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United States General Accounting Office
Washington, DC 20548

June 2, 2003

The Honorable Jerry Lewis
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

Subject: *Military Space Operations: Common Problems and Their Effects on Satellite and Related Acquisitions*

Dear Mr. Chairman:

In fiscal year 2003, the Department of Defense expects to spend more than $18 billion to develop, acquire, and operate satellites and other space-related systems. Satellite systems collect information on the capabilities and intentions of potential adversaries. They enable military forces to be warned of a missile attack and to communicate and navigate while avoiding hostile action. And they provide information that allows forces to precisely attack targets in ways that minimize collateral damage and loss of life. DOD's satellites also enable global communications, television broadcasts, weather forecasting; navigation of ships, planes, trucks, and cars; and synchronization of computers, communications, and electric power grids.

You requested that we review reports we issued on satellite and other space-related programs over the past two decades and identify common problems affecting these programs. In addition to analyzing past reports, we interviewed Air Force space acquisition officials and reviewed past DOD studies as well as DOD's selected acquisition reports to the Congress. As agreed with your office, given the short timeframe of this assignment, we did not thoroughly assess underlying causes of problems identified or the effectiveness of actions being taken to address these problems. However, we plan to do so as part of a follow-on study. To the extent possible, we looked at the current status of programs we reviewed. However, because we principally relied on past GAO and DOD reports, some recent changes in status and cost may not be reflected. We conducted our review from April 2003 through May 2003 in accordance with generally accepted government auditing standards.

RESULTS IN BRIEF

The majority of satellite programs cost more than expected and took longer to develop and launch than planned. In reviewing our past reports, we found that these results were commonly tied to the following problems.

(1) Requirements for what the satellite needed to do and how well it must perform were not adequately defined at the beginning of a program or were changed significantly once the program had already begun.
(2) Investment practices were weak. For example, potentially more cost-effective approaches were not examined and cost estimates were optimistic.
(3) Acquisition strategies were poorly executed. For example, competition was reduced for the sake of schedule or DOD did not adequately oversee contractors.
(4) Technologies were not mature enough to be included in product development.

Several factors contributed to these problems. First, DOD often took a schedule-driven instead of a knowledge-driven approach to the acquisition process. As a result, activities essential to containing costs, maximizing competition among contractors and testing technologies were compressed or not done. Second, there is a diverse array of organizations with competing interests involved in overall satellite development—from the individual military services, to testing organizations, contractors, civilian agencies, and in some cases international partners. This created challenges in making tough tradeoff decisions, particularly since, for many years, there was no high-level official within the Office of the Secretary of Defense dedicated to developing and enforcing an overall investment strategy for space. Third, space acquisition programs have historically attempted to satisfy all requirements in a single step, regardless of the design challenge or the maturity of technologies to achieve the full capability. This approach made it difficult to match requirements to available resources (in terms of time, money, and technology).

Other factors also created challenges for the satellite acquisition programs we reviewed. These include a shrinking industrial base, a declining space workforce, difficulties associated with testing satellites in a realistic environment, as well as challenges associated with launching satellites.

DOD has studied problems affecting its satellite acquisitions and is undertaking efforts to address these problems. We plan to evaluate these efforts in a subsequent review. Therefore, we are not making recommendations in this report.

BACKGROUND

DOD's current space network is comprised of constellations of satellites, ground-based systems, and associated terminals and receivers. Among other things, these assets are used to perform intelligence, surveillance, and reconnaissance functions; perform missile warning; provide communication services to DOD and other government users; provide weather and environmental data; and provide positioning and precise timing data to U.S. forces as well as national security, civil, and commercial users. Table 1 identifies specific satellite systems used for these purposes. Appendix I describes these systems in more detail.

Table 1: Current and Planned Satellite Systems

Function	Current Systems	Planned Systems
Missile warning and tracking	• Defense Support Program (DSP)	• Space-Based Infrared System (High) • Space Tracking and Surveillance System (STSS)
Intelligence, Surveillance and Reconnaissance	• National Reconnaissance Office satellites (not covered in this review)	• NRO satellites • DOD's Space-based Radar (not covered in this review)
Communications		
Wideband/ high capacity systems	• Defense Satellite Communications System (DSCS) • Global Broadcasting Service (GBS) (not covered by GAO reports)	• Wideband Gapfiller Satellite (WGS) • Advanced Wideband System (AWS)
Protected systems (antijam, survivable)	• Milstar	• Advanced Extremely High Frequency (AEHF) • Advanced Polar System
Narrowband systems	• Ultra High Frequency Follow-On satellite communications system (UFO) (not covered by GAO reports)	• Mobile User Objective System (MUOS) (not covered by GAO reports)
Navigation, Positioning, Timing	• Global Positioning System (GPS)	• Next Generation GPS
Weather/ Environmental	• Defense Meteorological Satellite Program (DMSP)	• National Polar-orbiting Operational Environmental Satellite System (NPOESS)

All of these systems are playing an increasingly important role in military operations. According to DOD officials, for example, in Operation Iraqi Freedom, approximately 70 percent of weapons were precision-guided, most of those utilizing GPS capabilities. Weather satellites enabled warfighters to not only prepare for, but also to take advantage of blinding sandstorms. Communications and intelligence satellites were also heavily used to plan and carry out attacks and to assess post-strike damage.

Some of DOD's satellite systems—such as GPS—have also grown into international use for civil and military applications and commercial and personal uses. In addition, many satellites launched over the past two decades have lasted longer than expected. For example, some of the later DSP spacecraft have operated for more than 10 years—well past design lifetime.

The Joint Staff and the Combatant Commands are responsible for establishing overall requirements while the services are responsible for satisfying these requirements to the maximum extent practical through their individual planning, programming, and budgeting systems. According to DOD, the Office of the Secretary of Defense and the intelligence community's Community Management Staff provide high-level leadership for national security space activities. The Air Force is the primary procurer and operator of space systems and spends the largest share of defense space funds, annually averaging about 85 percent. The Air Force Space Command is the major component providing space forces for the U.S. Strategic Command.

The Army controls the Defense Satellite Communications System and operates ground mobile terminals. The Navy operates the Ultra High Frequency follow-on satellites, the Geosat follow-on satellites, a weather satellite, and some space systems that contribute to surveillance and warning. And the National Reconnaissance Office designs, procures, and operates space systems for intelligence and defense activities.

In addition, the National Security Space Architect and National Security Space Integration Directorate coordinate national security space architectures and plans for future national security space activities. The Office of the Secretary of Defense, the Marine Corps, and other DOD agencies also participate in national security space activities.

COMMON PROBLEMS AFFECTING SATELLITE ACQUISITIONS

The majority of satellite programs we have reviewed over the past two decades experienced problems during acquisition that drove up costs and schedules and increased technical risks.

First, requirements for what the satellite needed to do and how well it must perform were not adequately defined at the beginning of a program or were changed significantly once the program had already begun. This made it more difficult for programs to ensure that they could match their requirements to their resources (in terms of money, time, and technology). The more requirements were added or changed, the more that cost and schedule increased.

Second, investment practices were weak. At times, programs did not explore potentially more cost-effective investment approaches. Once they settled on an approach, programs often did not develop realistic cost estimates. From a broader perspective, investments in programs were not made in accordance with an overall space investment strategy for DOD. Funds were sometimes shifted from healthier programs to pay for weaker ones. Further, according to DOD officials, decisions external to the program office were sometimes imposed that resulted in unexpected funding cuts.

Third, acquisition strategies were poorly executed. For example, competition was reduced for the sake of schedule or DOD did not adequately oversee contractors. At times, contract type was not suitable for the work being done.

Fourth, programs did not always ensure that technologies were mature before making heavy investments in the program. This often caused cost and schedule increases due to the need to fix problems later in development. A continuing problem is that software needs are poorly understood at the beginning of a program.

Table 2 identifies examples of problems identified in our reports and affected systems.

Table 2: Specific Common Problems Identified in GAO Reports

Problems	Systems Affected by One or More Problems
Requirements—Defining what the system needs to do and how well it needs to perform • Program did not adequately define requirements • Unresolved conflicts among users on requirements • Frequent changes made to requirements after product development began	• DSP replacement programs • Milstar • AEHF • SBIRS-High
Investment Strategy—Choosing a path that offers the most cost-effective solution and ensuring costs are contained • Program did not adequately analyze investment alternatives • Cost and/or schedule estimates were optimistic • Funding was unstable	• DSP replacement programs • SBIRS-Low/STSS • Milstar • AEHF • SBIRS-High • GPS III
Acquisition Strategy—Maximizing competition and contractor reliability • Level of competition was reduced or eliminated • Contract type was not suitable for work being done • Poor oversight over contractors	• AEHF • SBIRS-High • SBIRS-Low • STSS • EELV
Technology—Ensuring technology is mature before heavy investments are made in the program • Technology not sufficiently mature at program start • Software needs poorly understood • Testing compressed, skipped, or done concurrently with production	• DSP replacement programs • Milstar • SBIRS-Low • AEHF • SBIRS-High

Several factors contributed to the problems identified in our reports. First, DOD took a schedule-driven versus a knowledge-driven approach to the acquisition process. As a result, activities essential to containing costs, maximizing competition among contractors and testing technologies were shortchanged. Second, there was a diverse array of organizations with competing interests involved in overall satellite development—from the individual military services, to testing organizations, contractors, civilian agencies, and in some cases, even international partners. This created challenges in making tough tradeoff decisions, particularly since, for many years, there was no high-level official within the Office of the Secretary of Defense dedicated to developing and implementing an overall investment strategy for space.[1] Often, disagreements within DOD would go unresolved for a long period of time. Third, space acquisition programs have historically attempted to satisfy all requirements in a single step, regardless of the design challenge or the maturity of technologies to achieve the full capability. This approach made it difficult to match requirements to available resources (in terms of time, money, and technology).

[1] In 1994, DOD established the Office of the Deputy Under Secretary of Defense for Space. The Deputy was responsible for developing, coordinating, and overseeing the implementation of space policy. The Deputy also had oversight responsibility for space architectures as well as space acquisition programs. In 1998, this office was dissolved and its responsibilities divided and given to other offices within OSD and the military services.

Table 3 further illustrates how these cross-cutting factors can contribute to problems in requirements, investment strategy, acquisition strategy and technology.

