. However, actions, such as development of a national SSA architecture, are being taken that could help facilitate management and oversight governmentwide. The National Space Policy, which recognizes the importance of SSA, directs other positive steps, such as the determination of roles, missions, and responsibilities to manage national security space capabilities and the development of options for new measures for improving SSA capabilities. Furthermore, the recently-issued National Security Space Strategy could help guide the implementation of the new space policy. GAO has recommended since 2003 that such a strategy be issued. Finally, though the commercial sector and the international community are to play a pivotal role in the SSA mission, it is too early to tell whether DOD's efforts to expand and make permanent its Commercial and Foreign Entities SSA data-sharing pilot program will be effective in integrating efforts to develop SSA capabilities.

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Abbreviations

AFSSS	Air Force Space Surveillance System
ALCOR	Advanced Research Projects Agency Lincoln C-Band Observables Radar
ALTAIR	Advanced Research Projects Agency Long Range Tracking and Instrumentation Radar
ARPA	Advanced Research Projects Agency
ASD/NII	Assistant Secretary of Defense for Networks and Information Integration

BMEWS	Ballistic Missile Early Warning System
CDD	capability development document
COTS	commercial off-the-shelf
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
FY	fiscal year
GEODSS	Ground-Based Electro-Optical Deep Space System
GOTS	government off-the-shelf
HUSIR	Haystack Ultra-Wideband Satellite Imaging Radar
JMS	Joint Space Operations Center Mission System
JSpOC	Joint Space Operations Center
KPP	key performance parameter
MMW	Millimeter Wave
MOSS	Morón Optical Space Surveillance
MSSS	Maui Space Surveillance System
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NSSO	National Security Space Office
ODNI	Office of the Director of National Intelligence
OPAF	other procurement, Air Force
PARCS	Perimeter Acquisition Radar Attack Characterization System
PAVE PAWS	PAVE Phased Array Warning System
RAIDRS	Rapid Attack Identification Detection and Reporting System
RCS	radar cross section
RDT&E	research, development, test, and evaluation
SBSS	Space Based Space Surveillance
SLEP	service life extension program
SOI	space object identification
SPADOC	Space Defense Operations Center
SSA	space situational awareness
SSN	Space Surveillance Network
SST	Space Surveillance Telescope
TRADEX	Target Resolution and Discrimination Experiment
TRL	technology readiness level
UHF	ultra high frequency

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United States Government Accountability Office
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May 27, 2011

The Honorable Michael R. Turner
Chairman
The Honorable Loretta Sanchez
Ranking Member
Subcommittee on Strategic Forces
Committee on Armed Services
House of Representatives

The United States' growing dependence on space systems for its security and well-being—such as for missile warning; intelligence, surveillance, and reconnaissance; communications; scientific research; weather and climate monitoring; and positioning, navigation, and timing—makes these systems vulnerable to a range of intentional and unintentional threats. These threats range from adversary attacks such as antisatellite weapons, signal jamming, and cyber attacks, to environmental threats such as harsh temperatures, radiation, and collisions with debris and other man-made or natural objects, which have been increasing rapidly over the past several years. While the Department of Defense's (DOD) space surveillance network tracked about 4,600 objects in 1980, it currently tracks more than 22,000. It is therefore becoming increasingly important for the U.S. government to have sufficient space situational awareness (SSA), defined by the interim report of the Space Posture Review as "the requisite foundational, current and predictive knowledge and characterization of space objects and the operational environment upon which space operations depend."[1]

DOD has undertaken, over a period of years, a number of ground- and space-based efforts to provide SSA. Accordingly, you asked us to (1) review key systems being planned and acquired to provide SSA, with focus

[1] *Space Posture Review Interim Report* (March 12, 2010). Section 913 of the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009 directed the Secretary of Defense and the Director of National Intelligence to jointly conduct a comprehensive review of the space posture of the United States, including, among other things, the definition, policy, requirements, and objectives for space situational awareness. Pub. L. No. 110-417, § 913 (2008). The full definition for SSA contained in this report is "the requisite foundational, current and predictive knowledge and characterization of space objects and the operational environment upon which space operations depend—including physical, virtual, information, and human domains—as well as all factors, activities, and events of all entities conducting, or preparing to conduct, space operations."

on their progress in meeting cost, schedule, and performance goals; and (2) determine the extent to which an integrated approach is being used to manage and oversee efforts to develop SSA capabilities.

To review key systems being planned and acquired to provide SSA, we examined development of acquisition efforts that are expected to deliver large gains in capability in fiscal years 2010 through 2015, including new SSA sensor systems, SSA sensor upgrade and life-extension efforts, and the development of a new space command and control system that is to integrate data and provide real-time SSA information. In doing so, we analyzed documentation and interviewed officials on the status and progress of SSA development efforts in areas such as requirements, budgets, cost, funding, schedule, contracting, technology maturation, testing, and personnel. Using criteria we developed through our best practices work on commercial sector acquisitions, we assessed the levels of knowledge acquisition efforts had attained at their current development stages and related risks.[2] For example, we have found that fully maturing technologies critical to the success of an acquisition program prior to beginning product development, following an incremental development path toward meeting user needs, and matching available resources (that is, technology, time, money, and people) to requirements at program start can significantly reduce risks to achieving cost, schedule, and performance goals. To determine whether a program is following this practice, we reported the readiness of critical technologies (as assessed by DOD), using technology readiness levels, a metric originally developed by the National Aeronautics and Space Administration (NASA) and used across space programs.

To determine the extent to which an integrated approach is being used to manage and oversee efforts to develop SSA capabilities, we analyzed documents and interviewed officials from 30 organizations within the SSA stakeholder community—users and providers of SSA information represented by DOD, the intelligence community, civil government agencies, and commercial industry—to examine (1) management and oversight efforts to develop, acquire, and manage SSA capabilities; and (2) planning activities for SSA architectures, investments, and requirements. We also analyzed documentation and interviewed DOD and commercial industry officials relating to DOD's implementation of its SSA sharing mission (formerly the Commercial and Foreign Entities pilot program)

[2] Our best practices reviews are identified in related GAO products at the end of this report.

under which SSA information is to be shared among DOD, industry, and foreign entities for collision avoidance purposes. Our work is based on the most current information available as of October 1, 2010. In February 2011, we reported to you on the results of our work in a classified report. This report is an unclassified version of that report. We excluded all information that DOD identified as being classified or sensitive in nature which must be protected from public disclosure. This included certain specific information relating to SSA mission and challenges.

We conducted this performance audit from October 2009 to December 2010 in accordance with generally accepted government auditing standards.[3] 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 objectives, scope, and methodology are provided in appendix I.

Background

According to DOD and the Office of the Director of National Intelligence (ODNI),[4] the space domain is becoming increasingly congested, contested, and complex. Consequently, space systems are increasingly vulnerable to a variety of intentional and unintentional threats, such as radio frequency interference (including jamming); laser dazzling and blinding; kinetic intercept vehicles; ground system attacks; an increase in the number of orbiting space objects (including active and inactive satellites, spent rocket bodies, and other fragments and debris); and space weather environmental effects. The government's SSA efforts are designed to mitigate these threats via a variety of space- and ground-based sensors and systems that detect, track, and characterize space objects and space-related events and forecast which assets may be at risk. Recent events, such as the January 2007 Chinese antisatellite weapon test—when China

[3] While we completed audit work in December 2010, DOD's security classification review postponed the release of the classified version of this report until February 2011.

[4] The National Security Intelligence Reform Act of 2004 created a Director of National Intelligence to head the U.S. intelligence community, serve as the principal intelligence adviser to the President, and oversee and direct the implementation of the National Intelligence Program. Pub. L. No. 108-458, § 1011(a) (codified at 50 U.S.C. §§ 403,403-1). The U.S. intelligence community is a federation of 16 different defense and nondefense intelligence agencies that carries out intelligence activities necessary for the conduct of foreign relations and the protection of national security.

used a missile to destroy one of its old weather satellites—and the February 2009 collision between an operational Iridium commercial communications satellite and a nonfunctioning Russian communications satellite, have created thousands of additional debris objects and called attention to the need for better SSA capabilities. SSA is fundamental to conducting space operations and forms the foundation for accomplishing space control, which DOD defines as operations to ensure freedom of action in space for the United States and its allies, and when directed, denying an adversary freedom of action in space.

Organizational SSA Responsibilities and Requirements

Top-level guidance for SSA efforts includes the Administration's 2010 National Space Policy of the United States of America—a Presidential Policy Directive that establishes overarching national policy that governs the conduct of U.S. space activities—and the Department of Defense's 2006 Space Control Joint Capabilities Document. The National Space Policy states that the Secretary of Defense and the Director of National Intelligence shall maintain and integrate space surveillance, intelligence, and other information to develop accurate and timely SSA, as well as to improve, develop, and demonstrate, in cooperation with relevant departments and agencies and commercial and foreign entities, the ability to rapidly detect, warn, characterize, and attribute natural and man-made disturbances to space systems of U.S. interest.

The National Space Policy assigns the Secretary of Defense the responsibility, with support from the Director of National Intelligence, for the development, acquisition, operation, maintenance, and modernization of SSA capabilities governmentwide. It assigns the Director of National Intelligence the responsibility for providing robust, timely, and effective collection, processing, analysis, and dissemination of information on foreign space and supporting information system activities and for integrating all-source intelligence of foreign space capabilities and intentions with space surveillance information to produce enhanced intelligence products that support SSA.

The 2006 Space Control Joint Capabilities Document identifies SSA as a key capability needed to enable freedom of action in space, identifies capability gaps in SSA capabilities, and contains overarching SSA requirements for addressing the gaps in the following task areas:

- Orbital and network information—detect, track, identify, and catalog man-made space objects and provide services including overflight warning, signal/laser deconfliction, and conjunction assessment.[5]

- Environmental information—monitor, characterize, predict, and report on the space-related environment.

- Event information—detect, process, and report space events, such as launches, orbital maneuvers, satellite breakups, space object reentries, orbital decay, space object separations, dockings, and changes in baseline status beyond nominal operating parameters; also, characterize, assess, and resolve anomalies/attacks on all space systems.

- U.S., allied, and coalition space system information—maintain the status and characteristics of U.S., allied, and coalition space forces and assets.

- Space intelligence information—provide status and characterization of foreign and adversary space-related assets, strategies, tactics, intent, activities, and knowledge.

The requirements contained in the Space Control Joint Capabilities Document form the basis for ongoing and planned DOD SSA acquisition efforts.

U.S. Strategic Command is responsible for planning and conducting DOD space operations.[6] The Joint Functional Component Command for Space, a component of U.S. Strategic Command, coordinates, plans, integrates, commands, and controls space operations through its Joint Space

[5] Detect is the ability to collect positional data on an object. Track is the ability to collect successive sets of positional data on an object to determine its orbit. Identify is the ability to distinguish a tracked object from all others and involves characterization—determining an object's size, shape, motion, and type. Catalog is the ability to archive, integrate, disseminate, and exploit data obtained from detection, tracking, and identification.

[6] The Unified Command Plan, signed by the President of the United States, establishes the missions, responsibilities, and geographic areas of responsibility of commanders of combatant commands. This plan assigns the commander of U.S. Strategic Command with responsibility for planning and conducting space operations.

Operations Center (JSpOC). A major function of the JSpOC is to maintain SSA.[7]

The SSA Mission is Complex and Is Increasing in Difficulty

A multitude of tasks and functions must be performed to meet the broad definition of SSA. For example, according to the Space Posture Review interim report, SSA includes, at a minimum, continual awareness of orbiting objects; real-time search and high-fidelity information; threat detection, identification, and location; predictive intelligence collection and analysis of foreign space capability and intent in a geopolitical context; and a global reporting capability for friendly space systems. The interim report divides SSA into four major functional capabilities: (1) detect, track, and identify—the ability to discover, track, and differentiate among space objects; (2) threat warning and assessment—the ability to predict and differentiate among potential or actual attacks, space weather environment effects, and space system anomalies; (3) intelligence characterization—the ability to determine performance and characteristics of current and future foreign space and counterspace system capabilities, as well as foreign adversary intentions; and (4) data integration—the ability to correlate and integrate multisource data into a single common operational picture and enable dynamic decision making. Consequently, the JSpOC relies on numerous sources of data and information to maintain SSA, including space surveillance sensors; the intelligence community; and academic, commercial, and foreign collaboration.

A significant aspect of SSA involves tracking many thousands of man-made space objects that typically travel 9 times the speed of a bullet[8] and reside in a search volume 220,000 times the volume of Earth's oceans. SSA also involves knowing where each of these objects came from (who owns them), where it is and where it is going, its purpose, and its capabilities. And, if an anomaly occurs, such as satellite communications interference or loss of satellite functionality, ascertaining the reasons why.