Table 3: Cross-cutting Factors Contributing to Space Acquisition Problems and Potential Outcomes

Cross-Cutting Factors	Requirements	Investment	Acquisition Strategy	Technology
Schedule driven vs. knowledge driven approach →	Requirements not fully known at start of program ↓ Changes drive up costs and schedule	Planning is optimistic; costs not fully known at start of program. Alternatives not analyzed or eliminated to meet schedule pressures ↓ Solution being pursued may not be the most cost-effective; decisionmakers lack insight into cost growth	Competition may be shortchanged in an attempt to accelerate development ↓ Best technical solution may be ignored; costs go up due to lack of competition	Testing schedule is compressed to meet target launch date or it is done concurrently with production. Less time to fix problems that arise during testing ↓ Costs and schedule increase due to need to fix problems later in product development
Multiple players (Air Force, Army, Naval, Space Commands, testing organizations, contractors, other agencies, international partners); no "honest broker" at OSD level. →	Competing/ conflicting requirements set. Changes made throughout product development ↓ Requirements cannot be matched to resources	Original cost estimates become invalid. Investments not made in accordance with overall space investment strategy for DOD ↓ Overall investment in space may not be optimized		
Single-step development vs. evolutionary development →	Requirements exceed resources (time, money, technology) at time of product development			Technology too immature at product development

Other Factors Created Challenges for Acquisitions

Other factors also created challenges for the satellite acquisition programs we reviewed. Specifically, as with other defense industry sectors, the satellite industry has seen a high rate of consolidation resulting in reduced levels of competition. In 1998, we reported that since 1990 the number of defense satellite contractors shrunk from 8 to 5. Moreover, in recent years, the U.S. commercial space industry has seen decreasing demand and increasing international competition. Our work has found varying levels of success in maintaining and promoting competition within this environment.

DOD has also had difficulty in maintaining the capability to launch its satellites—partly due to problems within the expendable launch sector and partly due to a decision in the 1970s to fly all DOD spacecraft on NASA's space shuttle. According to a DOD report[2], as a result of the latter, DOD investments in space launch infrastructure and vehicle improvements virtually halted until the Challenger accident of 1986. The accident itself disrupted launch schedules for programs such as GPS. At the same time, the lack of investment in launch capabilities for so many years contributed to higher launch costs after the accident and serious operational limitations due to aging and obsolete launch vehicle components and a dependence on outdated launch vehicle production lines. In 1998, we reported that the number of contractors in this sector fell from 6 to 2.

Air Force officials also cited challenges related to DOD's space workforce. In 2001, a congressionally chartered commission looking at space issues, known as the Space Commission, noted that from its inception the defense space program has benefited from world-class scientists, engineers, and operators, but now many experienced personnel are retiring and recruitment and retention of qualified space personnel is a problem. Further, the commission concluded that DOD does not have the strong military space culture—including focused career development and education and training—it needs to create and maintain a highly trained and experienced cadre of space professionals who can master highly complex technology as well as develop new concepts of operation for offensive and defensive space operations.

Unique aspects of satellite development and testing also presented challenges for programs we reviewed. For example, some testing on satellites can be done on the ground in thermovac or other environmental simulation chambers. Some systems can also be tested via aircraft. However, the only way to test satellites in the true operational space environment is to build one or more demonstrator satellites and launch them into orbit. Launching demonstrators is costly and time-consuming but it offers greater assurance that satellites will work as intended. Also, a high degree of coordination between space and ground segments as well as user equipment is necessary. Typically, satellite software is used to test the satellite before it is shipped for launch. Ground control software is typically installed/fielded a year before launch to allow for training and rehearsals. Therefore, scheduling slips within any one of

[2] Aspin, Les, Secretary of Defense, *Report on the Bottom-up Review*, October 1993.

these activities can cause problems for other activities. At the same time, the timing of the launching of satellites must coincide with the deployment of ground receivers, but this can be difficult to do when ground and space segments are funded by different military services.

In addition, satellite programs require a significantly larger investment in the acquisition phase than other weapons systems. This is because satellites are RDT&E intensive, go through extensive development testing, and need to have all of their sustainment capabilities on board when launched. Once on orbit they require a reduced amount of funding to operate when compared with the funding profile of a typical, large production DOD program. Air Force space acquisition officials stated that the funding profile for a satellite program is typically the reverse of the funding profile for a typical DOD program. The notional DOD lifecycle profile shows approximately 28 percent of a program's budget funding its development and 72 percent of its budget funding the production of hundreds of units and paying for the operations and sustainment that goes with it. For a satellite program, the funding profile is "front-loaded" with 60-70 percent of its budget funding development and launch with 30-40 percent of the budget funding operations and maintenance of the satellite system. According to Air Force officials, this sort of profile makes it difficult to adapt to unknowns that arise since it is not possible to trade out-year production funding to fund near-term problems since the production numbers for satellite systems are so small.

HOW PROBLEMS AFFECTED SPECIFIC PROGRAMS

Nearly every program we reviewed over the past several decades experienced one or more of the problems we identified and experienced cost and scheduling increases as a result. Corrective actions were taken on some programs to reduce cost, schedule or technical risks after they were identified. For example, the NPOESS program took a range of actions to reduce program risks, including deferring development of requirements, deciding to rely on existing versus new technology for some sensors, and using aircraft to test sensors. In other cases, problems were allowed to persist to the point where DOD needed to step in a restructure the program. SBIRS-Low, for example, was restructured after continuing to experience cost growth and scheduling delays, and SBIRS-High was restructured last year after experiencing continued cost growth and schedule delays. In the 1990s, three separate programs designed to replace DSP satellites were abandoned after it became clear that they would be either too costly and/or technically risky to pursue.

Recent cases are discussed in more detail below. A chronology of our findings related to individual systems is also provided in appendix I.

Advanced EHF Satellite

The AEHF is a satellite system intended to replace the existing Milstar system and to be DOD's next generation of higher speed, protected communication satellites. We recently reported that cost estimates developed by the Air Force for this program increased from $4.4 billion in January 1999 to $5.6 billion in June 2001 for five satellites. Moreover, DOD will not meet its accelerated targeted date for launching the first satellite in December 2004. In fact, the first satellite's new launch date is December 2006. (DOD has since decided to purchase three satellites with options to purchase the fourth and fifth. The December 2002 Selected Acquisition Report for the AEHF showed current program costs at $4.7 billion for three satellites.)

Several factors contributed to cost and schedule overruns and performance shortfalls. First, in the early phases of the AEHF program, DOD substantially and frequently altered requirements. Although considered necessary, many changes were substantial, leading to cost increases of hundreds of millions of dollars because they required major design modifications. Second, based on a satellite constellation gap caused by the failure of a Milstar satellite, DOD decided to accelerate its plans to build the AEHF satellites. The contractors proposed, and DOD accepted, a high risk schedule that turned out to be overly optimistic and highly compressed-leaving little room for error and depending on a chain of events taking place at certain times. Substantial delays occurred when some events did not occur on time. DOD decided to take this approach on the grounds it offered a chance to meet unmet warfighter requirements caused by the loss of the Milstar satellite. Third, at the time DOD decided to accelerate the program, it did not have the funding needed to support the activities and the manpower needed to design and build the satellites quicker. The lack of funding also contributed to schedule delays, which in turn, caused more cost increases.

Advanced Wideband Satellite System (AWS)

AWS (also known as the Transformational Communications Satellite or TSAT) is a fairly new program focused on supplementing AEHF and replacing DOD’s Wideband Gapfiller Satellite system (WGS). DOD plans to include laser crosslinks on the satellite to significantly increase capacity. In 2003, GAO reported that the AWS program is scheduled to enter product development with only one of its five critical technologies mature according to best practice standards. Four immature technologies were scheduled to reach maturity by January 2006, more than 2 years after development start. Three of four technologies have a backup technology in case of development difficulties. But the Single Access Laser Communications technology has no backup, and according to program officials, any delay in maturing this technology would result in a slip in the expected launch date.

SBIRS-High

SBIRS-High satellites are being developed to replace DOD’s older missile warning satellites. In addition to missile warning and missile defense missions, the satellites will perform technical intelligence and battlespace characterization missions. After the program was initiated in 1994, it faced cost, scheduling, and technology problems.

GAO reports from 1995 through 2001, for example, noted that the program was facing serious hardware and software design problems. In 2001, the program reported that it had exceeded the 25 percent cost threshold established in 10 U.S.C. 2433. In 2002, an independent review team chartered by DOD to examine the reasons behind cost and scheduling problems in the SBIRS-High program reported that a key root cause was that system requirements were not well-understood when the program began and as it evolved. In addition, the requirements setting process was often adhoc with many decisions being deferred to the contractor. The review team also found that the program was too immature to enter system design and development. Further, there was too much instability on the program after the contract award—with DOD undertaking four major replanning efforts. DOD has since restructured the program and taken corrective actions, but the team noted that there were still risks within the program, including risks related to the schedule.

<u>SBIRS-Low</u>

SBIRS-Low satellites are to perform missile warning and missile tracking functions. Because of their low-earth orbit, they may be particularly useful in tracking missiles through the midcourse of their flight—when missiles themselves have cooled down and become more difficult to track.

SBIRS-Low has been restructured due to cost, scheduling, and technical problems. Despite spending several billion dollars on these efforts, DOD has not launched a single satellite or demonstrated any space-based missile tracking capabilities from space using technologies similar to those to be used by SBIRS-Low (now called the Space Tracking and Surveillance System, or STSS). In 2001, GAO reported that DOD was not adequately analyzing or identifying cost-effective alternatives to SBIRS-Low that could satisfy critical missile defense requirements, such as a Navy ship-based radar capability. At the time, other studies supported the possibility that other types of sensors could be used to track missiles in midcourse of their flight and to cue interceptors. In 2001, GAO reported that the SBIRS-Low acquisition schedule was at high risk of not delivering the system on time or at cost or within expected performance. Satellite development and production, for example, were to be done concurrently, leaving the Air Force at risk of having to correct problems discovered during testing at late stages of the acquisition process, when they are more expensive and time-consuming to fix. SBIRS-Low also had high technical risks because some critical satellite technologies were judged to be immature for the current stage of the program, including the scanning infrared sensor, tracking infrared sensor, and technologies used to cool down satellite sensors. As the program was experiencing cost and schedule problems, DOD restructured the program, moving it from the Air Force to the Missile Defense Agency to reflect the increased focus on missile defense and renaming it the Space Tracking and Surveillance System (STSS).

In May 2003, we reported that the STSS program was not considering two potentially more cost effective alternatives—(1) delaying the launch date by one year and (2) stopping efforts to launch existing technology for research purposes and concentrating instead on new technology. Moreover, the program faced investment and scheduling risks since it recently reduced competition within the program and it decided on a 2007 launch date without knowing the extent of work that must be done on the satellite equipment it plans to assemble and launch.

National Polar-orbiting Operational Environmental Satellite System (NPOESS)

This program essentially combined separate weather satellite efforts being pursued by DOD and the National Oceanic and Atmospheric Administration (NOAA) after it was determined that doing so could reduce duplication and save money. Our earlier reviews identified potential requirements setting problems attributable to the broad base of internal customers each agency has and the diversity of requirements that needed to be met. DOD's selected acquisition report on NPOESS stated that coordination and validation of the broad-based requirements took longer than anticipated and delayed a request for proposal release by 6 months. In 1997, the NPOESS program assessed specific technical, scheduling, and cost risks facing the program, and determined there were risks within the interface data processing segment, the space segment, and the overall system integration segment. To reduce these risks, the program deferred development of requirements either because the technology needed to implement them did not exist or the requirement was too costly. It undertook earlier development of some satellite sensors in order to allow more time to mature technologies. It decided, in some cases, to use existing sensor technologies instead of building new ones. It also increased testing to demonstrate satellite sensors and to deliver early data to users to that they could begin to work with the data.

Global Positioning System (GPS)

GPS satellites, which provide positioning, navigation, and timing information to military forces and civilian users, have existed for over 25 years, but a full constellation of satellites has been operational for only 7 years. In 1980, we reported that the cost to acquire and maintain GPS satellites through 2000 increased from $1.7 billion to $8.6 billion due largely to estimates not previously included for replenishment satellites, launches, and user equipment. In 1983, we reported that costs might still be understated since system design changes were being considered. Costs and schedule were significantly affected in 1987 as a result of the Challenger accident, since DOD was depending on the space shuttle to launch GPS satellites. Reliability problems with GPS receivers also affected schedule throughout the program. In 1991, for example, we reported that DOD postponed full-rate production for receiver sets by 2 years due to reliability problems. Last fall, according to GPS program officials, the program was on track to launch the first GPS III satellite in 2012. However, following a review by the Under Secretary of the Air Force, funding for the program was zeroed for fiscal year 2004, and $46 million was withheld from the fiscal year 2003 budget. Without a full release of the withheld funding, the program office believes the launch date may slip past 2012.

DOD HAS STUDIED ACQUISITION PROBLEMS

DOD has studied many of the problems related to satellite acquisitions identified in our reviews and is making changes. A 1994 study performed by the U.S. Space Command, for example, stated that DOD's process of defining requirements for space systems needed to be improved to ensure greater Joint Staff and Service influence in decisionmaking. With increasing budget pressures and dramatically different post

Cold War strategies, the U.S. Space Command also noted that it was essential for all services to better understand the costs and benefits of requirements. A 1998 study performed by the United States Air Force Scientific Advisory Board advocated adopting commercial practices such as business case analysis, streamlined procurement, and spiral development of ground segments as a way to improve acquisition practices. The study also called for improved oversight by high-level officials, development of improved cost/performance models that increase visibility into program status and emerging problems, and maintaining adequate budget reserves in acquisition programs to minimize reprogramming actions and avoid program disruptions.

More recently, the U.S. Space Commission, chaired by Donald Rumsfeld, found that DOD's budgeting process and declining space workforce created difficulties for acquisitions. Specifically, the Commission noted that when satellite programs are funded in one budget and terminals in another, the decentralized arrangement can result in program disconnects and duplication. It can result in lack of synchronization in the acquisition of satellites and their associated terminals. It can also be difficult for user requirements to be incorporated into the satellite system if the organization funding the system does not agree with and support those user requirements.

Last year, the independent review team studying the SBIRS-High program recognized that there were broad, systemic issues that need to be addressed on space programs. These include: the need for pre-acquisition rigor up front (requirements); increased funding stability; and the need for block upgrades since preplanned product improvements are very difficult for space systems, particularly for space craft. The team also noted that space programs tend to have "inclusive" requirements supporting multiple DOD and warfighting needs with many mission partners.

A range of actions are being undertaken by DOD and individual military services to streamline space acquisition. For example, the Air Force has developed a new space system acquisition process designed to shorten timeframes for technical assessments and facilitate faster decisionmaking. This approach will establish key decision points earlier in the acquisition process, as compared to the acquisition process for non-space systems, and will provide more oversight earlier in the development of complex satellite technology. According to DOD, the new process will conduct an independent cost estimate as part of the key decision point (KDP) authorizing the start of the system design effort and will then also conduct another cost estimate after the design is complete as part of the KDP prior to the start of system build, test and launch activities. A key feature of the new process is that it will use an independent program assessment team composed of members with appropriate expertise to thoroughly review a space program before each KDP. The assessment will be done on a full-time basis over a two to four week period in an effort to perform relevant technical and programmatic reviews in less time than the traditional, part-time, multi-layered integrated product team approach. We plan to study DOD's new space policy as part of our follow-on review and to assess whether DOD will have adequate knowledge about technology, design, and costs for making its decisions.

To strengthen space planning, DOD undertook efforts to develop a plan that would set overall objectives for space and provide a high-level 10- to 15-year roadmap for the direction of space program. The plan is expected to be completed sometime in fiscal year 2003. In response to the Space Commission's recommendation,[3] the Secretary of Defense also designated the Air Force to be the executive agent for space within DOD, with departmentwide responsibility for planning, programming, and acquiring space systems. In October 2001, DOD established a "virtual" major force program for space to increase visibility of resources allocated for space activities. The virtual major force program identifies spending on space activities within the other major force programs in DOD's Future Years Defense Budget and provides information by functional area. Further, in recent testimony, the Under Secretary of the Air Force noted that the Air Force was working with the Director of OSD Cost Analysis Improvement Group to form a national security space cost assessment team to provide a useful, accurate, and timely independent cost estimate with common methodology in support of space acquisition.

We plan to review these and other actions being taken to address satellite acquisition problems in a subsequent review.

AGENCY COMMENTS

DOD provided technical comments on a draft of this letter. These comments were largely focused on ensuring technical accuracy in our reporting of individual systems and providing updated information. We incorporated these comments where possible. DOD did not comment on our overall findings.

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We are sending copies of this report to the Secretary of Defense and interested congressional committees. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841. Key contributors to this report were Cristina Chaplain, Jean Harker, Natalie Britton, Bradley Terry and Art Gallegos.

Katherine V. Schinasi
Director, Acquisition and Sourcing Management

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[3] We recently reported on the status of DOD's efforts to implement the Commission's recommendations. See *Defense Space Activities: Organizational Changes Initiated, but Further Management Actions Needed* (GAO-03-379, April 2003).

Appendix I
Profiles of Satellite Acquisitions

This appendix profiles satellite programs covered by GAO reviews during the past two decades. It also profiles two launch systems, given their importance to the success of satellite programs. Among other things, the profiles describe the programs'

- Mission
- Primary users
- Manager
- Architecture and key technologies
- Contractors/contract type
- Original cost/quantity and current cost/quantity[4]
- Total spent/percent total spent[5]

The profiles also identify key GAO findings related to requirements, investment planning, acquisition strategy, and technology. A summary of these findings and our report coverage are highlighted below. In addition to analyzing past GAO reports, we also relied on DOD Selected Acquisition Reports to the Congress and several DOD studies.

Table I.1 Summary of GAO Coverage and Key Findings

Mission	Program	Require-ments	Invest-ment	Acquisition	Technology
Missile Warning/ Tracking	DSP proposed replacements (FEWS, ALARM)	✔	✔		✔
	SBIRS High	✔	✔	✔	✔
	STSS (including Brillant Eyes, SMTS, SBIRS-Low)	✔	✔	✔	✔
Communi-cations	Milstar	✔	✔	✔	
	DSCS		✔		
	AEHF	✔	✔	✔	✔
	WGS (new effort, covered in a recent, broader GAO assessment of major weapon system programs)				✔
	AWS (new effort, covered in a recent, broader GAO assessment of major weapon system programs)				✔
Navigation	GPS		✔		✔
Weather	NPOESS		✔		✔
Launch	Titan IV		✔		✔
	EELV	✔	✔	✔	✔

[4]Original and current cost estimates were inflated from the base year reported in the SAR to 2003 current dollars using DOD escalation factors. For older SARs with very early base years such as DSP, inflating the dollar amounts may be subject to error based on accuracy of escalation factors. In some cases, DOD provided us with updated cost information.

[5] Total dollars spent were inflated from the year the SAR was issued to 2003 dollars. The percent total spent was taken from the latest SAR available and was not calculated by GAO. In some cases, DOD provided us with updated cost information.

Mission: Missile Warning
Program: Defense Support Program (DSP) and early proposed replacements

Background information

DSP is a strategic surveillance and warning satellite system with an infrared capability to detect ballistic missile launches (intercontinental and submarine-launched). It provides near real-time detection information in support of DOD'S integrated tactical warning and attack assessment (ITW/AA) mission. DSP began in 1967, and the first operational satellite was deployed in 1971. The most recent DSP satellite launch (number 21) was in August 2001. In the late 1970s, DOD decided that DSP should be replaced since the system did not satisfy all the validated military requirements for a space-based ITW/AA sensor. It followed this decision with several attempts to develop replacement systems, but these efforts failed due to high costs and technology immaturity. DOD eventually made enhancements to DSP. The SBIRS-High program is focused on replacing DSP.

Architecture/Key Technologies

The number of DSP satellites in orbit is classified SECRET. DSP satellites use infrared sensors to detect heat from missile and booster plumes against the earth's background. Over the last 29 years, there have been five major design changes. Historically, DSP satellites have been launched atop the Titan III & IV family of launch vehicles; one was launched aboard the Space Shuttle. Currently, DSP satellites are launched into geo-synchronous orbit using a Titan IV-B launch vehicle with an Inertial Upper Stage. DSP Flight 23 will be launched on an Evolved Expendable Launch Vehicle (EELV).