[7] In 2006, the commander of U.S. Strategic Command established the Joint Functional Component Command for Space to optimize planning, execution, and force management of assigned missions to coordinate, plan, and conduct space operations. The JSpOC provides the personnel, facilities, and equipment for carrying out the Joint Functional Component Command for Space's mission.

[8] Objects in low Earth orbit—defined as an orbit between approximately 100 and 1,000 miles from Earth—typically travel at about 17,000 miles per hour. Objects in higher orbits typically do not travel as fast.

The JSpOC relies on the space surveillance network (SSN) to detect, track, identify, and catalog space objects. The SSN, primarily operated and maintained by the Air Force, consists of a worldwide network of 29 ground-based radars and optical sensors, data processing capabilities, and supporting communication systems. DOD started to build the SSN subsequent to the former Soviet Union's launch of its first Sputnik satellite in 1957. Some of the sensor systems built in the 1960s and 1970s have undergone modernization and sustainment efforts and are still operational today. Appendix II discusses the composition of the SSN.

The JSpOC uses SSN data to accomplish the following: maintain the space object catalog; analyze new space launches; detect new man-made objects in space, perform conjunction assessments (predict potential collisions between space objects and inform NASA and other government, commercial, and foreign entities if objects may interfere with the orbits of the Space Shuttle, International Space Station, and operational satellite platforms); and conduct space object atmospheric reentry assessments (predict when and where a space object will reenter the Earth's atmosphere, determine who owns the object, prevent a returning space object—which to radar looks like a missile—from triggering a false alarm in missile-attack warning sensors of the United States and other countries, and predict surface impacts of reentering objects).[9] SSN information is also used for developing space intelligence, which, in turn, is used to support SSA operations.

The JSpOC also relies on ground- and space-based sensors that make space weather observations to detect and forecast solar storms that may be harmful to space system operations. These sensors are owned, operated, and developed by DOD, NASA, the National Oceanic and Atmospheric Administration (NOAA), and foreign providers. Examples of space weather observations include bursts of solar energy called solar flares, solar winds, geomagnetic activity associated with solar storms, solar X-ray images and fluctuations, and solar ultraviolet images and fluctuations. These observations are associated with geomagnetic storms, electromagnetic radiation, ionospheric scintillation, high-energy particles, and solar radio bursts that can adversely impact space and ground assets and operations, terrestrial communications, and transmissions between

[9] In addition to these functions, the JSpOC uses SSA products to support functions including laser clearinghouse, launch collision avoidance, breakup processing, sensor network tasking, and threat assessment and reporting.

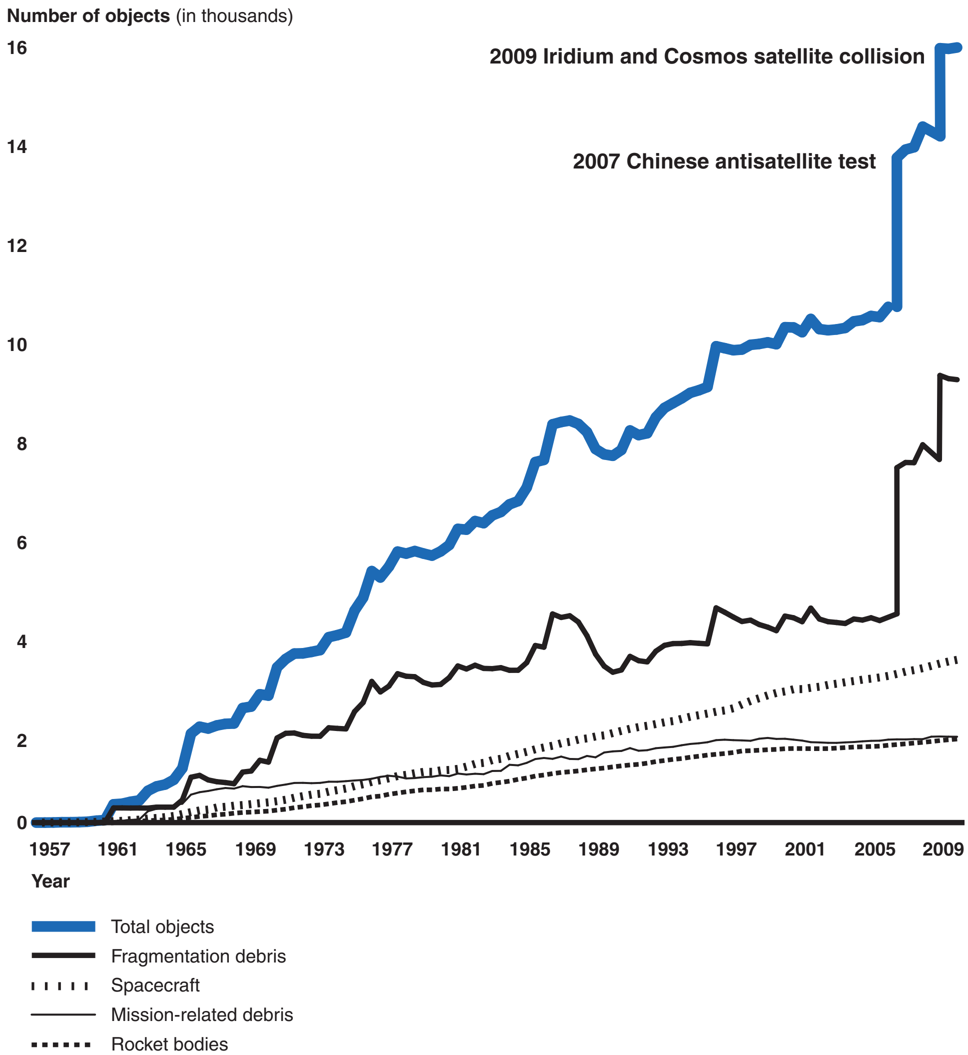
Global Positioning System satellites and ground-based receivers. According to Air Force and NOAA officials, the subject area of space weather is relatively immature, and is comparable to the maturity of terrestrial weather research and prediction capabilities that existed 20 to 30 years ago.

SSA mission complexity is also exemplified by the many and varied organizations that are SSA stakeholders (users and providers of SSA information). For example, according to Air Force Space Command and the National Security Space Office (NSSO),[10] 39 organizations across the military, intelligence, and civil government are involved in efforts to develop a new SSA architecture (discussed later in this report). This becomes more complex with the addition of commercial and foreign organizations. Such a diverse array of stakeholders complicates architecture and requirements development, acquisition program oversight, as well as SSA operations.

The SSA mission is also becoming more difficult. For example, as shown in figure 1, the number of space objects has been increasing over the past 50 years, resulting from increasing use of space as well as events such as the 2007 Chinese antisatellite test and 2009 Iridium/Cosmos satellite collision, which, according to NASA, together had increased the number of cataloged space objects by more than 60 percent.

[10] NSSO supports the Secretary of the Air Force who, as the DOD Executive Agent for Space, is responsible for developing, coordinating, and integrating plans and programs for space systems and the acquisition of DOD space major defense acquisition programs, and is responsible for executing the space major defense acquisition programs, when delegated that authority by the Under Secretary of Defense for Acquisition, Technology and Logistics. The specific roles and responsibilities of the DOD Executive Agent for Space are defined in Department of Defense Directive 5101.2, *DOD Executive Agent for Space* (June 3, 2003).

Figure 1: Number of Catalogeda Space Objects



Source: GAO analysis of NASA data.

[a]The number of tracked items exceeds that for cataloged items because cataloging requires additional analyses such as determining an object's origins and other characteristics such as the object's radar cross section and predicted date of orbital decay.

DOD Has Made Limited Progress in Delivering Improved Capabilities to Address SSA Shortfalls and Delivery of New Capabilities Expected within the Next 5 Years Faces Challenges

DOD has significantly increased its investment and planned investment in SSA acquisition efforts in recent years to address growing SSA capability shortfalls. Most efforts designed to meet these shortfalls have struggled with cost, schedule, and performance challenges which are rooted in systemic problems that most space acquisition programs have encountered over the past decade. Consequently, in the past 5 fiscal years, DOD has not delivered significant new SSA capabilities as originally expected. To its credit, the Air Force recently launched a space-based sensor that is expected to appreciably enhance SSA. In addition, two of the acquisition efforts that are to provide significant capability increases are scheduled to begin product development within the next 2 years—Space Fence and the Joint Space Operations Center Mission System (JMS). However, both face challenges and risks, such as the use of immature technologies and planning to deliver all capabilities in a single, large increment, versus smaller and more manageable increments. While DOD plans to begin delivering other new capabilities in the coming 5 years, it is too early to determine the extent to which these additions will address capability shortfalls.

DOD Is Increasing Its Investment in SSA Acquisition Efforts

DOD has significantly increased its investment and planned investment in SSA acquisition and sustainment efforts in recent years to address growing SSA capability shortfalls, and has many separate development efforts—at least 17—ongoing.[11] DOD plans to spend a total of about $5.3 billion on SSA projects from fiscal year 2006 through fiscal year 2015, as shown in figure 2. DOD has invested almost $2 billion from fiscal year 2006 to fiscal year 2010 in SSA projects, and plans to invest an additional $3.3 billion from fiscal year 2011 through fiscal year 2015, representing about a 65 percent increase over the preceding 5 years. In the coming 5 years, DOD expects to spend

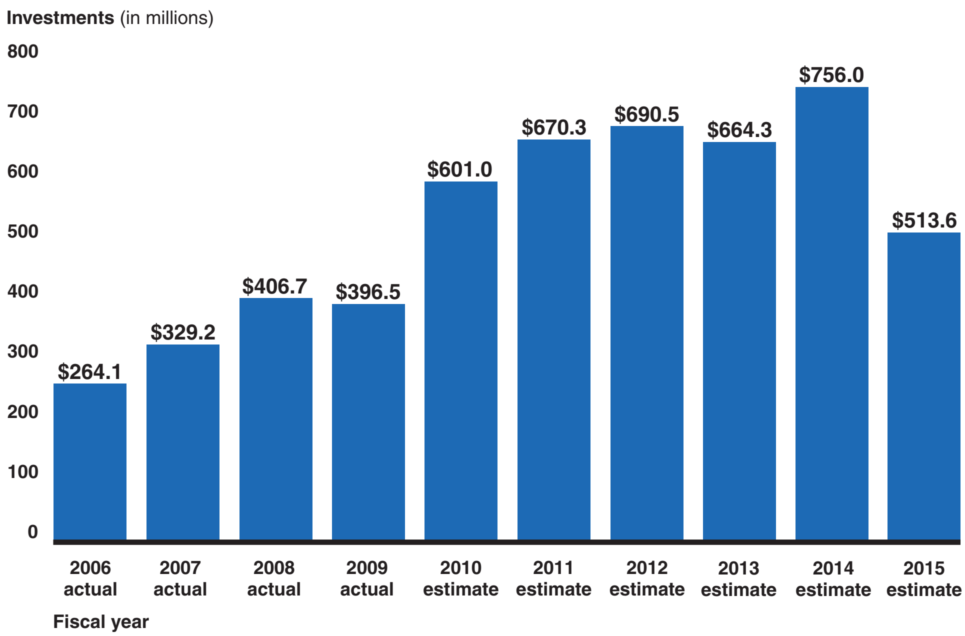
- about 66 percent of this investment on new sensors to detect, track, and characterize emerging space threats;
- about another 21 percent on a new command and control system that is to integrate data to provide real-time information for SSA and command and control of space forces; and
- the remainder on continuing to extend the life of existing sensors to forestall degradation to current capabilities—according to the Air

[11] See app. III, which identifies and provides investment and budget details for these efforts.

Force, the primary risks associated with the SSN are related to the age of the sensor systems—and other SSA-related programs.

The Air Force is, and has been, responsible for the vast majority of DOD's SSA acquisition investments (accounting for about 94 percent of the total[12]). Additional details of DOD's SSA-related investments are provided in appendix III.

Figure 2: DOD SSA-Related Investment from Fiscal Year 2006 through Fiscal Year 2015



Source: GAO analysis of unclassified DOD budget submission data for fiscal years 2008 through 2011.

Recent Investments Have Not Delivered Significant New SSA Capabilities and Many Ongoing and New Development Efforts Face Challenges

Despite recent investments, existing SSA capabilities continue to fall short of operational needs and space policy objectives. In the past 5 fiscal years, while DOD continued its investments in SSA, it has not delivered significant new SSA capabilities to the warfighter as originally expected. Capabilities that were delivered served to sustain or modernize existing systems versus closing gaps. For example, DOD has extended the service lives of some sensors supporting SSA capabilities and has added

[12] The Defense Advanced Research Projects Agency (DARPA) accounts for the remainder.

additional processors and servers to the SSA's command and control system's computer, as well as adding analysts and operational personnel. However, Joint Functional Component Command for Space officials did not characterize these efforts as delivering significant increases in capability.