Users	Strategic and tactical forces across military services	**Original cost/ quantity:**	$10.8 billion 19 satellites
Manager	Air Force	**Current cost/ quantity:**	$14.7 billion 23 satellites
Contractors/ Contract type	TRW for satellites Fixed price with Incentive Gencorp, Aerojet for sensors Fixed price with Incentive *(note: contract has since changed)*	**Total spent/ % total spent**	$7.8 Billion 75.4%

Source: 12/31/1996 Selected Acquisition Report (all dollar amounts in 2003 dollars) and DOD provided updates

Key Issues Affecting Program

- Technology immaturity
- Unanticipated costs
- Lack of adequate analysis of alternatives

Note: Issues mostly affecting DSP replacement programs

Chronology of Key Findings

- 1992 GAO reported that DOD was not adequately analyzing alternatives to DSP. DOD first proposed replacing DSP with a system called the Advanced Warning System (AWS), but this proposal never fully materialized because of immature technology and high costs. A subsequent proposal, the Boost Surveillance and Tracking System was discontinued after DOD decided to pursue other technologies for tracking ballistic missiles. AWS was proposed for remaining tactical warning and attack assessment missions in 1990 but was later scaled down to a less costly and less capable system called the Follow-on Early Warning system (FEWS). GAO reported that while the current proposal for FEWS may provide more capability than the existing DSP system, DOD still needed to consider other alternatives, including an enhanced DSP which could be nearly as effective and cost billions dollars less than a fully capable FEWS. Several DOD studies supported this point.

- 1993 GAO reported that adding global processing capability—which would enable processing of data generated by the satellite constellation network to be done in a single station--in upgrades to ground processing stations for DSP might not be cost-effective. One reason was that there were no corresponding plans to reduce the number of ground stations. Another reason was that operational requirements were not yet complete.

- 1994 GAO reported that Congress had appropriated $515 million for FEWS for fiscal years 1992 through 1994, but terminated the program in late 1993 based on affordability reasons. In late 1994, the Air Force selected ALARM (Alert, Locate, and Report Missiles system) to be DSP's replacement. ALARM was to be smaller than DSP and less capable than FEWS with an emphasis on greater support to tactical forces. At the time of GAO's review, concerns were that DOD was about to make a substantial investment in ALARM without fully defining operational requirements. Moreover, while DOD cost estimates showed ALARM to be more affordable than FEWS in the short term, the total life cycle costs lead GAO to question whether ALARM, with projected upgrades, would actually be a more expensive system.

- 1994 GAO reported that the Air Force plans to accelerate ALARM schedule by 2 years from 2004 to 2002 could add costs to the program which in turn could put DOD in a similar unaffordable position when it rejected the FEWS program. At the time, the program office had identified an additional $434 million that would be needed to support the new schedule. Accelerating schedule could also save as much as $700 million because it could obviate the need to procure an additional DSP satellite, its launcher, and an inertial upper stage. However, acceleration could also create program risks by shortening the demonstration and validation phase of the acquisition process by 10 months and performing the critical design review a full year ahead of the original schedule. Air Force officials contended that previous engineering efforts on DSP earlier replacement programs provided enough experience to offset this risk.

- 1994 GAO reported that funds for developing two critical technologies for ALARM—infrared focal plane array and radiation-hardened electronics—were frozen. Contractors stated that no private sector funds would be available for these technologies.

- 2003 CRS report recapped history of DSP, noting that none of the proposed replacement programs reached fruition, and instead, enhancements were made to the DSP series. For example, DSP was designed to detect launches of strategic long range missiles (such as intercontinental ballistic missiles) but following the Persian Gulf War DOD recognized that the threat was changing from intercontinental ballistic missiles to tactical missiles like the SCUD-C. In 1995, DOD added the ALERT (Attack and Launch Early Reporting to Theater) system, a ground-processing center that uses DSP data, to augment its missile warning capabilities.

GAO Reports

GAO/NSIAD-92-39, GAO/NSIAD-93-148, GAO/T-NSIAD-94-108, GAO/T-NSIAD-94-164, GAO/NSIAD-94-253

Mission: Missile Warning
Program: Space Based Infrared System-High (SBIRS-High)

Background information

The SBIRS system was initiated in 1994 as an effort to replace DSP, the current system used to detect missile launches. Until recently, SBIRS had two components: SBIRS-High, which would consist of launch detection satellites in geo-synchronous and highly elliptical orbits and SBIRS-Low which would consist of launch detection and tracking satellites in low earth orbits. In 2000, SBIRS-Low was shifted back to the Ballistic Missile Defense Organization, which is now the Missile Defense Agency. SBIRS-Low is primarily focused on supporting the missile defense mission. SBIRS-High is being managed by the Air Force. It is focused on missile warning, missile defense, technical intelligence, and battlespace characterization.

Architecture/Key Technologies

SBIRS-High features a mix of four geo-synchronous earth orbit (GEO) satellites and a spare, two highly elliptical earth orbit (HEO) payloads, and associated ground hardware and software. SBIRS-High will have both improved sensor flexibility and sensitivity over DSP. Sensors will cover short-wave infrared like its predecessor, expanded mid-wave infrared and see-to-the-ground bands allowing it to perform a broader set of capabilities as compared to DSP. Currently in the engineering, manufacturing, and development phase, the first SBIRS-High HEO payload is scheduled for delivery in 2003 and the first GEO satellite is expected to launch in 2006.

Users	Strategic and tactical forces across military services	**Original cost estimate/quantity:**	$4.1 billion 5 satellites
Manager	Air Force	**Current cost/quantity:**	$8.5 billion 5 satellites
Contractors/ Contract type	RDT&E – SBIRS-High EMD Mod: Lockheed Martin Space Systems Cost Plus Award Fee October 1995 *(note: contract has since changed)*	**Total spent/ % total spent**	$3.0 billion 34.9%

Source: 12/31/2002 Selected Acquisition Report (all dollar amounts in 2003 dollars) and DOD provided updates

Key Issues Affecting Program

- Requirements definition
- Technology immaturity
- Unanticipated software growth
- Significant cost growth
- Schedule delay
- Program instability

Chronology of Key Findings

- 1995-2001 GAO reports found the program was facing serious hardware and software design problems including sensor jitter, inadequate infrared sensitivity, and stray sunlight.

- 2001 DOD selected acquisition report stated the program experienced significant cost growth and schedule delays. Driven by poor cost and schedule performance and the contractor's projection of a fiscal year 2002 funding shortfall, the System Program Office and Lockheed Martin Space Systems Company (LMSSC) completed a preliminary Estimate at Completion (EAC) exercise in October 2001. The preliminary EAC results indicated potential cost growth in excess of $2 billion across the Engineering and Manufacturing Development contract and schedule delays of 12 to 36 months.

- 2001 Secretary of Air Force reported a Nunn McCurdy Unit Cost Breach (10 U.S.C. 2433) exceeding 25 percent to Congress. House Appropriations Committee report (House Report 107-298) cited scheduling, cost, and technology problems, including unanticipated software code growth, high number of discrepancy reports in ground mission software, unbudgeted payload redesign activities, notable schedule slippages.

- 2002 An Independent Review Team (IRT) was chartered by DOD to look at the reasons behind significant cost increases, and program management and execution problems affecting the program. Key root causes identified included: (1) the program was too immature to enter system design and development, (2) system requirements decomposition and flowdown were not well understood as the program evolved, and (3) there was a significant breakdown in execution management.

- 2002 IRT reported that in general, the complexity, schedule, and resources required to develop SBIRS were, in hindsight, misunderstood. This led to an immature understanding of how requirements translate into detailed engineering solutions. In addition, the requirements setting process was often ad hoc with many decisions being deferred to the contractor. While SBIRS-High adopted a more commercial approach to doing business within the defense related industry—the winning contractor assumed Total System Performance Responsibility (TSPR) for the integrated architecture—TSPR was not properly understood or implemented on the SBIRS-High program. The way TSPR was initially applied circumvented traditional program management and integrated product team roles and responsibilities.

- 2002 IRT also observed that there had been far too much instability on the program since the contract award. In a 5-year timeframe, the program underwent four major replanning efforts and four program directors. The team acknowledged that corrective actions were being taken on the program, but noted that there were still significant risks within the program, including risks related to the schedule for first high-elliptical orbit launch and ground software.

- 2002 Under Secretary of Defense for Acquisition, Technology, and Logistics certified SBIRS-High to Congress as essential to national security, no alternatives offering equal or greater military capability at same or lower costs existed, new cost estimates were reasonable, and management structure was adequate to manage and control unit costs.

- 2003 CRS reported that SBIRS-High has become controversial because of cost growth and schedule slippage caused by technical challenges that have been encountered in developing the sensors and satellites.

- 2003 GAO reported that three critical technologies—the infrared sensor, thermal management, and on-board processor—are now mature. When the program began in 1996, none of its critical technologies were mature. GAO could not assess design stability relative to best practices, because program was not tracking the number of releasable drawings and did not know how many total drawings were expected for SBIRS-High. However, GAO reported that design stability has been an issue for this program. GAO could not assess production maturity relative to best practices because the contractor does not use statistical process control to assure that production processes are stable.

GAO Reports

Three reports from 1995-2001 and GAO-03-476

Mission: Missile Warning/Tracking
Program: Space Based Infrared System-Low (SBIRS-Low); now known as the Space Tracking and Surveillance System (STSS)

Background

STSS started in 1990 as Brilliant Eyes, was transferred in 1993 from the Ballistic Missile Defense Organization (BMDO) to the Air Force and renamed the Space and Missile Tracking System (SMTS). In 1994, DOD terminated the SMTS program, consolidated its infrared space requirements, and selected SBIRS as a "system of systems" approach with two components: SBIRS-High, which would consist of launch detection satellites in geo-synchronous and highly elliptical orbits and SBIRS-Low, which would consist of launch detection and tracking satellites in low earth orbits. In 2000, SBIRS-Low was shifted back from the Air Force to the BMDO, which is now the Missile Defense Agency (MDA). In 2002, SBIRS-Low was renamed STSS. While STSS is primarily focused on supporting the missile defense mission, SBIRS-High is focused on missile warning, missile defense, technical intelligence, and battlespace characterization and is managed by the Air Force.