DOD plans to begin delivering major new additions in capability in the coming 5 years, including the Air Force's recently launched space-based sensor that is expected to appreciably enhance SSA. However, it is too early to determine the extent to which these new capabilities or additions will address capability shortfalls. As described below, many of these efforts—those expected to provide the biggest gains in capability—have struggled or are struggling with cost, schedule, and performance challenges and face risks to meeting their acquisition goals, potentially exacerbating SSA capability shortfalls. Two new SSA acquisition efforts are scheduled to begin product development within the next 2 years—Space Fence and JMS, which are described below, together with five other key efforts. JMS will be essential to providing and enhancing future space command and control and SSA capabilities, while Space Fence is to be the single largest SSA investment. The challenges and risks these programs face include the potential employment of immature critical technologies, program office staffing and skill shortages, complex integration tasks, the integration of data from numerous heterogeneous sources, operations in a multiple security level environment (information assurance), not utilizing an incremental development approach, and overloading of DOD's current space object tracking system with data from new sensor systems coming on line over the next 5 years. Table 1 describes, in more detail, the status of SSA development efforts that are expected to deliver large gains in capability over the next 5 years and the challenges and risks they face.

Table 1: Descriptions, Status, and Challenges and Risks of SSA Programs and Projects that Are Expected to Deliver Large Gains in Capability in Fiscal Years 2010 through 2015

New sensors	
Space Based Space Surveillance (SBSS)	**Description/Status:** • The Air Force's initial SBSS effort consists of a single satellite—using an electro-optical telescope—and associated command, control, communications, and ground processing equipment, to collect positional and characterization data on Earth-orbiting objects, replacing a predecessor, the Midcourse Space Experiment Space Based Visible sensor, which significantly contributed to the detection and tracking of deep space objects and which ended its mission in July 2008. SBSS is expected to provide timely detection, tracking, and identification data to significantly increase DOD's ability to understand the location and mission capabilities of satellites and other objects, particularly in geosynchronous Earth orbits. The space vehicle was launched in September 2010. The expected duration of the satellite mission is about 5.5 years. The Air Force and DOD are studying options to provide a follow-on capability to SBSS. **Challenges and risks:** • Cost and schedule: The on-orbit SSA sensing capability is being replaced by SBSS when it becomes operational, estimated for the end of May 2011. SBSS experienced a delay of over 3 years—along with about a 163 percent cost increase, from about $332 million at development start in 2003 to about $873 million. The SBSS program was restructured in 2006 after an independent review team found that the program's original cost and schedule baseline was not executable; the assembly, integration, and test plan was risky; and the requirements were overstated. The restructure provided for increased funding and schedule margin; streamlined the assembly, integration, and test plan; and relaxed requirements. The SBSS program office attributes the causes of the schedule delay and cost increase that led to the restructure to technical requirements volatility (including a change to a much more complex sensor design, which became the program's largest cost driver); a late development contract award; and a change in the planned launch vehicle type (from a Delta II to a Minotaur IV) which required the program to fund the launch. Subsequent to the restructure, technical issues relating to the Minotaur IV caused additional delays. • Data processing: The Air Force's Joint Space Operations Center Mission System (described below) will need to be available to process all SBSS data.
Rapid Attack Identification Detection and Reporting System (RAIDRS)[a]	**Description/status:** • The Air Force's initial RAIDRS effort is to develop ground-based systems consisting of antennas and data processing equipment that are to rapidly detect and report electromagnetic interference attacks on DOD satellite communication assets in the C, X, and Ku radio frequency bands. The Air Force initiated the program in March 2005 with a development cost estimate of $226 million and initial operational capability estimated for 2008. **Challenges:** • Cost and schedule: The program has undergone multiple rebaselines, the most recent in 2009, because of contract cost increases totaling about $78.5 million and about 4 years of schedule growth. The RAIDRS program office attributes the cost increases and schedule delay to technical requirements and design instability; overly optimistic cost estimates; incorrect assumption of utilizing government-furnished antennas which proved nonviable and which required producing new antennas; and an inexperienced and substandard prime contractor. Initial operational capability is estimated for fiscal year 2012 and a revised cost estimate was expected to be developed by August 2010. • Performance: The most recent program rebaseline resulted in a simplified system: from nine systems—six fixed and three deployable—to five deployable systems. The program estimates the simplified system will satisfy 92 percent of the program requirements, with reduced simultaneous geolocation and detection capabilities; no off-line processing, test, and exercise functions; and reduced ultra high

	frequency (UHF) interference capabilities (the latter was a Key Performance Parameter (KPP) under the previous Capability Development Document (CDD)[b]—according to the program office, the CDD is being updated to revise the UHF requirement).
Space Fence	**Description/status:** • The Air Force's Space Fence is to be a new system of ground-based phased-array radars costing potentially as much as $6.1 billion, according to the Air Force Electronic Systems Center (the product center responsible for acquiring Space Fence). Space Fence is intended to replace and expand coverage provided by the aging Air Force Space Surveillance System using higher radio frequencies to detect and track smaller Earth-orbiting objects. The system was to consist originally of up to three geographically dispersed radars (notionally located in Australia; Ascension Island, south Atlantic Ocean; or Kwajalein Atoll, Marshall Islands); however, recent analysis shows that a three-site system may not provide adequate cost-benefit over a two-site system and, therefore, the Air Force considers the likelihood of a two-site solution is very high. Currently, the effort is in the technology development phase, where the Air Force is actively assessing trade-off options between system performance—such as detection altitude and accuracy—and affordability. System development is scheduled to begin in June 2012, with the first Space Fence radar site providing initial operational capability by the end of fiscal year 2015, and the final site providing full capability by 2020. **Challenges and risks:** • Data processing: The primary program risk, according to the Electronic Systems Center, is that the new Joint Space Operations Center Mission System (described below) will need to be available to process Space Fence data, as the amount of data provided will result in an increase in uncued detection and tracking capacity from 10,000 to 100,000 objects. • Integration, information assurance: The Space Fence program office states other risks of the program include large-scale integration and calibration of radar arrays, scalability of the design for the digital beam former,[c] and development of information assurance certification criteria. • Technology: All five critical Space Fence technologies identified by the program office are immature—one at technology readiness level (TRL) 4 and four at TRL 5[d]—which increases risk to cost and schedule goals. Given that technology discovery cannot be scheduled, the immature technologies raise the risk of having to defer product development until these technologies become mature. Although mature backup critical technologies exist which could be used if the primary technologies do not mature by the start of system development, all have potentially higher acquisition costs and in some cases, higher operating costs as well, according to the program office. While the program has a critical technology maturity goal of TRL 6 prior to preliminary design review (which is in accordance with DOD's acquisition policy),[e] our best practices work has shown technology development to TRL 7 could significantly reduce risk to meeting cost, schedule and performance goals.
Space Surveillance Telescope (SST)	**Description/status:** • SST is a Defense Advanced Research Projects Agency (DARPA) development effort intended to demonstrate an advanced ground-based electro-optical telescope with a large focal plane array that is to be based at White Sands Missile Range, New Mexico. The telescope is designed to have the ability to search quickly over a wide area and provide detection, tracking, and characterization of small-sized dimly lit objects in deep space that significantly exceeds current capabilities. **Challenges and risks:** • Schedule: The Air Force was originally expected to assume control over the SST in 2009. But this is not scheduled to happen until 2012 because of technical challenges. The telescope is scheduled for first use in early calendar year 2011. A memorandum of agreement has been established with Air Force Space Command for the transition.

Space command and control	
Joint Space Operations Center Mission System (JMS)	**Description/status:** • The Air Force began the JMS acquisition effort in 2009 as part of a consolidation of several SSA-related development efforts that proceeded from earlier, problematic, space command and control replacement efforts begun over the past 3 decades. Under an effort initiated in 2000, called the Combatant Commanders' Integrated Command and Control System program, the development of space-related capabilities—which was to be completed by fiscal year 2006—was deferred multiple times and eventually canceled because of unanticipated technical challenges and cost overruns of efforts that were to precede the development of space capabilities. • JMS, which DOD has categorized as a major automated information system,[f] is a new program that is to provide the Joint Functional Component Command for Space with an integrated, net-centric space command and control and SSA capability. In June 2010, the Air Force rescheduled development start for March 2011, a delay of about 6 months from the previous estimate, because the program had not completed and documented preparations required to proceed with development. JMS is to be deployed in a single increment with five releases beginning in fiscal year 2011, with final delivery in 2016. • JMS is essential to providing and enhancing SSA capabilities because the current space command and control capability relies on antiquated hardware and software that is becoming unsupportable, is fragmented across disparate systems, is not well-integrated, and is not capable of processing the increased amount of data being delivered by current and to be delivered by future SSA sensor systems. Without JMS, most SSA sensor data could not be readily used. **Challenges and risks:** • Acquisition approach: GAO's best practices work has shown that large system projects divided into a series of smaller incremental acquisition efforts made on the basis of reliable analysis of estimated costs, expected benefits, and anticipated risks, permits informed investment decision making. However, the current JMS acquisition approach is not adopting an incremental approach, as exemplified by its plans to proceed without knowledge of all critical technologies and deferral of other planning activities. This lack of knowledge could result in unanticipated costs and other programmatic risks to the acquisition effort. First, although our best practices work and DOD guidance call for critical technologies to be identified and matured by development start,[g] the JMS program does not plan to identify and assess the maturity of all critical technologies by that time. Instead, JMS plans are to identify and assess critical technologies prior to each release. Consequently, the program will not have assurance that the needed technologies will be mature when needed and that cost estimates—based on the development of all five releases—are reliable. Second, the program is deferring detailed planning work on future releases which could further imperil its ability to meet requirements, such as the delivery of multiple security level information assurance capability, within cost and schedule goals.[h] • Data integration: JMS and DOD officials pointed to data integration issues as one of the top risks for the JMS program. More specifically, JMS will need to integrate data from numerous heterogeneous sources, many of which are not net-centric. To ensure the data from these sources are compatible, the Air Force is currently working to ensure these sources are net-centric before JMS is complete. • Integration and information assurance: A major challenge JMS faces is the planned system's complexity – it will need to integrate multiple capabilities and services that the system is intended to provide. Furthermore, the program is expected to provide information at multiple classification levels, called a multiple security level environment. Identifying and carrying out the information assurance practices necessary to provide information at multiple classification levels is a challenge because of the complexities involved with defining, certifying, and accrediting automated solutions for ensuring information is not accessible by unauthorized users. Air Force officials stated that they are not aware of any Air Force information technology systems that provide information at as many classification levels as JMS is intended to provide. • Technologies: Our best practices work has shown that maturing technology to TRL 7 prior to development start reduces risk to meeting cost, schedule, and performance goals. However, the JMS program plans to use technologies, such as service information exchange capabilities to allow applications to send data and information to other applications and servers, that only have been matured to TRL 6 or greater prior to the start of development for each release.

	• Personnel: The JMS program office stated it was experiencing a shortage of systems engineering personnel, creating challenges to completing program planning documentation. The program office stated it has since made strides in hiring systems engineers and other personnel, as well as increasing contractor support. As of September 2010, the program was staffed to 83 percent of required positions (133 of 160 positions).
Existing sensors	
Haystack Ultra-Wideband Satellite Imaging Radar (HUSIR)	**Description/status:** • The HUSIR effort is to upgrade the existing X-band Haystack Imaging Radar, operated by Massachusetts Institute of Technology Lincoln Laboratory for the Air Force, by adding W-band capability and enhancing imaging resolution (from 25 cm to 1cm) to characterize smaller objects in low Earth orbit and add deep-space tracking capability. **Challenges and risks:** • Cost and schedule: HUSIR began development in July 2004 with an expected initial operational capability in fiscal year 2008. However, operations are currently scheduled to begin 4 years later in fiscal year 2012, and costs increased about 170 percent from \$40.5 million to \$109.7 million. According to the Air Force Electronic Systems Center which manages the program, cost and schedule slips are attributable to the subcontractor's inadequate understanding of work scope and inadequate control of vendor costs. The subcontractor was terminated, requiring significant rework of remaining designs and fabrication. New technical requirements were also added to the program scope. According to Electronic Systems Center documentation, Air Force oversight of Massachusetts Institute of Technology Lincoln Laboratory, the prime contractor for the effort, was increased and a traditional government program office was established. A new acquisition program baseline has yet to be approved. • Technical: The Electronic Systems Center states that the primary risks to the upgrade program include excessive aperture deformation over the 37-meter (about 121 feet) diameter radar dish, inadequate antenna control system accuracy, and delays to the modification schedule (caused by, for example, welding inspection failures and associated rework). According to the Electronic Systems Center, various technical and process mitigation strategies are in place to manage these risks.
New Service Life Extension Programs	**Description/status:** • According to the Electronic Systems Center, many existing sensor systems contain obsolete and unsupportable hardware and software that are expected to degrade over time without near-term replacement. When a system has reached a substantially elevated risk level, beyond what can be managed through normal annual sustainment actions, a larger effort to extend the service life is initiated. Three sensors have ongoing Service Life Extension Programs (SLEPs) to address these issues for the most critical elements. The Eglin (AN/FPS-85) SLEP has been ongoing since 2006, and two new SLEPs were funded to begin in fiscal year 2010 for the Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) telescope and the Globus II radar. **Challenges:** • Personnel: According to Air Force documentation, personnel shortfalls are negatively impacting sustainment and service-life extension efforts. According to the Air Force Electronic Systems Center, which is responsible for conducting these efforts, the shortfall is because of the increase in the number of large ongoing system life extension programs and the resultant necessary increase in government execution oversight. The Electronic Systems Center maintains that much work remains to address the personnel shortage issue, but it has initiated several actions, such as hiring additional support contractors, reallocating some existing internal resources to the new sensor service life extension programs, and moving to a matrix approach for key functional areas such as contracting and engineering.

Source: GAO analysis of DOD data.

[a]While DOD does not categorize the initial RAIDRS effort as developing a SSA sensor system, we included it in the new sensors category of this table because the program is to develop sensors that are to provide capabilities that are included as part of the SSA mission—to characterize attacks on space systems. Follow-on RAIDRS efforts are now a part of the JMS effort.

[b]KPPs are critical requirements (or capabilities) considered most essential for an effective military capability. CDDs are documents that capture the information necessary (primarily requirements) to develop a proposed program.

[c]In general terms, the Space Fence phased array radar—analogous to tens of thousands to hundreds of thousands of miniature radar antennas—is to use digital beam forming, which allows the antennas to work in concert, creating sufficient power transmitted and received to conduct the space surveillance and tracking mission.

[d]NASA originally developed TRLs as a tool to assess technology maturity. TRLs are measured on a scale from 1 to 9, beginning with paper studies of a technology's feasibility (TRL 1) and culminating with application of the technology in its final form and under mission conditions (TRL 9). Demonstration that pieces will work together in a laboratory is TRL 4. Demonstration in a simulated environment is TRL 5. Our best practices work has shown that a technology readiness level of 7—demonstration of a technology in a realistic environment—is the level of technology maturity that constitutes a low risk for starting a product development program. We ordinarily assess satellite technologies that have achieved TRL 6, a prototype demonstrated in a relevant environment, as fully mature because of the difficulty of demonstrating maturity in a realistic environment—space. However, this does not apply to programs such as Space Fence which are ground-based. See app. IV for a detailed description of TRLs.

[e]Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* paragraph 5.d.(7) (Dec. 8, 2008) states that a project shall exit the Technology Development Phase when the technology has been demonstrated in a relevant environment, which is TRL 6.

[f]A major automated information system is defined as a DOD acquisition program that is designated by the Secretary of Defense as a major automated information system or whose estimated dollar value (in fiscal year 2000 constant dollars) is $32 million for all program costs in a single fiscal year, $126 million for all program acquisition costs for the entire program, or $378 million for the total life-cycle costs of the program (including operation and maintenance costs). 10 U.S.C. § 2445a(a).

[g]The Office of the Director, Defense Research and Engineering, *Department of Defense Technology Readiness Assessment (TRA) Deskbook* Table 3-1 and Appendix B (July 2009); Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* Enclosure 2 paragraphs 5.a and 5.d.(4) (Dec. 8, 2008).

[h]According to DOD, it selected a single increment, multiple release approach as the most efficient means to develop capabilities when needed, based on technology maturity and available funding.

SSA Acquisition Challenges Are Similar to Problems Affecting the Broader Space Portfolio

The cost, schedule, and performance challenges we have identified with SSA efforts are reflective of systemic acquisition problems affecting the space portfolio. Our past work has identified a number of causes behind the cost growth and related problems, but several consistently stand out.[13] First, DOD often takes a schedule-driven versus a knowledge-driven approach to the acquisition process. As a result, activities essential to

[13] GAO, *Defense Acquisitions: Risks Posed by DOD's New Space Systems Acquisition Policy*, GAO-04-379R (Washington, D.C.: Jan. 29, 2004); *Space Acquisition: Stronger Development Practices and Improvement Planning Needed to Address Continuing Problems*, GAO-05-891T (Washington, D.C.: July 12, 2005); *Space Acquisitions: Improvements Needed in Space Systems Acquisitions and Keys to Achieving Them*, GAO-06-626T (Washington, D.C.: Apr. 6, 2006); *Space Acquisitions: Actions Needed to Expand and Sustain Use of Best Practices*, GAO-07-730T (Washington, D.C.: Apr. 19, 2007); and *Space Acquisitions: DOD Poised to Enhance Space Capabilities, but Persistent Challenges Remain in Developing Space Systems*, GAO-10-447T (Washington, D.C.: Mar. 10, 2010).

containing costs, maximizing competition among contractors, and testing technologies are shortchanged. Second, on a broad scale, DOD starts more weapon programs than it can afford, creating a competition for funding that encourages low cost estimates, overly optimistic scheduling, overpromising, suppressing bad news, and for space programs, forsaking the opportunity to identify and assess potentially more executable alternatives. Third, DOD has tended to start its space programs too early, that is, before it has the assurance that the capabilities it is pursuing can be achieved within available resources and time constraints. This tendency is caused largely by the funding process, since acquisition programs attract more dollars than efforts concentrating solely on proving technologies. Nevertheless, when DOD chooses to extend technology invention into acquisition, programs experience technical problems that require large amounts of time and money to fix. Moreover, there is no way to accurately estimate how long it would take to design, develop, and build a satellite system when critical technologies planned for that system are still in relatively early stages of discovery and invention. Fourth, programs have historically attempted to satisfy all requirements in a single step, regardless of the design challenge or the maturity of the technologies necessary to achieve the full capability. This has stretched technology challenges beyond current capabilities in some cases and vastly increased the complexities related to software. Fifth, we have reported that space programs are particularly affected by the wide disparity of users with competing interests, including DOD, the intelligence community, other federal agencies, and in some cases, other countries, U.S. businesses, and citizens.

In addition, we have reported in the past that shortages of skilled and experienced space acquisition personnel, and personnel who are technically proficient to meet security space needs, have magnified the challenge of developing complex and intricate space systems.[14] These shortages are the result of a combination of factors including funding limitations, recruiting challenges, and limited training and education opportunities. Moreover, problematic implementation of an acquisition strategy in the 1990s, known as Total System Performance Responsibility, for space systems resulted in losses of technical expertise (including cost estimating and systems engineering staff) and weaknesses in contracting

[14] GAO, *Space Acquisitions: Government and Industry Partners Face Substantial Challenges in Developing New DOD Space Systems*, GAO-09-648T (Washington, D.C.: Apr. 30, 2009).

strategies—the effects of which space programs are still dealing with. The existence of these problems was confirmed by a congressionally directed independent assessment panel (also known as the Allard Commission),[15] which cited the reduced availability of technically competent government personnel as a major factor that has reduced the government's capability to acquire space systems and a likely cause of acquisition program failures.

Our work—which is largely based on best practices in the commercial sector—has recommended numerous actions that can be taken to address the problems we identified.[16] 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. DOD has generally concurred with our recommendations and has modified its acquisition guidance to incorporate them. One exception for space systems is that DOD has not adopted our recommendation that critical technologies be matured to a point where they are demonstrated in a realistic (for hardware) or operational (for software) environment (TRL 7) because it is exceedingly expensive to test technologies in space. However, it does require that space systems demonstrate that critical technologies can operate in a relevant environment (TRL 6).[17] 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 could benefit space programs. These practices are highlighted in table 2.

[15] Institute for Defense Analyses, *Leadership, Management, and Organization for National Security Space: Report to Congress of the Independent Assessment Panel on the Organization and Management of National Security Space* (Alexandria, Va.: July 15, 2008), alternatively known as the Allard Commission Report.

[16] Our best practices reviews are identified in related GAO products at the end of this report.

[17] Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* Enclosure 2 paragraph 5.d.(4) (Dec. 8, 2008).

Table 2: Actions Based on Best Practices Needed to Address Space and Weapon Acquisition Problems

Before undertaking new programs
• Prioritize investments so that projects can be fully funded and it is clear where projects stand in relation to the overall portfolio.
• Follow an evolutionary path toward meeting mission needs rather than attempting to satisfy all needs in a single step.
• Match requirements to resources—that is, time, money, technology, and people—before undertaking a new development effort.
• Research and define requirements before programs are started and limit changes after they are started.
• Ensure that cost estimates are complete, accurate, and updated regularly.
• Commit to fully fund projects before they begin.
• Ensure that critical technologies are proven to work as intended before programs are started.
• Assign more ambitious technology development efforts to research departments until they are ready to be added to future generations (increments) of a product.
• Use systems engineering to close gaps between resources and requirements before launching the development process.
During program development
• Use quantifiable data and demonstrable knowledge to make go/no-go decisions, covering critical facets of the program such as cost, schedule, technology readiness, design readiness, production readiness, and relationships with suppliers.
• Do not allow development to proceed until certain thresholds are met—for example, a high proportion of engineering drawings completed or production processes under statistical control.
• Empower program managers to make decisions on the direction of the program and to resolve problems and implement solutions.
• Hold program managers accountable for their choices.
• Require program managers to stay with a project to its end.
• Hold suppliers accountable to deliver high-quality parts for their products through such activities as regular supplier audits and performance evaluations of quality and delivery, among other things.
• Encourage program managers to share bad news, and encourage collaboration and communication.

Source: GAO.

We have found that when DOD chooses to extend technology development into acquisition, programs generally experience technical problems that require large amounts of time and money to fix. Moreover, there is no way to accurately estimate how long it would take to design, develop, and build a weapon system when critical technologies planned for that system are still in relatively early stages of discovery and invention. Most of the major space programs we have studied over the past decade, for example, have incurred substantial cost increases and schedule delays because they were approved without demonstrating that their technologies could work as intended in a relevant or realistic environment. In fact, at the time DOD made multibillion-dollar commitments to start certain programs, technologies were sometimes still in a proof-of-concept or component validation phase (TRL 3 and 4), that is, components had not yet been built or integrated beyond a laboratory environment. As a result, significant technology-related rework was needed in the costlier and more complex phases of the acquisition process. In addition, most of the programs we studied could not reliably estimate costs because there were too many unknowns about technology and requirements. A factor that contributed to the tendency to extend technology invention into later phases of acquisition is that programs have historically attempted to satisfy all requirements in a single step, regardless of the design challenge or the maturity of the technologies necessary to achieve the full capability, stretching technologies beyond current capabilities in some cases and vastly increasing the complexities related to software.[18]

Given the early stages of the Space Fence and JMS acquisition efforts, the high estimated acquisition costs, and the challenges and risks they face, opportunities exist to help ensure the acquisition problems that have affected or are affecting other SSA development efforts are avoided. For example, utilizing an incremental development approach that would facilitate, prior to beginning product development, (1) the identification and assessment of all critical technologies and (2) the inclusion of only fully mature technologies, would significantly increase the reliability of, and chances of meeting, program cost, schedule, and performance goals. Because both the Space Fence and JMS are to be ground-based systems, technologies developed to a level they can be demonstrated in a realistic or operational environment (TRL 7) would be considered mature according to our best practices criteria. One way to mitigate technology maturity risk is to rely on backup technologies, should newer technologies not mature in time or otherwise be problematic during product development. However, the use of backup technologies would likely present cost, schedule, and performance implications, such as with the Space Fence effort. Additionally, establishing comprehensive plans to mitigate other key risks, such as those relating to protecting national security information, would also help ensure acquisition success. DOD has already adopted similar practices for its newest major space acquisition—the Global Positioning System IIIA program—and has embraced the knowledge-based concepts behind our previous recommendations as a means of preventing large cost overruns and schedule delays.

[18] GAO-10-447T.

Space Situational Awareness Faces Significant Governmentwide Management and Oversight Challenges

There are significant inherent challenges to executing and overseeing the SSA mission, largely due to the sheer number of organizations and assets involved in the mission, and the fact that, while the new National Space Policy assigns SSA responsibility to the Secretary of Defense, the Secretary does not necessarily have the corresponding *authority* to execute this responsibility. However, actions are being taken that could help facilitate management and oversight governmentwide. Additionally, the recently issued National Space Policy, which recognizes the importance of SSA, and among other things, directs the determination of roles, missions, and responsibilities to manage national security space capabilities and the need to develop specific measures for improving SSA capabilities, is also a positive step. Lastly, though the commercial sector and the international community are to play pivotal roles in the SSA mission, it is too early to tell whether DOD's efforts to expand and make permanent its Commercial and Foreign Entities SSA data-sharing pilot program will be effective in integrating efforts to develop SSA capabilities. Establishing effective commercial and international relationships will be another significant challenge given decisions that will be required on how much and what types of data can and should be shared.