Architecture/Key Technologies

STSS is a capabilities-based development. STSS will build a few satellites at a time with later satellites being more capable than earlier ones. Using the advantage of a lower operational altitude, STSS will track tactical and strategic ballistic missiles against the cold background of space. The satellite's sensors will operate across long and short-wave infrared, as well as the visible light spectrum. These wavebands allow the sensors to acquire and track missiles during the boost phase as well as in midcourse. STSS is expected to launch its first satellites in 2007.

Users	Strategic and tactical forces across military services	**Original cost estimate/quantity:**	Not Available
Manager	Missile Defense Agency	**Current cost/quantity:**	Quantity undetermined but more than 20 satellites would be needed for worldwide coverage
Contractors/ Contract type	Prime Contractor: Northrop Grumman Cost Plus Award Fee	**Total spent/ % total spent**	Not available

Source: GAO analysis.

Key Issues Affecting Program

- Requirements definition
- Technology immaturity
- Lack of competition
- Cost growth
- Inadequate analysis of alternatives

Note: Problems mostly affecting past SBIRS-Low efforts

Chronology of Key Findings

- 1997 GAO assessed various options for accelerating SBIRS-Low deployment date, which had been set for 2006, given congressional concerns about direction of the program. GAO reported that moving up the date by 3 or 4 years would result in high program risk because of the high degree of concurrent activities between planned flight demonstrations and development and fabrication of satellites. Additional funding might also be required. Moving up the date 2 years would reduce the need for concurrency, and therefore lower risks, but still require additional funds to account for schedule compression. Moving up the date 1 year would reduce scheduling risks and could require less funding. DOD subsequently changed deployment date to 2004.

- 2001 GAO reported that SBIRS-Low acquisition schedule was at high risk of not delivering the system on time or at cost or within expected performance because satellite development and production, for example, was expected to be done concurrently. SBIRS-Low program also had high technical risks because some critical satellite technologies were judged to be immature for the current stage of the program, including scanning infrared sensor, tracking infrared sensor, and technologies used to cool down satellite systems.

- 2001 GAO also reported that DOD was not adequately analyzing or identifying cost-effective alternatives to SBIRS-Low that could satisfy critical missile defense requirements, such as a Navy ship-based radar capability. At the time, other studies supported the possibility that other types of sensors could be used to track missiles in midcourse of their flight and to cue interceptors.

- Subsequent to 2001 GAO report, DOD restructured the SBIRS-Low program because of cost and scheduling problems, and put the equipment it had partially built into storage. In 2000, the Congress directed the Air Force to transfer the program to the Ballistic Missile Defense Organization (now MDA). DOD was also directed to study alternatives (such as ground-based radar systems) to SBIRS-Low.

- May 2003 GAO reported that DOD believed that a discrimination capability (that is, the ability to detect and track multiple objects and differentiate the threatening warhead from decoys) would significantly enhance a space-based missile tracking system like STSS. However, DOD deferred plans to achieve this capability for STSS given technical challenges. GAO also reported that DOD's unwillingness to relax requirements for capabilities such as discrimination during earlier SIBRS-low efforts contributed to cost and scheduling problems.

- May 2003 GAO reported that in taking on the restructured SBIRS-Low program, now called Space Tracking and Surveillance System (STSS), MDA purposely set out to adopt a strategy that would evolve STSS over time, deferring some requirements, and calling for competition in development of sensors aboard the satellite. However, recent decisions were limiting MDA's ability to achieve its original goals as well as knowledge that could be gained from its satellite demonstrations. For example, plans were eliminated to have contractors compete for production of the sensor to detect missile launches. If it chose to keep STSS as part of the missile defense system, STSS could end up being more expensive in the future because MDA could be locked into a single contractor for the design and product of the larger constellation of satellites.

- May 2003 GAO reported that MDA was focused on launching its satellites by 2007 in order to assess its performance in the missile defense tests. However, it made this decision without completing its assessment of the working condition of the equipment it planned to assemble and use to demonstrate STSS capabilities. Also, MDA was not considering other approaches to demonstrating capabilities because they would not allow STSS to participate in 2006-2007 missile defense tests. These include (1) launching satellites in 2008 instead of 2007 and (2) dropping effort to demonstrate capabilities with legacy satellites that were based on older technology and focusing instead on developing new technology. Both approaches would enable MDA to inject more competition into STSS program, reduce scheduling risks, and demonstrate more capabilities. However, they also have drawbacks; primarily, they would delay MDA's ability to make informed tradeoffs on missile defense sensors.

GAO Reports

GAO/NSIAD-97-16, GAO-01-6, GAO-03-597

Mission: Current Communication Systems
Programs: Defense Satellite Communication System (DSCS) and Milstar

Background information

DSCS and Milstar are current DOD communication satellite systems that provide protected communications to support globally distributed military users. The Air Force began launching the current DSCS satellites in 1982. The Air Force initiated the Milstar program in 1981, but the first Milstar satellite was launched in 1994 and the last one in April 2003.

Architecture/Key Technologies

Currently, ten DSCS satellites and five Milstar satellites operate in geo-synchronous orbit. The DSCS satellites utilize super high frequency transponder channels that provide the highest data capability, but require large antennas (4 to 60 feet) for receiving large amounts of data. The Milstar satellites utilize extremely high frequency transponder channels that provide low to medium data rate communications but require small antennas (5 inches to 10 feet) and provide communications that are more survivable and resistant to jamming than the DSCS. The Milstar satellites are launched onthe Titan IV and weigh about 10,000 pounds. The last two DSCS satellites will be launched by the EELV and weigh about 2,500 pounds.

Users	Strategic and tactical forces across military services	**Original cost/ quantity:**	Not Available – Milstar $1.7 billion -DSCS 14 satellites
Manager	Air Force	**Current cost/ quantity:**	Not Available – Milstar $2.7 billion-DSCS 14 satellites
Contractors/ Contract type	RDT&E – Milstar II Satellites: Lockheed MSL & Space Co October 1992 Cost plus award fee DSCS III Production: General Electric Co November 1984 Firm fixed price	**Total spent/% total spent**	Not Available – Milstar and DSCS

Source: Milstar – 12/31/1999 Selected Acquisition Report and DSCS – 9/30/91 (all dollar amounts in 2003 dollars)

Key Issues Affecting Programs

- Cost growth
- Requirements changes

Chronology of Key Findings

- 1986 GAO reported that in late 1982 the Air Force realized that the Milstar configuration could not be achieved given existing schedule and budgetary constraints. As a result, the program office began rescoping the program to conform to the budgetary constraints in a design-to-budget exercise. In 1983 the program office rescoped the program for a second time—this time adding requirements due to user input and concerns.

- 1986 GAO reported that DOD revised the acquisition strategy from a total system integration package to an associate contractor approach because the teaming of TRW and Hughes (they had previously performed the majority of extremely high frequency work) presented an insurmountable challenge to other contractors. Under the associate contractor approach, rather than contracting for the whole system with a prime contractor, the government contracts with different firms for components of the system.

- 1992 GAO reported that the National Defense Authorization Act for FY1991 directed the Secretary of Defense to develop or carry out a plan for either a restructured Milstar or an alternative advanced communications satellite program that would substantially reduce program costs. DOD chose to restructure the program and lower costs by reducing the constellation size from 8 to 6 satellites, the number of control stations from 25 to 9, and the number of terminals from 1,721 to 1,467. To provide greater system utility to tactical forces, DOD decided to add a medium data rate capability to the satellite (this would increase the volume of information that could be processed through the satellites).

- 1992 GAO reported that some satellite issues related to the Army's tactical use of Milstar had not been resolved. For example, formal agreement had not been reached on sufficient capacity that the Army claimed it needed. While DOD expected the medium data rate capacity to allow about 40 million bits of information to be passed through the satellite each second, Army representatives stated that to satisfy critical Army communication requirements, at least 34.4 million bits per second would be needed—about 86 percent of the total planned throughput capacity for each satellite. After considering the multiservice aspects of the Milstar program, the Army concluded that to justify its participation in the Milstar program, the minimum throughput capacity acceptable would be 30.7 million bits per second—about 77 percent of the total planned capacity for each satellite. The remaining capacity would be allocated among the Air Force, the Navy, and the Marine Corps.

- 1993 GAO reported that in 1991 as directed by Congress, DOD published its military satellite communications architecture study that identified 12 alternatives for various communications approaches that ranged from using all commercial to all military satellite programs. From among the 12 alternatives, DOD selected an all military approach consisting of existing systems. GAO reported that DOD did not select one alternative, the dual common bus that provided a better way to demonstrate advanced technologies.

- 1994 GAO reported that in response to our 1993 report, DOD agreed with the need to move away from customized, unique busses toward common busses and stated that the most cost effective approach for inserting modern technology was to begin developing an advanced, lower cost, lower weight payload capability.

- 1994 GAO reported that congressional directives and national policy emphasized greater use of commercial satellite services to reduce costs of military satellite services. However, a new criterion used by DOD for establishing communication requirements reduced general purpose requirements by over 40 percent. This change has reduced the potential for using commercial satellite communication services. (It should be noted, according to DOD officials, that there were some pointed objections in the past year to the DOD's use of commercial satellite systems such as INTELSAT and INMARSAT because they were "part owned" by countries such as Iraq and Iran.)

- 1997 GAO reported that during the next decade, DOD anticipated a significant increase in its high-capacity satellite communications (DSCS) because of the shift in the national military strategy and availability of advanced technologies. DOD planned to replenish the existing DSCS constellation during fiscal year 1997-2003 with the five satellites remaining in inventory. DOD was modifying four of these satellites to double each satellite's capacity from 100 megabits per second (MBPS) to about 200 MBPS and to replace potentially defective parts with improved electronic components. Even so DSCS's replenishment satellites were not expected to keep pace with the projected requirements, thus an alternative would have been to lease satellite communications from commercial providers. However, according to DOD analysis, commercial leasing was more costly than acquiring equivalent commercial like capabilities.

- 1999 GAO reported that in 1998 a draft operational test report identified four limitations associated with Milstar I capabilities to support strategic missions. While DOD had identified corrective actions, final resolutions were dependent on approval of requirements, verification through testing, a certification process, or obtaining necessary funds. Regarding tactical missions, the Air Force had encountered schedule delays related to software development for a critical Milstar component—called the automated communications management system—that could adversely affect Milstar II's timely support to tactical forces.

- 2003 GAO reported that in 2000, DOD recognized the need to address the capabilities and coverage gap caused by the April 1999 Milstar launch failure and adopted a high-risk accelerated schedule for the Advanced Extremely High Frequency (AEHF) satellite system.

GAO Reports

GAO/NSIAD-86-45S-15,GAO/NSIAD-92-121, GAO/T-NSIAD-92-39, GAO/NSIAD-94-48, GAO/NSIAD-97-159, GAO/NSIAD-99-2, GAO/NSIAD-93-216, GAO/T-NSIAD-94-108, GAO/T-NSIAD-94-164, GAO/NSIAD-94-253

Mission: Planned Communication Systems
Programs: Advanced Extremely High Frequency (AEHF) Communications Satellite, Wideband Gapfiller Satellite (WGS), and Advanced Wideband Satellite (AWS)

Background information

The current military satellite communications network represents decades-old technology. To meet the heightened demands of national security in the coming years, newer and more powerful systems are being developed. The AEHF is a satellite system intended to replace the existing Milstar system and to be DOD's next generation of higher speed, protected communication satellites. WGS will augment communications services currently provided by the Defense Satellite Communications System (DSCS), which provides super high frequency wideband communications. WGS will provide an interim solution to assure DOD's existing worldwide communication support is maintained until the development and deployment of the Advanced Wideband Satellite System (AWS) also known as TSAT. AWS is intended to become the cornerstone of DOD's future communications architecture that includes supplementing the AEHF system and replacing the WGS system.

Architecture/Key Technologies

AEHF started in 1998 and the constellation will consist of three satellites in low inclined geo-synchronous orbits (requirements still call for five satellites-four operational and one spare) that can transmit data to each other via cross-links. AEHF entered the Engineering Manufacturing Development/Production acquisition phase in November 2001. Each satellite will be launched with the Evolved Expendable Launch Vehicle (EELV); the initial launch is planned for December 2006.

WGS started in 2001 and the constellation was planned to have 3 satellites, but the program recently added two more satellites because the initial capability of AWS, which is intended to replace AEHF and some aspects of WGS, may not be able to support all the super high frequency services that the users require. Thus additional WGS spacecraft are being acquired to bridge this gap. WGS combines commercial capabilities—phased array antennas and digital signal processing technology—into a flexible architecture that will allow WGS to evolve and satisfy the growing wideband communication requirements of the warfighter. WGS is currently in full rate production with the first satellite scheduled for a June 2004 launch aboard an EELV vehicle.

AWS' final configuration has not yet solidified under ongoing milsatcom transformational efforts, but the concept is one of applied technology and engineering that will remove capacity as a constraint on warfare communications. AWS plans to take advantage of the commercial and government technology advances of the first half of this decade to meet expected needs. Some of the technologies that AWS plans to use are laser crosslinks, space-based data processing and routing systems, and highly agile multibeam/phased-array antennas. DOD plans for the program to enter product development in October 2003 with the first satellite to be launched at the end of 2009. A key program review is planned for November 2004 to determine if sufficient technology development has occurred to warrant continuing the program at its planned schedule or whether the 4th and 5th AEHF satellites should be acquired.

Users	Military Strategic and Tactical	**Original cost/ quantity:**	$5.4 billion - AEHF 5 satellites $1.0 billion – WGS 3 satellites

Manager	Air Force	**Current cost/ quantity:**	$4.8 billion -AEHF 3 satellites $1.5 billion -WGS 5 satellites
Contractors/ Contract types	AEHF's system development and demonstration: Lockheed Martin November 2001 Cost plus award fee WGS' RDT&E and procurement: Boeing Satellite Systems January 2001 Firm fixed price	**Total spent/ % total spent**	$1.1 billion - AEHF 21.2% $.28 billion – WGS 17.5%

Source: AEHF and WGS -12/31/2002 Selected Acquisition Report (all dollars amounts in 2003 dollars)

Key Issues Affecting Programs

- Cost growth
- Scheduling risks
- Requirements Changes
- Immature technology

Note: Problems reported primarily affect AEHF.

Chronology of Key Findings

AEHF

- 2002 DOD selected acquisition report commented on funding cuts. In fiscal year 2002, AEHF sustained a $70 million fiscal year 2002 congressional reduction to RDT&E funding. The AEHF space segment was a firm fixed price contract. According to DOD, this sizable reduction would likely result in a six-month launch delay to satellites 1-3, breach of initial operational capability and a significant overall program cost increase.

- In 2002, the Deputy Secretary of Defense decided to change the acquisition strategy of AEHF from a 5-satellite program to a 3-satellite program. Under the revised strategy, full capability may no longer be satisfied by an AEHF-only constellation. (According to DOD officials, the current DOD plan is to meet the full AEHF operational capability requirement with three AEHF spacecraft and a combination of one or two AWS spacecraft and zero, one or two Advanced Polar System spacecraft – this plan is driving the AWS first launch date of late 2009.)

- 2003 GAO reported in the early phases of the program, DOD substantially and frequently altered its requirements; the system design changed. While considered necessary, some changes increased costs by hundred of millions of dollars and caused scheduling delays.

- 2003 GAO reported that in December 1999, the two contactor teams that had been awarded engineering manufacturing and development contracts a few months earlier offered to form a "national team" to accelerate the AEHF program. DOD agreed to the national team proposal even though DOD recognized it meant lack of benefits from competition.

- 2003 GAO reported that once DOD decided to accelerate its plans to build the satellites, the contractors proposed and DOD agreed to support a high-risk schedule that turned out to be overly optimistic and highly compressed—leaving little room for error and depending on a chain of events taking place at certain times. Substantial delays occurred when some events, such as the award of the contract or the availability of equipment, did not occur on time. In commenting on the AEHF report, DOD noted the decision to accelerate the program was based on a satellite constellation gap caused by the loss of a Milstar satellite. DOD also stated many in DOD expressed concern about the risks, but believed the risk was acceptable based on information known at the time.

- 2003 GAO reported that at the time DOD decided to accelerate the program, it did not have the funding needed to support the activities and manpower needed to design and build the satellites quicker. The lack of funding also contributed to schedule delays, which in turn, caused more cost increases.

- 2003 GAO reported that the program demonstrated most technology knowledge at development with 11 of 12 critical technologies having reached maturity according to best practice standards. However, the program office did not project achieving maturity on the remaining technology— the phased array antenna— by the design review in June 2004 and did not have a backup capability. Program officials assessed the software development for the mission control system as moderate risk and have developed a risk mitigation strategy. However, until these mitigation actions are completed, software may be at risk for unplanned cost and schedule growth.

- 2003 GAO reported that significant design changes affected cost and delayed the AEHF schedule. For example, software growth occurred as more requirements were added and as the design of the system stabilized. These increases in software requirements for both the satellite and the mission control segments increased the software cost estimate by over 77 percent or about $223 million.

- 2003 GAO reported in the area of production maturity that any future problems with the fabrication of the communications and transmission security microprocessor, a component designed to limit access to satellite transmissions to authorized users, could delay the production schedule and the launch of the first satellite planned for December 2006.

WGS

- 2003 GAO reported that WGS' critical technologies, design, and production processes are mature. DOD plans to rely on commercial technologies that will not require extensive product development. Program officials were concerned about WGS production risk that was to be reduced during production of commercial satellite orders. However, due to drastic loss of commercial satellite orders, only one commercial satellite with similar technologies as WGS is now leading WGS in the manufacturing schedule. Recently identified problems found on the "leader" program will impact WGS manufacturing schedule and might result in a first launch schedule delay of four to six months.

- 2003 GAO reported that the 4th and 5th satellites have been directed by DOD to be launched in fiscal year 2009 and fiscal year 2010 respectively. These dates are outside the allowable dates of the WGS contract options clauses and will require renegotiation to finalize their cost. These later launch dates could result in cost increases to compensate for loss of learning curve from over a three-year break in production, parts obsolescence, and inflation.

AWS

- 2003 GAO reported that AWS is scheduled to enter product development with only one of its five critical technologies mature. The four immature technologies are scheduled to reach maturity by January 2006, more than two years after development start. Three of the four technologies have a backup technology in case of development difficulties. However, the Single Access Laser Communications technology has no backup and according to program officials any delay in maturing this technology would result in a slip in the expected launch date.

- 2003 GAO reported that the program plans an aggressive development cycle even though the AWS is expected to provide a transformational leap in satellite communications capability.

GAO Reports

GAO-03-476, a report that covers multiple systems, and an AEHF report in 2003.

Mission: Navigation
Program: NAVSTAR Global Positioning System (GPS)

Background information

GPS is a space-based radio-positioning system nominally consisting of a 24-satellite constellation that provides navigation and timing information to military and civilian users worldwide. The full constellation of GPS satellites has been operational for 7 years. Total program investment over a 43-year period (through 2016) is estimated at $18.4 billion.

Architecture/Key Technologies

GPS satellites, in one of six medium earth orbits, circle the earth every 12 hours emitting continuous navigation signals on two different frequencies. In addition to the satellites, the system consists of a worldwide satellite control network and GPS receiver units that acquire the satellite's signals and translate them into precise position and timing information. Four generations of GPS satellites have flown in the constellation: the Block I, the Block II, the Block IIA, and the Block IIR. Block I satellites were used to test the principles of space-based navigation, and lessons learned from these 11 satellites were incorporated into later blocks. Block II, IIA and IIR satellites make up the current constellation. Block IIRs began replacing older Block II/IIAs in 1997. There are currently eight Block IIR satellites on orbit and they have reprogramable satellite processors enabling problem fixes and upgrades in flight. Up to eight IIR satellites are being modified to radiate both a new civil signal (L2C) and a new military signal (M-Code) for a more robust and capable signal structure. The first modified Block IIR (designated as the IIR-M) is planned for launch in 2004. Block IIF satellites are the next generation of GPS satellites. Block IIF provides all the capabilities of the previous blocks with some additional benefits as well. Improvements include an extended design life of 12 years, faster processors with more memory, and a new civil signal on a third frequency. The first Block IIF satellite is scheduled to launch in 2006. The Delta II has launched the Block II, IIA, and IIR satellites, and the EELV (Delta IV and Atlas V) will launch the Block IIF satellites.