Large Number of SSA Stakeholders Complicates Management and Oversight Efforts

Because SSA encompasses a broad range of needed capabilities, it involves a large number of stakeholders. While DOD and the intelligence community comprise the vast majority of organizations involved in SSA, the civil government, commercial sector, and foreign entities also play, or are expected to play, key roles. For example, key civil government organizations include:

- NASA—which works with officials from the Joint Functional Component Command for Space to conduct conjunction assessments, that is, close approach predictions, to avoid collisions between NASA's space assets and other known resident space objects.
- The Department of Commerce's National Oceanic and Atmospheric Administration—which provides space weather information to the Air Force as well as NASA and others.
- The Department of Energy—which has classified and unclassified sensors that collect space weather data that can be used for SSA. Also, its laboratories are currently utilizing and modifying existing computer modeling and simulation capabilities, and are collaborating with the Defense Advanced Research Projects Agency and the Air Force

Research Laboratory on several risk reduction efforts to develop data integration capabilities for JMS.

- The Department of State—which is responsible for international matters including SSA, such as orbital debris mitigation and space surveillance for debris monitoring and awareness.
- The Department of Transportation's Federal Aviation Administration Office of Commercial Space Transportation—which is responsible for regulating the commercial space transportation industry, including matters relating to SSA, such as space debris management.

Moreover, commercial and foreign entities are expected to provide SSA data in the future under an expanded SSA data-sharing program described later. Figure 3 shows the stakeholders involved in SSA.

Figure 3: Stakeholders Involved in SSA

DOD

Office of the Secretary of Defense
Under Secretary of Defense for Acquisition, Technology, and Logistics
Under Secretary of Defense for Intelligence
Under Secretary of Defense for Policy
Assistant Secretary of Defense, Networks and Information Integration
Defense Advanced Research Projects Agency
Defense Special Missile and Astronautics Center
Director of Cost Assessment and Program Evaluation
Director of Operational Test and Evaluation
Joint Chiefs of Staff
Office of the Secretary of the Air Force
U.S. Strategic Command
Joint Functional Component Command for Space
Joint Forces Command
Pacific Command
Office of the Chief of Naval Operations
14th Air Force
Air Force Materiel Command
Air Force Intelligence, Surveillance and Reconnaissance Agency
Air Force Program Executive Officer for Command and Control, and Combat Support
Air Force Program Executive Officer for Space
Air Force Research Laboratory
Air Force Space Command
Air Force Technical Applications Center
Electronics Systems Center, 850th Electronic Systems Group
Missile Defense Agency
National Security Space Office
Army Space and Missile Defense Command
Space and Missile Systems Center
Space Protection Office
US Marine Corp, Plans, Policies and Operations

Intelligence community

Office of the Director of National Intelligence
Central Intelligence Agency
National Air and Space Intelligence Center
Defense Intelligence Agency
National Geospatial-Intelligence Agency
National Reconnaissance Office
National Security Agency

Civil government

Department of Commerce
Department of Energy
Department of State
Department of Transportation
National Oceanic and Atmospheric Administration
National Aeronautics and Space Administration
Lawrence Livermore Laboratory
Los Alamos National Laboratory
Massachusetts Institute of Technology, Lincoln Laboratory
Sandia National Laboratory

Commercial and foreign entities

Satellite operators
Satellite developers
Foreign government space agencies

Source: GAO analysis of DOD documentation.

No Governmentwide Authority for SSA, but Actions Are Being Taken to Improve Management and Oversight

At the governmentwide level, while current National Space Policy assigns SSA responsibility to the Secretary of Defense to develop capabilities, plans, and options, the Secretary does not necessarily have the corresponding *authority* to execute this responsibility. That is, the Secretary cannot direct resources to the highest priority sensors or systems if they belong to an agency outside DOD, adjudicate among competing requirements, or ensure that agencies are setting aside funding needed for SSA over the long term. This is made even more difficult because of differing missions among the large range of SSA stakeholders. However, several actions are being taken that could help address these differences, and therefore facilitate SSA management and oversight governmentwide, including the following:

- Initial capabilities document. An initial capabilities document summarizes and justifies the requirements for a materiel or nonmateriel approach, or an approach that is a combination of both, to satisfy specific capability gaps. The document is typically required for a materiel development decision review and is to support a milestone A decision in DOD's acquisition process, which determines whether an acquisition effort may move into the technology development phase.[19] The NSSO and Air Force Space Command have developed a draft national SSA Initial Capabilities Document to highlight the capabilities required to satisfy national-level SSA needs called for in the National Space Policy. The development of this document has a governmentwide perspective. Specifically, according to NSSO documentation, development efforts have included input from DOD and intelligence community organizations (including ODNI), as well as civilian government agencies, such as NASA, the National Oceanic and Atmospheric Agency, the Department of Commerce, the Department of Energy, the Department of State, and the Department of Transportation. According to ODNI, the intelligence community plays a critical role in SSA, especially for analytical support. The draft SSA Initial Capabilities Document was submitted to U.S. Strategic Command in August 2010. The U.S. Strategic Command, responsible for planning and conducting space operations including SSA, is to review and sponsor this document through the Joint Capabilities Integration and Development System review process. Due to common interests between DOD and the intelligence community for SSA, the document will be processed in accordance with joint DOD and ODNI guidelines.

[19] The materiel development decision review is the formal entry point into the acquisition process, and is mandatory for all programs. Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* Enclosure 2 paragraph 4.c.(1) (Dec. 8, 2008).

- National SSA architecture.[20] A national SSA architecture is under development to highlight the required capabilities to satisfy national-level SSA needs identified in the SSA Initial Capabilities Document. In April 2008, the Assistant Secretary of Defense for Networks and Information Integration (ASD/NII)—the principal staff assistant for SSA capabilities responsible for assuring SSA efforts track toward top-level architecture end states—tasked the Air Force and the Executive Agent for Space to develop an interim SSA architecture to support the fiscal year 2010 to 2015 program and budget review.[21] Subsequently, the Joint Requirements Oversight Council requested further action from the Air Force, which tasked NSSO to serve as the architecture integrator across DOD and to coordinate with ODNI in the development of a more broadly focused national SSA architecture.[22] NSSO and Air Force Space Command cochair the current architecture development effort initiated in November 2008. As with the development of the initial capabilities document, the architecture has a governmentwide perspective. According to NSSO, in light of the new National Space Policy, one of the biggest challenges in developing the national SSA architecture is the amount of limited analyses available to support the broader Presidential direction to have an SSA system that uses commercial and foreign data. Subsequent iterations of the national SSA architecture are expected to address commercial and foreign capabilities. Drafting of the national SSA architecture was slated for completion in the October/November 2010 time frame, after

[20] An architecture can be viewed as a blueprint that links an enterprise's strategic plan to the programs and supporting systems that it intends to implement to accomplish the mission goals and objectives laid out in the strategic plan. Moreover, it provides these perspectives both from the enterprise's current (or "as-is") environment and for its targeted future (or "to-be") environment, as well as for the transition for moving from the "as-is" to the "to-be" environment.

[21] The ASD/NII's responsibilities include serving as the principal staff assistant on nonintelligence space matters, information technology, including National Security Systems, information resource management, and sensitive information integration. The ASD/NII also serves as the principal staff assistant for issues such as command and control and net-centric capabilities. In August 2010, the Secretary of Defense announced the elimination of ASD/NII as part of a broader effort to eliminate organizations performing duplicative functions, or that have outlived their purpose.

[22] The Joint Requirements Oversight Council assists the Chairman of the Joint Chiefs of Staff in identifying and assessing the priority of joint military requirements (including existing systems and equipment) to meet the national military and defense strategies, and in considering alternatives to any acquisition program that has been identified to meet military capabilities by evaluating the cost, schedule, and performance criteria of the program and of the identified alternatives.

which the document was to be approved through the DOD's and the intelligence community's requirements review processes.

- National Security Space Strategy. We have recommended since 2003 that space activities (which include SSA) need to include a national security space strategy tied to overall department-level space goals, time lines, and performance measures to assess space activities' progress in achieving national security space goals identified in the National Space Policy.[23] In January 2011, DOD and ODNI issued the National Security Space Strategy.

New National Space Policy Mandates Additional Measures Designed to Strengthen Governmentwide Management and Oversight

In June 2010, the White House issued a new National Space Policy which emphasizes the need to strengthen stability in the space environment, including improved information collection and sharing for space object collision avoidance; protection of critical space systems and supporting infrastructures, with special attention to the critical interdependence of space and information systems; and strengthening measures to mitigate orbital debris. The space policy also emphasizes the need to improve, develop, and demonstrate, in cooperation with relevant departments and agencies and commercial and foreign entities, the ability to rapidly detect, warn, characterize, and attribute natural and man-made disturbances to space systems of U.S. interests. Furthermore, the space policy identifies specific implementation actions by key national security space stakeholders, including directing the following:

- The Secretary of Defense and the Director of National Intelligence, in coordination with the Secretary of State, to develop options, due in 180 days of the issuance date of the policy, to determine roles, missions, and authorities with respect to the management of national security space capabilities.

- The Secretaries of Defense and Transportation, the Director of National Intelligence, and the NASA administrator, in coordination with the Secretary of State and other relevant departments and agencies, to provide, in 270 days, options for the development, communication, and implementation of new space collision warning measures to the National Security Advisor, the Assistant to the

[23] GAO, *Defense Space Activities: Organizational Changes Initiated, but Further Management Actions Needed*, GAO-03-379 (Washington, D.C.: Apr. 18, 2003); and *Defense Space Activities: National Security Space Strategy Needed to Guide Future DOD Space Efforts*, GAO-08-431 (Washington, D.C.: Mar. 27, 2008).

President for Science and Technology, and the Director of the Office of Science and Technology Policy. These options are to include measures for improving SSA capabilities; maintaining and improving space object databases; pursuing common international data standards; disseminating orbital tracking information; and improving and disseminating predictions of space object conjunction.

- The Secretary of Transportation, in coordination with the Secretaries of Defense and Commerce, as well as other relevant departments and agencies, due in 180 days, to identify options, requirements, and potential implementing structures for providing space traffic management services, which fuse and coordinate SSA, space environmental information, air traffic services, radio frequency spectrum, and orbital debris mitigation policies, to reduce risk and enhance safe space launch, operations in space, and return from space.

The new National Space Policy increases the number of stakeholders that must participate in the development of planning documents that, among other things, identify the roles to manage national security space capabilities and develop specific measures for improving SSA capabilities. While identifying roles and having input from more SSA stakeholders are positive first steps and may result in more inclusive and robust planning efforts, it is too early to assess the effect of these provisions on managing and overseeing governmentwide SSA efforts.

It Is Too Early to Tell Whether DOD's Efforts to Expand and Make Permanent Its Commercial and Foreign Entities Pilot Program Will Be Effective in Integrating Efforts to Develop SSA Capabilities

The United States is recognized as a key player in SSA. However, the U.S. government realizes that no single nation has the necessary resources or geography to precisely track every object in order to support the long-term sustainability of safe space operations for all space-faring nations. Therefore, in order to improve its ability to conduct SSA, the U.S. government has emphasized the need to reach out to the international community for greater cooperation and information sharing. In 2004, DOD established, pursuant to congressional authorization, the Commercial and Foreign Entities pilot program to provide non-U.S. government entities, state and local governments, and foreign governments and entities, SSA data to, among other things, avoid damage to satellites in space. Through the National Defenses Authorization Act for Fiscal Year 2010, Congress made the Commercial and Foreign Entities pilot a permanent program, commonly known as U.S. Strategic Command's SSA sharing mission.[24]

U.S. Strategic Command manages and is creating policies and procedures to execute the mission, which expands data sharing and consists of three levels of SSA services to commercial entities and international governments: (1) a basic service consisting of information posted to an internet Website, (2) advanced services available to entities under a negotiated agreement, and (3) emergency notifications alerting satellite operators to hazardous situations. U.S. Strategic Command's mission is also to enhance the U.S. government's SSA capabilities by utilizing SSA information provided by commercial and foreign entities. The U.S. Department of State intends to reach out in the near future to all space-faring nations to ensure that the JSpOC has current contact information for both government and private sector satellite operations centers. Additionally, U.S. Strategic Command plans to begin reaching out to international and commercial partners to seek a dialogue and agreement for information exchange. Key issues remaining to be addressed include developing mechanisms for:

- making SSA data more useable—according to a DOD study of the Iridium/Cosmos satellite collision, as well as a 2009 European Union study,[25] the United States does not fully disclose data on satellite orbits and debris objects (because of the sensitivity of the information), rendering the data available on the internet Web site insufficiently accurate for collision avoidance purposes; this includes determining what data to share, the mechanisms for sharing, and at the same time protecting sensitive U.S. government and other stakeholders' SSA information; and
- verifying and validating SSA information provided by commercial and foreign entities to help ensure the reliability of U.S. SSA data products.