GPS Blocks IIF and IIR

Users	Military and Civilian	**Original cost/ quantity:**	$5.3 billion 33 satellites
Manager	Air Force	**Current cost/ quantity:**	$5.8 billion 37 satellites
Contractors/ contract type	GPS IIF OCS/MOSC development: BOEING NORTH AMERICAN, April 22, 1996 Cost Plus Award Fee Block IIR SAT development: Lockheed Martin August 2000 Firm fixed price/cost plus incentive	**Total spent/ % total spent**	$2.3 billion 39.7%

Source: 12/31/2002 Selected Acquisition Report (all dollar amounts in 2003 dollars) and DOD provided updates

Key Issues Affecting Program

- Cost Growth
- Schedule risk
- Component reliability problems

Chronology of Key Findings

- 1980 GAO reported program cost (to acquire and maintain the program through the year 2000) increased from $1.7 billion to $8.6 billion due largely to estimates not previously included for replenishment satellites, launches, and user equipment. Beginning in 1983, DOD planned to use the Space Shuttle to launch the NAVSTAR satellites. In the event of Space Shuttle problems, Atlas or Titan launches would need to be used as an alternative at an additional cost of $12 million to $38 million per satellite launch. The original full operational capability date of August 1985 slipped 25 months.

- 1980 GAO reported that survivability of GPS satellites was a concern due to Soviet testing of an anti-satellite system and reliability of GPS satellite atomic clocks emerged during the demonstration and validation phase when 80 percent either failed or acted abnormally.

- 1983 GAO reported that the multiyear procurement estimate of $1.4 billion was likely understated because indications are that the prime contractor would propose a higher cost and that multiyear procurement savings were not correctly calculated using the present value analysis method. System design changes were being considered that would add considerable cost to the program. The program office expressed concern about the lack of backup launch vehicles in the event of problems with the Space Shuttle.

- 1983 GAO reported that integration testing of the spacecraft with the qualification test vehicle was scheduled to begin 7 to 18 months after the planned March 1983 award date of the production contract. The consequences of concurrency could lead to design changes and additional costs. The program office was considering two design changes to the production spacecraft, a W-sensor and enhancements related to GPS survivability.

- 1987 GAO reported that following the Challenger accident in January 1986, the Air Force reduced the number of GPS satellites planned for launch on the Space Shuttle from 28 to 8, because it had awarded a contract to McDonnell Douglas to build and launch 7 medium expendable launch vehicles with an option to purchase up to 13 more.

- 1987 GAO reported GPS acquisition changes after the Space Shuttle Challenger's accident: (1) NASA slipped the date for the first launch schedule for the Block II satellites from January 1987 to June 1989, (2) since the GPS program was in the production and deployment phase, the Air Force began stretching out the procurement process, and (3) the Air Force postponed a planned buy of 20 Block II-R replenishment satellites because the program office's estimated need date for these replenishment satellites had slipped 3 years.

- 1987 GAO reported that since development of GPS user equipment (consists of 1-,2-, and 5-channel radio receiver sets) was almost 3 years behind schedule due to technical problems, the Challenger loss caused no further adjustment to user equipment production.

- 1987 GAO reported that even though user equipment technology was changing rapidly with miniaturized and less costly sets currently available from several manufacturers, program office officials expressed concern about incurring substantial costs by changing to the new equipment and that the new equipment would not meet military specifications.

- 1991 GAO reported that DOD postponed full-rate production for receiver sets from March 1989 to September 1991 due to lingering receiver set reliability problems and reevaluation of program requirements. During development testing the Army discovered reliability problems with the one- and two-channel GPS receiver sets. One 5-channel set experienced a number of failures during multiservice testing and this led to a marginal rating of all 5-channel receivers.

GAO Reports

GAO/PSAD-80-21, GAO/MASAD-83-9, GAO/NSIAD-87-209BR, GAO/NSIAD-91-74

Mission: Weather
Programs: Defense Meteorological Satellite Program (DMSP) and National Polar-orbiting Operational Environmental Satellite System (NPOESS)

Background information

Since the 1960s, the U.S. has operated two separate polar-orbiting meteorological satellite systems. These systems are known as the Polar-orbiting Operational Environmental Satellites (POES), managed by the National Oceanic and Atmospheric Administration (NOAA), and the Defense Meteorological Satellite Program (DMSP), managed by DOD. These satellites obtain environmental data that are the predominate input to numerical weather prediction models—all used by weather forecasters, the military and the public. Polar satellites also provide data used to monitor environmental phenomena as well as data that are used by researchers for a variety of other studies, such as climate monitoring. Given the expectation that converging the POES and DMSP program would reduce duplication and result in sizable cost savings, a May 1994 Presidential Decision Directive required NOAA and DOD to converge the two satellite programs into a single program capable of satisfying both military and civilian requirements. The converged program is called the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

Architecture/Key Technologies

DMSP satellites circle the Earth at an altitude of about 500 miles in a near-polar, sun-synchronous orbit. Each scans an area 1,800 miles wide and covers the entire Earth in about 12 hours. Pointing accuracy of the satellites is maintained by four reaction wheel assemblies that provide three-axis stabilization. The primary sensor on board is the Operational Linescan System that observes clouds via visible and infrared imagery for use in worldwide forecasts. A second important sensor is the Special Sensor Microwave Imager, which provides all-weather capability for worldwide tactical operations and is particularly useful in typing and forecasting severe storm activity. DMSP satellites also carry a suite of additional sensors, which collect a broad range of meteorological and space environmental data for forecasting and analysis. Historically DMSP satellites have been launched on Titan II boosters from Vandenberg Air Force Base with the most recent launch occurring on December 12, 1999. One more DMSP satellite will be launched on a Titan II booster. The remaining four DMSP satellites will be launched on Evolved Expendable Launch Vehicle (EELV) boosters from Vandenberg Air Force Base. There are two operational DMSP satellites.

NPOESS program acquisition plans call for the procurement and launch of six NPOESS satellites over the life of the program and the integration of 14 instruments, including 12 environmental sensors. Together, the sensors and spacecraft receive and transmit data on atmospheric, cloud cover, environmental, climate, oceanographic, and solar-geophysical observations. Additional instruments are carried to support search and rescue efforts and data collection from a variety of globally deployed transmitters. NPOESS will be a launch-on-demand system, and satellites must be available to back up the planned launches of the final POES and DMSP satellites. The first NPOESS satellite—designated C1—is scheduled for delivery in late 2009, according to Air Force officials.

Users	DMSP focuses on military users. NPOESS will be available to military, civil, and international users.	**Original cost estimate/quantity:**	$5.6 billion 6 satellites (NPOESS only)
Manager	DMSP is managed by the Air Force. NPOESS is managed tri-agency integrated program office (DOD, DOC, NASA), located within NOAA.	**Current cost/quantity:**	$6.1 billion 6 satellites (NPOESS only)

Contractors/ Contract type	Engineering and Manufacturing Development/Production and Operations Northrop Grumman, August 2002 Cost plus award fee/performance incentive, Fixed price incentive production options, Fixed price operation and support options	**Total spent/% total spent**	$857.9 million 14.0 percent (NPOESS only)

Source: 12/31/2002 Selected Acquisition Report (All dollar amounts in 2003 dollars) and DOD provided updates

Key Issues Affecting Program

- Requirements definition/meeting user needs
- Technical/scheduling risks

Note: Problems reported affect NPOESS rather than DMSP

Chronology of Key Findings

- 1987 GAO reported that the program could save millions of dollars by converging NOAA and DOD weather satellite programs, which would reduce the number of satellites from four to three.

- 1987 GAO reported that NOAA and Air Force requirements were diverging in several respects, making the effort to converge the two programs more difficult. For example, NOAA wanted to change its approach from using expendable convention satellites to installing sensors on serviceable platforms. The Air Force plans to continue using its current, conventional design of DMSPs (expendable and rocket launched) into the late 1990s before redesigning a new system. NOAA and Air Force also differed on quality standards for electronic components.

- 1995 GAO reported that while the planned delivery date for the first satellite was 2004, transferring two DMSP satellites to NOAA might require that delivery be accelerated to as early as 2001. Such an action would increase both technical and schedule risks and require substantial increases in the convergence program's near-term budget.

- 1995 GAO reported that interchangeable components between DMSP and NOAA satellites were less than earlier estimated. Of 63 platform components, only 15 (24 percent), such as the inertial measurement unit and earth and sun sensing equipment, could be used on NOAA satellites without modifications. Another 13 components (21 percent), such as the power supply electronics, battery charge assembly, and solar array electronics, could be used if they were modified, at additional cost. The remaining 35 components (55 percent) were either substantially different or unique and had no value to NOAA. Additionally, DMSP mission sensors could not be used because they are unique and would not satisfy NOAA' s requirements.

- 1997 NPOESS integrated program office determined that there were scheduling, technical and cost risks associated with the interface data processing segment and overall system integration and with the space segment.

- 2001 DOD selected acquisition report commented on schedule delays being reported to Congress. Specifically, DOD stated that the Joint Agency Requirements Group final review of the updated NPOESS requirements took longer than planned. As a result the engineering and manufacturing development request for proposal release, initiation of the life cycle cost estimate update, and the final release of the technical requirements document were delayed. The milestone decision was moved from February 2002 to August 2002.

- 2002 GAO reported that technical, schedule, and cost risks were being reduced by deferring development of requirements, initiating earlier development of sensors and/or relying on existing versus new technology, conducting ground-based demonstrations of data processing system, and using aircraft to test sensors, among other activities.

- 2002 GAO reported that processing centers face challenges in handling the massive increase in the volume of data that would be sent by the new satellites. Whereas current polar satellites produce approximately 10 gigabytes of data per day, NPOESS is expected to provide 10 times that amount. Agencies involved in the program were working to address this problem by improving data management infrastructure, but more could be done to coordinate and further define these efforts.

- 2003 GAO reported that NPOESS entered product development in August 2002 with most of its technologies mature. The program also completed a significant portion of the engineering drawings well in advance of the design review; however, the total number has yet to be determined. Over 5 years ago, program officials considered the program to have several high-risk areas. Since then, officials have implemented several efforts, which are expected to reduce all program areas to low risk by the first NPOESS launch, currently scheduled for the 2008- 2009 time frame.

GAO Reports

GAO/NSIAD-87-107, GAO/NSIAD-95-87R, GAO-02-684, GAO/NSIAD-94-253

Mission: Launch
Programs: Titan IV and Evolved Expendable Launch Vehicle (EELV)

Background information

Over the years DOD has used a fleet of expendable launch vehicles—Delta, Atlas, and Titan—to transport a variety of satellites into space. The Titan IV is a heavy-lift space launch vehicle used to carry DOD payloads such as Defense Support Program (DSP) and Milstar satellites into space. The Titan IV was designed to complement the National Space Transportation System (Space Shuttle) and serve as an independent vehicle system to assist in assuring DOD access to space. Air Force contracted for a total of 41 Titan IV vehicles with the last launch scheduled for 2004. DOD considers these launch vehicles to currently operate at or near their maximum performance capacity and to be very costly to produce and launch. Since 1987, the government has made several attempts to develop a new launch vehicle, but these attempts were canceled either because of funding issues, changing requirements, or controversy regarding the best solution.

In 1994, by congressional direction, DOD developed a space launch modernization plan that led to the initiation of the Evolved Expendable Launch Vehicle (EELV) program. With EELV, the Air Force hoped to cut its heavy-lift mission costs by about 50 percent and its overall launch mission costs by at least 25 percent. The intent of the EELV program was to develop a family of launch vehicles, using common components, standard services and supporting systems that would significantly reduce the life-cycle cost compared to today's systems. Due to a sudden projected increase in commercial demand that was forecast in 1997, Air Force approved a plan to develop the Atlas V and Delta IV EELVs, rather than just one of them. The additional cost of maintaining two EELV launch infrastructures was intended to be offset by more competitive pricing. The successful launches of the medium-lift models of the Atlas V and Delta IV rockets in 2002 fulfilled part of the engineering, manufacturing, and development segment of the Air Force EELV contract to Boeing and Lockheed Martin. In the initial launch service award (1998) Boeing was awarded 19 launch services and Lockheed Martin was awarded 9 launch services. Current launch services awards have been modified after the 2000 EELV restructure to 19 missions for Boeing and 7 missions for Lockheed Martin. Both contractors plan to deploy their commercial launch service to launch both commercial and government missions.

Architecture/Key Technologies

Each Titan launch vehicle is made up of a core, a fairing, and a set of solid rocket motors. Solid rocket motors along with liquid rockets in the core provide the propulsion for the Titan IV. The Titan IV may also have an optional upper stage to provide the additional booster capacity that some satellite payloads require to reach their intended orbit. The EELV will use the Delta IV launch vehicle built by Boeing and the Atlas V built by Lockheed Martin. Boeing developed the RS-68 liquid-oxygen/ liquid-hydrogen main engine, for the Delta IV, which is the first cryogenic engine built in the United States since the Space Shuttle Main Engine. Lockheed Martin's main engine, the RD-180, is a liquid-oxygen/kerosene engine developed in a joint venture between NPOEnergomash, a Russian company, and UTC/Pratt and Whitney.

Users	Military satellites are launched by Titan IV Military and commercial satellites are launched by EELV	**Original cost/ quantity:**	$14.7 billion - EELV 181 launch vehicles $3.2 billion - Titan IV 10 launch vehicles
Manager	Air Force	**Current cost/ quantity:**	$18.0 billion -EELV 182 launch vehicles $20.1 billion – Titan IV 39 launch vehicles

Contractors/ Contract type	EELV-Boeing and Lockheed Martin for EMD and initial launch services RDT&E: Other Transaction Launch Services: Firm Fixed Price *(note: contract has since changed)* Titan IV- Production: Lockheed Martin April 1996 Fixed-price incentive fee	**Total spent/ % total spent**	$2.0 billion - EELV 9.7% $16.4 billion – Titan IV 90.9 %

Source: Titan 12/31/2001 and EELV 12/31/2002 Selected Acquisition Report (all dollar amounts in 2003 dollars)

Key Issues Affecting Programs

- Schedule risk with transition to new launch vehicle
- Acquisition strategy changed DOD oversight role
- Cost reductions uncertain

Note: Problems report affect EELV rather than Titan IV

Chronology of Key Findings

Titan IV

- 1991 GAO reported that slowing down Titan IV production may eventually result in an overall increase in program costs, but that budgetary requirements may be reduced by $47 million in FY1992 and $11 million in FY1993.

- 1991 GAO reported that the Air Force planned to slowdown production of the Titan IV launch vehicle to better synchronize production and launch schedules. This restructuring of the program would result in slowing down production from 8-10 vehicles per year to not more than 6 vehicles per year beginning in 1992. The Titan IV has an optional upper stage, the Inertial Upper Stage (IUS) and the newer Centaur, to provide addition booster capacity for some satellite payloads like the DSP. However, the DSP satellites to be boosted by the IUS were not under contract and their launch was expected to be delayed. In addition, planned production of the IUS vehicles for 1992 would likely slip to 1995.

- 1991 GAO reported that numerous problems had delayed the transition of the solid rocket motor upgrade program from development and testing to production. For example, during the first static firing test of the rocket motor upgrade the test motor exploded which would likely result in at least a one-year delay in production from October 1991.

- 1993 DOD Bottom-Up Review noted that there are two types of requirements for space launch: (1) performance—the ability to deliver a satellite reliably to a specific orbit, and (2) operational flexibility. This review reported that current launch systems generally met the first objective but not the second. Performance and flexibility was inadequate because of (1) the need to sustain three separate launch teams and associated equipment; (2) the aging and obsolescence of major ELV components; and (3) continued dependence on outdated launch vehicle production lines and manpower-intensive launch processes. This report also found that there was overcapacity in the American space launch industry. As a result, the three manufacturers operated at less than 50% capacity, which raised the unit cost of each launch vehicle. The ability to sustain three launch suppliers over the long term was in doubt. Foreign competition was also a factor. DOD examined three options to address these issues: (1) extend the life of the current launch vehicle fleet to the year 2030; (2) develop a new family of expendable launch vehicles to replace the current fleet starting in 2004; and (3) pursue a technology-focused effort to develop a reusable launch vehicle. Option 1 was selected as the most cost-effective option in the near-term while meeting DOD's requirements.

- 1994 DOD Space Launch Modernization Plan sought to develop roadmap options establishing priorities, goals, and milestones for the modernization of U.S. space launch capabilities. This report cited the growing sense within Congress and others that while space launch is a critical issue for America's future in space, there is no coherent national plan to guide our actions into the next century. The study developed 15 recommendations concerning, among others, the industrial base, investment, requirements, and coordination. The most consistent theme of the study is that space launch is the key enabling capability for the Nation to exploit and explore space.

- 1994 GAO reported that according to the April 1994 Moorman report, fewer satellites, with longer lives, perform more work, which has resulted in decreased launch rates and excess launch vehicle production and processing capacity. The accompanying negative effect is low, inefficient production rates that raise unit costs.

- 1994 GAO reported that DOD lacked an adequate and validated set of requirements for a future launch system. While DOD desired to improve and evolve the existing expendable launch vehicle fleet, it hadn't established an approach for acquiring and evaluating Russian launch vehicle components and technologies to incorporate into future designs.

EELV

- 1997 GAO reported that cost risk was inherent in the vehicle acquisition plan because production could be initiated from 1 to 2 years before the first system development test flight. Such a strategy could result in costly modifications to the production vehicles. Since there was uncertainty in program cost the potential exists for program cost increases. Cost dictated that there would not be any launches for operational test and evaluation purposes.

- 1997 GAO reported that the program had schedule risk because DOD would purchase the last of its existing expendable launch vehicles before the first system development test flight was scheduled to occur. If the test flight was unsuccessful, coupled with the expiration of existing contracts, this could create a void in DOD's launch capability. GAO had reported on numerous occasions about the risks associated with program concurrency and initiating production without adequate testing.

- 1997 GAO reported that the Air Force had identified vehicle propulsion, systems integration, and software as technical risk areas. Propulsion systems were expected to require significant development. Integrating all design, engineering, testing, manufacturing, and launch functions and the software information system were expected to be challenging tasks. The commercial application of the EELV posed a unique situation for the government with the winning contractor potentially enjoying an enhanced competitive edge (the demand for commercial launches has not materialized and two contractors were awarded EELV contracts) from DOD's investment in the program.

- 1998 GAO reported that the primary benefits associated with the EELV program should be reduced cost to the government, but that DOD's cost reduction estimate was uncertain due to fluctuations in number, type and timing of launches.

- 1998 GAO reported that meeting launch site facility preparation schedules as the primary program risk because construction had to begin shortly after the milestone II decision in June 1998 to support the first EELV launch in fiscal year 2002.

- 1998 GAO reported that DOD's use of other transaction instruments, a relatively new acquisition method, would challenge DOD in determining how best to protect the government's interests. Other transactions are generally not subject to the federal laws and regulations governing standard procurement contracts. Consequently, when using other transaction (10 U.S.C. 2731) authority, contracting officials are not required to include standard contract provisions that typically address such issues as financial management or intellectual property rights, but rather may structure the agreements as they consider appropriate. In addition, the two contractors were not willing to guarantee system performance because DOD's financial risk was to be capped at $500 million per contractor, while the contractor's financial risk would be an open-ended commitment. As a result, the contractors would not guarantee a launch vehicle capability to meet the government's requirements (would only agree to provide a "best effort").

- 2001 DOD selected acquisition report commented on satellite weight growth for the Wideband Gapfiller Satellite (WGS) and Advanced Extremely High Frequency (AEHF) satellites. For example, the WGS spacecraft weight growth had driven a need to upgrade from Medium to Intermediate for both Delta IV and Atlas V launch vehicle configurations for the first three WGS missions. Spacecraft weight growth on the AEHF satellite had also resulted in additional funding being added to the budget in order to upgrade to an Intermediate class vehicle.

GAO Reports

GAO/NSIAD-91-271, GAO/NSIAD-94-253, GAO/NSIAD-97-130, GAO/NSIAD-98-151

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