[24] Pub. L. No. 111-84, § 912 (codified as amended at 10 U.S.C. § 2274). Congress authorized DOD to carry out a pilot program for providing space surveillance data support to non-U.S. government entities in section 913 of the National Defense Authorization Act for Fiscal Year 2004, Pub. L. No. 108-136, which added section 2274 to Title 10 of the U.S. Code. DOD subsequently created the Commercial and Foreign Entities pilot program.

[25] European Security and Defense Assembly, Assembly of Western European Union, *Space Situational Awareness* (June 4, 2009).

Because the SSA sharing mission is undergoing development, it is too early to tell whether it will be an effective mechanism for integrating SSA capability development efforts.

Conclusions

Recent events, such as the Chinese antisatellite test and the Iridium and Cosmos satellite collision, have highlighted the need for better SSA capabilities governmentwide. DOD has recognized that its existing SSA systems fall short of capability needs and has significantly increased its dollar investments to enhance SSA capabilities. Moreover, the Air Force successfully launched its SBSS satellite—after several years of delays—which is anticipated to appreciably enhance SSA. However, most other SSA acquisition efforts that focus on fielding major additions in capability over the next 5 years have or are facing significant challenges and risks, such as the use of immature technologies; planning to deliver all capabilities in a single, large increment, versus smaller and more manageable increments; technical requirements instability; operations in a multiple security level environment; and data integration issues. If these efforts do not progress as planned, risk of continuing or worsening SSA capability gaps will result. Therefore, while it is too early to determine the extent to which these new capabilities will address existing shortfalls, it is essential that new SSA system acquisitions are placed on a solid footing at the start of development to help ensure capabilities from these systems are delivered to the warfighter as and when promised. Should DOD decide to proceed on a path that leaves open important questions, including those about technologies, then it is important that this footing be based on thorough analyses of the risks involved—such as with the use of backup technologies—including cost, schedule, and performance implications. Such analyses could provide the knowledge needed to determine whether the acquisition program is worth pursuing or what trade-offs would need to be made with other investments should additional resources be required. We have consistently made recommendations for establishing reliable acquisition business cases, such as maturing technologies prior to development start, utilizing evolutionary development, and stabilizing requirements, and DOD has already embraced these for its newest major space acquisition—the Global Positioning System IIIA program.

A critical aspect in strengthening the SSA mission is ensuring there is effective coordination and collaboration across the federal government, especially given the many organizations involved with SSA, along with their differing missions. While the Secretary of Defense does not have explicit authority to execute his responsibility to develop capabilities, plans, and options for SSA, his responsibility has been clarified by the

National Space Policy and there are some actions in place or under development to facilitate SSA acquisitions, such as a national architecture and initial capabilities document. Nevertheless, given past difficulties in coordinating space acquisitions that span DOD and federal agencies, coordination and collaboration need to be carefully monitored and new oversight tools, such as the National Security Space Strategy, provide opportunities to clearly lay out expectations, responsibilities, and authorities. Because implementation of the National Space Policy is, in part, intended to address these issues, and given the National Security Space Strategy has only recently been issued, we are not making recommendations regarding coordination and collaboration at this time.

Recommendations for Executive Action

For major space acquisition programs, we have consistently made recommendations to help ensure acquisition efforts are placed on a solid footing at program start. For SSA in particular, we recommend that the Secretary of Defense direct the Under Secretary of Defense for Acquisition, Technology and Logistics to take the following two actions:

- Assure—as part of the approval for the Space Fence and JMS acquisition efforts to initiate product development—that all critical technologies are identified and matured to a level they can be demonstrated in a realistic or operational environment, and that other key program risks have been fully assessed to help ensure cost, schedule, and performance goals will be met (for JMS in particular, implementing this recommendation may require dividing the program into separate increments).

- If a determination is made that the effort should move forward into product development with less mature technologies, then conduct an assessment of available backup technologies that may lessen capability and add cost to the programs and the additional time, money, and effort that may be required to meet performance objectives.

Agency Comments and Our Evaluation

We provided a draft of this report to the Secretary of Defense and ODNI. Written comments from DOD are included in this report as appendix V. ODNI did not have any comments.

DOD concurred with our recommendation that the Under Secretary of Defense for Acquisition, Technology and Logistics assure—as part of the approval for the Space Fence and JMS acquisition efforts to initiate product development—that all critical technologies are identified and matured to a level they can be demonstrated in a realistic or operational environment, and that other key program risks have been fully assessed to help ensure cost, schedule, and performance goals will be met. DOD noted that the requirement to validate required technology maturity levels and assess other key program risks to ensure cost, schedule, and performance goals is part of the milestone B—which signifies the start of product development and the engineering and manufacturing development phase in DOD's acquisition process—review, approval, and certification process required by DOD guidance and statute.[26] While DOD guidance and law require acquisition efforts to mature technologies to a level commensurate with TRL 6—demonstration in a relevant environment—our recommendation is based on our best practices work which has shown that achieving a TRL 7—demonstration in a realistic or operational environment—is the level of technology maturity that constitutes low risk for starting a product development program. We ordinarily regard satellite technologies that have achieved TRL 6 as fully mature because of the difficulty and expense of demonstrating maturity in a realistic environment—space—which is what would be required to reach TRL 7; however, this does not apply to programs such as Space Fence and JMS which are ground-based. Additionally, we remain concerned that the JMS effort does not intend to identify all critical technologies prior to starting development. Although our best practices work and DOD guidance call for critical technologies to be identified and matured by development start, the JMS plans are only to identify and assess critical technologies prior to and specific for each release. Consequently, as currently planned, the JMS effort will not have assurance that all needed technologies will be mature when needed and that cost estimates—based on the development of all five releases—are reliable as of the start of product development.

DOD partially concurred with our recommendation that if a determination is made that the Space Fence or JMS effort should move forward into product development with less mature technologies, then conduct an assessment of available backup technologies that may lessen capability and add cost to the program and the additional time, money, and effort that may be required to meet performance objectives. DOD noted that an assessment of required technology readiness and appropriate mitigation plans is part of the process required for technology readiness decisions for milestone B, but that trades between cost, schedule, performance, and technology risks are more appropriately addressed after milestone B—

[26] Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* Enclosure 2 paragraph 5.d.(7) (Dec. 8, 2008); 10 U.S.C. § 2366b(a)(3)(D).

during the integrated system design portion of the engineering and manufacturing development phase where overall system-level risks are considered. We continue to believe an assessment of utilizing backup technologies should occur prior to the start of system development, as the results of such an assessment could provide knowledge needed to determine whether the acquisition program is still worth pursuing or what tradeoffs would need to be made with other investments should additional resources be required.

DOD also provided technical comments that have been incorporated where appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Under Secretary of Defense for Acquisition, Technology and Logistics, 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 VI.

Cristina T. Chaplain
Director
Acquisition and Sourcing Management

Appendix I: Objectives, Scope, and Methodology

Our objectives were to (1) review key systems being planned and acquired to provide space situational awareness (SSA) with focus on their progress in meeting cost, schedule, and performance goals; and (2) determine the extent to which an integrated approach is being used to oversee and plan efforts to develop SSA capabilities. Our work is based on the most current information available as of October 1, 2010.

To review key systems being planned and acquired to provide SSA, we examined Department of Defense (DOD) acquisition efforts that are expected to deliver large gains in SSA capabilities during fiscal years 2010 through 2015, including Space Surveillance Network sensor upgrade and life-extension efforts aimed to avoid gaps in operational capabilities; development of new sensors, such as the Space Based Space Surveillance, Space Fence, and Space Surveillance Telescope efforts; and the development of the Joint Space Operations Center Mission System to integrate data and provide real-time information for SSA and command and control of space forces. We analyzed documentation and interviewed officials on the status and progress of SSA development efforts in areas such as requirements, budgets, cost, funding, schedule, contracting, technology maturation, testing, and personnel. We assessed, using criteria we developed through our best practices work on commercial sector acquisitions, the levels of knowledge the acquisition efforts had attained at their current development stages and related risks.[1] For example, we have found that fully maturing technologies critical to the success of an acquisition program prior to beginning product development, following an incremental development path toward meeting user needs, and matching available resources (that is, technology, time, money, and people) to requirements at program start can significantly reduce risks to achieving cost, schedule, and performance goals. In assessing whether programs are adopting this practice, we reported the readiness of critical technologies (as assessed by DOD), using technology readiness levels, a metric originally developed by the National Aeronautics and Space Administration (NASA) and used across space programs. We also analyzed program-specific cost performance data obtained from various SSA acquisition program offices for which we did not perform data reliability assessments. For past and future DOD SSA-related investment amounts, we used DOD budget request documentation for fiscal years 2006 through 2011. Our analysis included not only efforts traditionally categorized as SSA, but also selected SSA-related efforts, typically budgeted for and

[1] Our best practices reviews are identified in related GAO products at the end of this report.

included under space control and counterspace systems, that are closely tied to the SSA mission. To assess the reliability of these budget estimates in determining DOD investments in SSA programs and projects, we reviewed and assessed Office of Management and Budget documentation related to the federal budget and DOD's Financial Management Regulations relating to preparation of budget reports and concluded that this documentary review was sufficient to determine that the data were reliable for purposes of this report.

To determine the extent to which an integrated approach is being used to manage and oversee efforts to develop SSA capabilities, we analyzed documents and interviewed officials from 30 organizations within the SSA stakeholder community—users and providers of SSA information represented by DOD, the intelligence community, civil government agencies, and commercial industry—to examine (1) management and oversight efforts to develop, acquire, and manage SSA capabilities; and (2) planning activities for SSA architectures, investments, and requirements. We also analyzed documentation and interviewed officials from DOD and commercial industry to assess the benefits and challenges relating to DOD's implementation of its SSA sharing program (formerly the Commercial and Foreign Entities program) under which SSA information is to be shared among DOD, industry, and foreign entities for collision avoidance purposes.

For both objectives, we analyzed documentation from and interviewed officials of the following organizations:

- Air Force—Office of the Under Secretary of the Air Force, Directorate of Space Acquisition, Arlington, Virginia; Air Force Space Command, Peterson Air Force Base, Colorado; Air Force Space and Missile Systems Center, Los Angeles Air Force Base, California; Air Force 850th Electronic Systems Group, Electronic Systems Center, Peterson Air Force Base, Colorado and Hanscom Air Force Base, Massachusetts; Air Force Weather Agency, Offutt Air Force Base, Nebraska.

- Other Defense—Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, Washington, D.C.; Office of the Under Secretary of Defense for Intelligence, Washington, D.C.; Office of the Under Secretary of Defense for Policy, Washington, D.C.; Office of the Assistant Secretary of Defense for Networks and Information Integration, Washington, D.C.; Office of the Director, Cost Assessment and Program Evaluation, Washington, D.C.; National Security Space

Office, Fairfax, Virginia; Defense Advanced Research Projects Agency, Arlington, Virginia; Missile Defense Agency, Arlington, Virginia; Directorate for Intelligence and Directorate for Force Structure, Resources, and Assessment, Office of the Joint Chiefs of Staff, Washington, D.C.; Capability and Resource Integration Directorate, U.S. Strategic Command, Offutt Air Force Base, Nebraska; Joint Functional Component Command for Space, Vandenberg Air Force Base, California.

- Intelligence Community—Office of the Director of National Intelligence, Washington, D.C.; National Air and Space Intelligence Center, Wright-Patterson Air Force Base, Ohio; National Geospatial-Intelligence Agency, Bethesda, Maryland; National Reconnaissance Office, Chantilly, Virginia; National Security Agency, Fort Meade, Maryland; Space Protection Program Office, Colorado Springs, Colorado.

- Other—Orbital Debris Program Office, National Aeronautics and Space Administration, Houston, Texas; Space Weather Prediction Center, National Oceanic and Atmospheric Administration, Boulder, Colorado; Aerospace Industries Association, Arlington, Virginia; Analytical Graphics, Inc., Washington, D.C.; Massachusetts Institute of Technology Lincoln Laboratory, Lexington, Massachusetts; Institute for Defense Analyses, Alexandria, Virginia.

We conducted this performance audit from October 2009 to December 2010 in accordance with generally accepted government auditing standards.[2] 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.

[2] While we completed audit work in December 2010, DOD's security classification review postponed the release of the classified version of this report until February 2011.

Appendix II: Space Surveillance Network Composition and Characteristics

The current space surveillance network includes 29 ground-based Department of Defense (DOD) and privately and foreign owned radar and optical sensors at 17 worldwide locations, a communications network, and primary and alternate operations centers for data processing. Most of the sensors are mechanical tracking, phased-array, and continuous-wave radars, but optical telescopes are also used.

The most common radar type is a movable radar antenna with a mechanical tracker, whereby energy is transmitted into space and reflected back by a space object to the same radar antenna. A phased-array radar consists of thousands of smaller individual antennas that produce and steer energy beams to different locations in space. A continuous-wave radar consists of several transmitters and receivers, each placed in a different physical location across a horizontal plane. Optical telescopes possess sensors that are capable of detecting the light reflected from space objects and tracking and characterizing the objects using this reflected light.

The support that the sensors provide to the space surveillance network is categorized as being dedicated, collateral, or contributing. Dedicated sensors support the space surveillance network as their primary purpose. Collateral sensors primarily support other missions, such as ballistic missile warning or launch vehicle range support, but also provide some space surveillance capabilities. Contributing sensors support the space surveillance network when requested by the U.S. Strategic Command and are operated under contract or agreement.

Space surveillance data needs are coordinated by the Joint Functional Component Command for Space through the Joint Space Operations Center, located at Vandenberg Air Force Base, California, or the alternate space control center, located at Dahlgren, Virginia. These operations centers direct the network sensors to collect data on a space object's metrics, or orbital position, such as the time that the space object is observed, its angle (elevation) from the point of observation, its direction (azimuth), and its distance (range) from the sensor. Information about a space object's characteristics, such as size, shape, motion, orientation, and surface materials, can also be obtained and is used for space object identification.

Table 3 lists the network sensors by category, with the sensor names and locations, types, and descriptions. Figure 4 graphically depicts the locations of these sensors.

Table 3: Space Surveillance Network Sensor Names, Locations, Types, and Descriptions

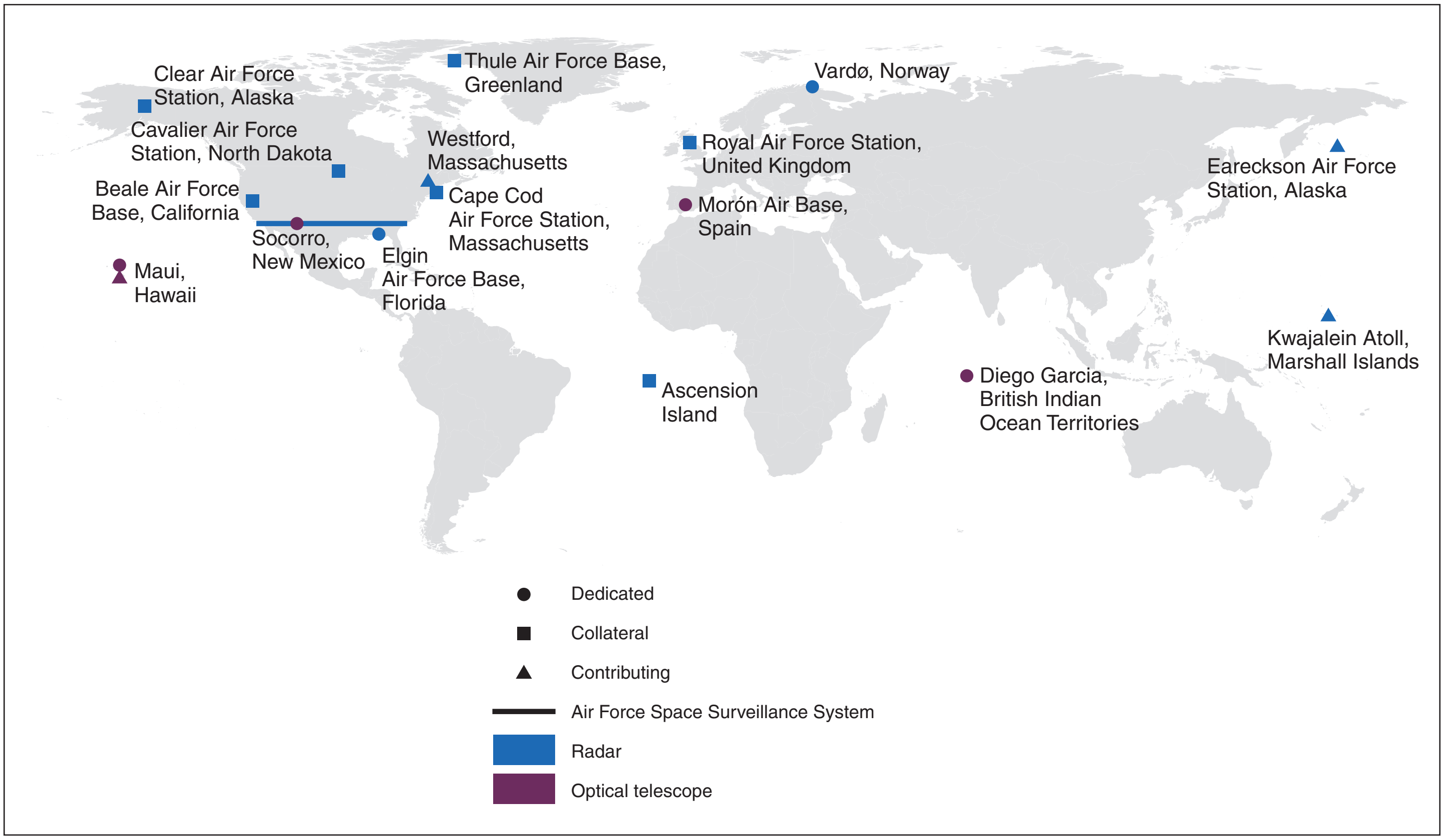
Sensor name and location	Sensor type	Year(s) fielded	Sensor description
Dedicated support to space surveillance			
Globus II; Vardø, Norway	Mechanical radar	1999	Provides near-Earth metric tracking and deep-space wideband images
Eglin (AN/FPS-85) Radar; Eglin Air Force Base, Florida	Phased array radar	1969	Primary sensor for near-Earth metric tracking; also provides radar cross section (RCS) measurements and limited deep-space metric tracking
Air Force Space Surveillance System (AFSSS); 3 transmit antennas and 6 receive antennas geographically located along the 33rd parallel of the United States, from Georgia to California	Continuous wave radar	1961	Provides high-volume near-Earth and deep-space metric tracking
Ground-Based Electro-Optical Deep Space Surveillance (GEODSS); Diego Garcia, British Indian Ocean Territories; Maui, Hawaii; and Socorro, New Mexico	Electro-optical telescopes at each site	Early 1980s	Primary sensor for deep-space metric tracking; also provides optical space object identification (SOI) data
Morón Optical Space Surveillance (MOSS) System; Morón Air Base, Spain	Electro-optical telescope	1998	Provides deep-space metric tracking and photometric SOI
Collateral support to space surveillance			
Ascension radar; Ascension Island, south Atlantic Ocean	Two mechanical radars	1971	Provides near-Earth metric tracking and RCS measurements
Ballistic Missile Early Warning System (BMEWS); Clear Air Force Station, Alaska;a Thule Air Force Base, Greenland; and Royal Air Force Station, Fylingdales, United Kingdom	Phased array radar at each site	Early 1960s	Provides near-Earth metric tracking and RCS measurements
PAVE Phased Array Warning System (PAVE PAWS); Cape Cod Air Force Station, Massachusetts and Beale Air Force Base, California	Phased array radar at each site	1980	Provides near-Earth metric tracking and RCS measurements
Perimeter Acquisition Radar Attack Characterization System (PARCS); Cavalier Air Force Station, North Dakota	Phased array radar	1975	Provides near-Earth metric tracking and RCS measurements
Contributing support to space surveillance			
Haystack Radar; Westford, Massachusetts	Mechanical radar	1963	Produces near-Earth and deep-space wideband images and RCS measurements
Haystack Auxiliary Radar; Westford, Massachusetts	Mechanical radar	1993	Produces near-Earth wideband images and RCS measurements
Millstone Hill Radar; Westford, Massachusetts	Two mechanical radars	1957	Produces near-Earth and deep-space metric tracking and RCS measurements

Sensor name and location	Sensor type	Year(s) fielded	Sensor description
Advanced Research Projects Agency (ARPA) Lincoln C-Band Observables Radar (ALCOR); Kwajalein Atoll, Marshall Islands	Mechanical radar	1970	Produces near-Earth wideband images and RCS measurements
ARPA Long Range Tracking and Instrumentation Radar (ALTAIR); Kwajalein Atoll, Marshall Islands	Mechanical radar	1970	Produces near-Earth and deep-space metric tracking and RCS measurements
Target Resolution and Discrimination Experiment (TRADEX); Kwajalein Atoll, Marshall Islands	Mechanical radar	1963	Produces near-Earth and deep-space metric tracking and RCS measurements
Millimeter Wave (MMW) Radar; Kwajalein Atoll, Marshall Islands	Mechanical radar	1983	Produces near-Earth wideband images and RCS measurements
Shemya (Cobra Dane) radar; Eareckson Air Force Station, Alaska	Phased Array Radar	1977	Provides near-Earth metric tracking and RCS measurements
Maui Space Surveillance System (MSSS); Maui, Hawaii	Five electro-optical telescopes	Mid 1970s	Produces deep-space metric tracking and photometric SOI, and near-Earth optical images

Source: GAO analysis of DOD data.

[a]BMEWS radar at Clear Air Force Station was originally fielded in 1986 as a PAVE PAWS radar in Eldorado, Texas. The radar was relocated and fielded at Clear Air Force Station in 2001.

Figure 4: Types and Locations of Space Surveillance Network Sensors



Source: GAO modification of Air Force figure based on GAO analysis of Air Force data (data), Map Resources (map).

Appendix III: DOD Space Situational Awareness-Related Investments

Table 4: DOD Space Situational Awareness (SSA)-Related Investments from Fiscal Year (FY) 2006 through 2015

Dollars in millions[a]

Cost elements/projects	Fiscal year										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
New sensor systems											
Space Based Space Surveillance (SBSS) Block 10 and Follow-on (RDT&E)[b]	107.01	155.44	169.17	143.14	144.24	185.92	210.01	186.28	127.52	7.34	**1,436.07**
SBSS	0.00	155.44	169.17	143.14	144.24	185.92	210.01	186.28	127.52	7.34	**1,329.05**
SBSS-Spacetrack	107.01										**107.01**
Space Fence (RDT&E)	6.90	0.00	13.85	25.51	60.23	164.79	242.02	264.95	334.93	204.20	**1,317.38**
Space Fence		0.00	13.85	25.51	60.23	164.79	242.02	264.95	334.93	204.20	**1,310.48**
Space Fence-Spacetrack	6.90										**6.90**
Net-Centric Sensors and Data Sources (RDT&E)	0.00	1.50	2.80	0.00	18.36	24.44	10.45	12.98	12.42	7.22	**90.16**
Net-Centric Sensors and Data Sources			0.00	0.00	18.36	24.44	10.45	12.98	12.42	7.22	**85.86**
Extended Space Sensors Architecture Advanced Concept Technology Demonstration	0.00	1.50	2.80								**4.30**
Space Surveillance Telescope (SST) (RDT&E)	18.59	19.77	12.83	3.13	14.96	12.79	0.00	0.00	0.00	0.00	**82.1**
SST						1.95	0.00	0.00	0.00	0.00	**1.95**
Defense Advanced Research Projects Agency (DARPA) SST work[c]	18.59	19.77	12.83	3.13	14.96	10.84					**80.13**
SSA Environmental Monitoring (RDT&E)			0.00	0.00	15.55	49.44	45.78	32.76	20.64	13.44	**177.61**
Total new sensor systems	**132.50**	**176.71**	**198.65**	**171.78**	**253.34**	**437.37**	**508.26**	**496.98**	**495.51**	**232.20**	**3,103.28**

Dollars in millions[a]

Cost elements/projects	Fiscal year 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Space command and control											
Joint Space Operations Center Mission System (JMS) (RDT&E and OPAF)b	0.00	0.00	0.00	0.00	136.27	132.71	127.64	107.97	159.50	157.17	**821.25**
Integrated SSA (RDT&E and OPAF)	0.00	9.76	20.55	52.20	0.00	0.00	0.00	0.00	0.00	0.00	**82.51**
Air Operations Center-Weapon System – Space Command and Control Operations (RDT&E)	0.00	0.00	8.22	23.73	0.00	0.00					**31.95**
Rapid Attack Identification Detection and Reporting System (RAIDRS) Block 20 (RDT&E)	0.00	0.79	10.63	6.15	0.00	0.00					**17.57**
Total space command and control	**0.00**	**10.55**	**39.40**	**82.08**	**136.27**	**132.71**	**127.64**	**107.97**	**159.50**	**157.17**	**953.28**
Service life extension efforts											
Sensor service life extension programs (SLEP's)	0.00	29.48	38.68	15.58	54.01	46.09	32.50	36.88	81.57	104.50	**439.27**
Eglin (RDT&E and OPAF)[c]	0.00	16.31	13.60	14.54	22.50	20.30					
Haystack Ultra-Wideband Satellite Imaging Radar (RDT&E)[c]	0.00	13.16	25.08	1.04	21.09	5.84					
Ground-based Electro-Optical Deep Space Surveillance (RDT&E)[c]	0.00	0.00	0.00	0.00	6.70	14.76					
Globus II (RDT&E)[c]	0.00	0.00	0.00	0.00	3.73	5.20					
Spacetrack Sensor SLEP's (RDT&E)	34.10										**34.10**
Air Force Space Surveillance System (OPAF)[c]	4.95	4.68	4.79	4.60	4.18	4.58					**27.78**
Command, Analysis and Verification of Ephemeris Network (OPAF)[c]			0.00	0.00	7.66	0.00					**7.66**
Total Service Life Extension Efforts	**39.05**	**34.16**	**43.47**	**20.18**	**65.85**	**50.66**	**32.50**	**36.88**	**81.57**	**104.50**	**508.82**

Dollars in millions[a]											
Cost elements/projects	**Fiscal year**										
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Total**
Other DOD SSA-related investments											
MAUI Space Surveillance System (RDT&E)	45.94	49.50	41.36	36.09	36.66	5.90	5.56	5.52	5.61	5.70	**237.86**
Technology Insertion Planning and Analysis	3.69	1.29	29.90	38.00	45.67	5.10					**123.64**
SSA efforts (including Congressional adds) (RDT&E)[c]	3.69	1.29	4.90	13.00	6.76	3.00					
Self Awareness SSA Tech Demo and Risk Reduction (RDT&E)[c]	0.00	0.00	25.00	25.00	34.47	2.10					
Spacetrack Integration Node Global Enhanced Reporting (RDT&E)[c]			0.00	0.00	4.43	0.00					
RAIDRS Block 10 (RDT&E and OPAF)	17.51	37.27	45.42	40.03	50.12	28.54	16.50	16.90	13.79	14.02	**280.09**
SSA Initiatives – Spacetrack (RDT&E)	14.47										**14.47**
Other DARPA SSA work	10.92	19.68	8.54	8.30	13.09	10.00					**70.53**
SSA and Counterspace Operations Response Environment (RDT&E)[c]	0.00	0.00	4.00	4.80	4.40	0.00					
Deep View (RDT&E)[c]	10.92	10.25	0.73	0.00	0.00						
Long View (RDT&E)[c]	0.00	9.43	3.81	0.00	0.00						
Bi-Static Shield/Multi-aperture Geosynchronous Imager (RDT&E)[c]	0.00	0.00	0.00	3.50	8.69	10.00					
SSA Initiatives (RDT&E)	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	**0.11**
Total other DOD SSA-related investments	92.54	107.74	125.21	122.44	145.55	49.55	22.08	22.44	19.42	19.74	**726.70**
TOTAL SSA-RELATED INVESTMENTS	**264.09**	**329.15**	**406.73**	**396.48**	**601.01**	**670.28**	**690.48**	**664.27**	**755.99**	**513.60**	**5,292.07**

Source: GAO analysis of unclassified DOD budget submission data for fiscal years 2008 through 2011.

[a]Fiscal years 2006 through 2009 are actual funding amounts; fiscal years 2010 through 2015 are budget estimates. Totals may not add due to rounding.

[b]RDT&E refers to Research, Development, Test, and Evaluation; OPAF refers to Other Procurement, Air Force.

[c]Data not supplied for these projects in fiscal years 2012 through 2015.

Appendix IV: Technology Readiness Levels

Table 5: Hardware Technology Readiness Levels

Technology readiness level	Description	Hardware	Demonstration environment
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.	None (paper studies and analysis)	None
2. Technology concept and application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof of detailed analysis to support the assumption. Examples are still limited to paper studies.	None (paper studies and analysis)	None
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Analytical studies and demonstration of nonscale individual components (pieces of subsystem)	Lab
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.	Low-fidelity breadboard. Integration of nonscale components to show pieces will work together. Not fully functional or form or fit but representative of technically feasible approach suitable for flight articles.	Lab
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.	High-fidelity breadboard. Functionally equivalent but not necessarily form and/or fit (size weight, materials, etc). Should be approaching appropriate scale. May include integration of several components with reasonably realistic support elements/subsystems to demonstrate functionality.	Lab demonstrating functionality but not form and fit. May include flight demonstrating breadboard in surrogate aircraft. Technology ready for detailed design studies.
6. System/ subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated realistic environment.	Prototype. Should be very close to form, fit, and function. Probably includes the integration of many new components and realistic supporting elements/subsystems if needed to demonstrate full functionality of the subsystem.	High-fidelity lab demonstration or limited/restricted flight demonstration for a relevant environment. Integration of technology is well defined.

Technology readiness level	Description	Hardware	Demonstration environment
7. System prototype demonstration in a realistic environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in a realistic environment, such as in an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.	Prototype. Should be form, fit, and function integrated with other key supporting elements/subsystems to demonstrate full functionality of subsystem.	Flight demonstration in representative realistic environment such as flying test bed or demonstrator aircraft. Technology is well substantiated with test data.
8. Actual system completed and "flight qualified" through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Flight-qualified hardware.	Developmental Test and Evaluation (DT&E) in the actual system application.
9. Actual system "flight proven" through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.	Actual system in final form.	Operational Test and Evaluation (OT&E) in operational mission conditions.

Source: GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-10-388SP (Washington, D.C.: March 30, 2010).

Table 6: Software Technology Readiness Levels

Technology readiness level	Description	Supporting Information
1. Basic principles observed and reported.	Lowest level of software technology readiness. A new software domain is being investigated by the basic research community. This level extends to the development of basic use, basic properties of software architecture, mathematical formulations, and general algorithms.	Basic research activities, research articles, peer-reviewed white papers, point papers, early lab model of basic concept may be useful for substantiating the TRL.
2. Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies using synthetic data.	Applied research activities, analytic studies, small code units, and papers comparing competing technologies.
3. Analytical and experimental critical function and/or characteristic proof of concept.	Active R&D is initiated. The level at which scientific feasibility is demonstrated through analytical and laboratory studies. This level extends to the development of limited functionality environments to validate critical properties and analytical predictions using non-integrated software components and partially representative data.	Algorithms run on a surrogate processor in a laboratory environment, instrumented components operating in a laboratory environment, laboratory results showing validation of critical properties

Technology readiness level	Description	Supporting Information
4. Module and/or subsystem validation in a laboratory environment (i.e., software prototype development environment).	Basic software components are integrated to establish that they will work together. They are relatively primitive with regard to efficiency and robustness compared with the eventual system. Architecture development initiated to include interoperability, reliability, maintainability, extensibility, scalability, and security issues. Emulation with current/legacy elements as appropriate. Prototypes developed to demonstrate different aspects of eventual system.	Advanced technology development, stand-alone prototype solving a synthetic full-scale problem, or standalone prototype processing fully representative data sets.
5. Module and/or subsystem validation in a relevant environment.	Level at which software technology is ready to start integration with existing systems. The prototype implementations conform to target environment/interfaces. Experiments with realistic problems. Simulated interfaces to existing systems. System software architecture established. Algorithms run on a processor(s) with characteristics expected in the operational environment.	System architecture diagram around technology element with critical performance requirements defined. Processor selection analysis, Simulation/Stimulation (Sim/Stim) Laboratory buildup plan. Software placed under configuration management. Commercial-off-the-shelf/government-off-the-shelf (COTS/GOTS) components in the system software architecture are identified.
6. Module and/or subsystem validation in a relevant end-to-end environment	Level at which the engineering feasibility of a software technology is demonstrated. This level extends to laboratory prototype implementation on full-scale realistic problems in which the software technology is partially integrated with existing hardware/software systems.	Results from laboratory testing of a prototype package that is near the desired configuration in terms of performance, including physical, logical, data, and security interfaces. Comparisons between tested environment and operational environment analytically understood. Analysis and test measurements quantifying contribution to system-wide requirements such as throughput, scalability, and reliability. Analysis of human-computer (user environment) begun.
7. System prototype demonstration in an operational, high-fidelity environment.	Level at which the program feasibility of a software technology is demonstrated. This level extends to operational environment prototype implementations, where critical technical risk functionality is available for demonstration and a test in which the software technology is well integrated with operational hardware/software systems.	Critical technological properties are measured against requirements in an operational environment.
8. Actual system completed and mission qualified through test and demonstration in an operational environment.	Level at which a software technology is fully integrated with operational hardware and software systems. Software development documentation is complete. All functionality tested in simulated and operational scenarios.	Published documentation and product technology refresh build schedule. Software resource reserve measured and tracked.

Technology readiness level	Description	Supporting Information
9. Actual system proven through successful mission-proven operational capabilities.	Level at which a software technology is readily repeatable and reusable. The software based on the technology is fully integrated with operational hardware/software systems. All software documentation verified. Successful operational experience. Sustaining software engineering support in place. Actual system.	Production configuration management reports. Technology integrated into a reuse "wizard."

Source: The Office of the Director, Defense Research and Engineering, *Department of Defense Technology Readiness Assessment (TRA) Deskbook* (July 2009).

Appendix V: Comments from the Department of Defense

Redacted information in this appendix refers to the classified version of this report.

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

ACQUISITION, TECHNOLOGY AND LOGISTICS

DEC 9 2010

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

Dear Ms. Chaplain:

This is the Department of Defense response to the GAO draft report, [redacted], on DoD Space Situational Awareness Acquisition Efforts, dated November 2, 2010 [redacted]. The Department of Defense acknowledges and generally agrees with the GAO's overall assessment and recommendations. Detailed comments on the report and the Department's response to the recommendations are enclosed.

Sincerely,

Gil I. Klinger
DASD for Space and Intelligence

Enclosures:
As stated

GAO DRAFT REPORT DATED NOVEMBER 2, 2010
[redacted]

[redacted]

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommends that the Secretary of Defense direct the Under Secretary of Defense for Acquisition, Technology and Logistics to assure - as part of the approval for the Space Fence and Joint Space Operations Center (JSpOC) Missions System (JMS) acquisition efforts to initiate product development - that all critical technologies are identified and mature to a level they can be demonstrated in a realistic or operational environment, and that other key program risks have been fully assessed to help ensure cost, schedule, and performance goals will be met. (See page 34/GAO Draft Report.)

DoD RESPONSE: The Department of Defense concurs with this recommendation. The requirement to validate required technology maturity levels and assess other key program risks to ensure cost, schedule, and performance goals is part of the Milestone (MS) B, Engineering and Manufacturing Development (EMD) Phase review, approval, and certification process per DoDI 5000.02, "Operation of the Defense Acquisition System;" Directive Type Memorandum DTM 09-27, "Implementation of the Weapons Systems Acquisition Reform Act of 2009, Public Law 111-23;" and section 2366b of title 10, United States Code.

The JMS program is planning for a MS B review in the spring of 2011. The Space Fence program is planning for a MS B review in the summer of 2012.

RECOMMENDATION 2: The GAO recommends that the Secretary of Defense direct the Under Secretary of Defense for Acquisition, Technology and Logistics to, if a determination is made that the effort should move forward into product development with less mature technologies, conduct an assessment of available backup technologies that may lessen capability and add cost to the programs and the additional time, money, and effort that may be required to meet performance objectives. (See page 34/GAO Draft Report.)

DoD RESPONSE: The Department of Defense partially concurs with this recommendation. An assessment of required technology readiness and appropriate mitigation plans is part of the process required for technology readiness decisions for MS B. Trades between cost, schedule, performance, and technology risks are more appropriately addressed during the integrated system design portion of the EMD phase where overall system-level risks are considered. Per DoDI 5000.02, during this phase, the Milestone Decision Authority shall conduct a formal Post-Preliminary Design Review (P-PDR) Assessment. The PDR report reflects any requirements trades based on the Program Manager's assessment of cost, schedule, and performance risks.

JMS is being developed as a Major Automated Information System (MAIS) program and consists of a single increment with multiple capability releases. For JMS capability releases, requirements trades based on cost, schedule, technology, and performance risks will be approved by the Requirements and Planning Council. The JMS Program Office has established a technology surveillance and evaluation process with various stakeholders. These efforts along with legacy capabilities provide back-up technologies for the JMS program.

The Space Fence is planning to complete its PDR in January 2012. A P-PDR Assessment will then be accomplished to review requirements trades based on the Program Manager's assessment of cost, schedule, and performance risk. This P-PDR Assessment will consider technology maturity risk to support the planned MS B decision in June 2012.

Appendix VI: GAO Contact and Staff Acknowledgments

GAO Contact

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

Staff Acknowledgments

In addition to the contact named above, key contributors to this report were Art Gallegos (Assistant Director), Kristine Hassinger, Arturo Holguín, Laura Holliday, Rich Horiuchi, Roxanna Sun, Robert Swierczek, Jay Tallon, and Peter Zwanzig.

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