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SPACE ACQUISITIONS

Actions Needed to Expand and Sustain Use of Best Practices

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GAO-07-730T

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Highlights

Highlights of GAO-07-730T, a testimony before the Subcommittee on Strategic Forces, Senate Committee on Armed Services

Why GAO Did This Study

DOD's space system acquisitions have experienced problems over the past several decades that have driven up costs by hundreds of millions, even billions of dollars, stretched schedules by years, and increased performance risks. DOD has recognized the need to change its approach to developing space systems and is attempting to instill best practices in new efforts. GAO was asked to testify on its findings on space acquisitions problems and steps needed to sustain and expand the use of best practices. In preparing this testimony, GAO relied on its detailed reviews of space programs as well as cross-cutting work on cost estimating and best practices.

GAO does not make recommendations in this testimony. However, GAO has made recommendations on steps DOD can take to ensure better outcomes for its space acquisitions programs. These include developing an overall investment strategy for acquisition programs, addressing human capital and other shortfalls in capacity, and revising policies supporting space to incorporate best practices.

www.gao.gov/cgi-bin/getrpt?GAO-07-730T.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

What GAO Found

The majority of major acquisition programs in DOD's space portfolio have experienced problems during the past two decades that have driven up cost and schedules and increased technical risks. At times, cost growth has come close to or exceeded 100-percent, causing DOD to nearly double its investment in the face of technical and other problems without realizing a better return on investment. Along with the increases, many programs are experiencing significant schedule delays—as much as 6 years—postponing delivery of promised capabilities to the warfighter. Outcomes have been so disappointing in some cases that DOD has had to go back to the drawing board to consider new ways to achieve the same, or less, capability.

GAO's reviews of space acquisitions this year found that some ongoing programs—for example, the Advanced Extremely High Frequency satellite program and the Wideband Global SATCOM program—have been able to work through the bulk of technical problems they were facing and are on track to meet revised targets, albeit at higher costs and with delayed capability. Others, however, including the Space-Based Infrared System High program, the Global Positioning System IIF, and the National Polar-orbiting Operational Environmental Satellite System, continue to face setbacks and further risks.

In recognizing the need to reform space acquisitions, DOD has taken steps to instill best practices in two new major space efforts—the Transformational Satellite Communications System (TSAT) and the Space Radar program—which are expected to be among the most complex and costly space programs ever. For these programs, DOD has taken steps to separate technology discovery from acquisition, establish an incremental path toward meeting user needs, obtain agreements on requirements before program start, and use quantifiable data and demonstrable knowledge to make decisions to move to next phases. If these actions can be sustained, DOD will greatly reduce technical risks, although not completely. There is still significant inherent risk associated with integrating critical technologies on board the satellites and with developing the software needed to achieve the capabilities of the satellites.

Moreover, sustaining these reforms on these two programs and expanding them to others will not be easy. Like all weapons programs, space programs continue to face funding pressures that have encouraged too much optimism. DOD has not prioritized its programs for funding even though its investment for all major space acquisitions is expected to increase about 46 percent in the next 3 years. It is likely to continue to face cost overruns on problematic programs, and it wants to undertake other major new efforts in addition to Space Radar and TSAT. In addition, new programs are being undertaken as DOD is addressing shortfalls in critical technical, business, and program management skills. In other words, DOD may not be able to obtain the right skills and experience to manage all of the new efforts.

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today to discuss the Department of Defense's (DOD) space acquisitions. Each year, DOD spends billions to acquire space-based capabilities to support current military and other government operations as well as to enable DOD to transform the way it collects and disseminates information, gathers data on adversaries, and attacks targets. In fiscal year 2008 alone, DOD expects to spend over $22 billion dollars to develop and procure satellites and other space systems, including nearly $10 billion on selected major space systems.[1] Despite its growing investment in space, however, DOD's space system acquisitions have experienced problems over the past several decades that have driven up costs by hundreds of millions, even billions of dollars; stretched schedules by years; and increased performance risks. In some cases, capabilities have not been delivered to the warfighter after decades of development.

In view of these problems, the Air Force, DOD's primary space system acquirer, has been attempting to instill best practices in two newer space programs—Space Radar and the Transformational Satellite Communications System (TSAT). These steps can help better position the two programs for success, but they will not work without adhering to commitments to delay milestone decisions if there are still gaps between requirements and resources, and to use more robust tools to analyze risks, costs, and schedule. Moreover, other space programs—new and old—are still facing setbacks, reflecting problems in technology development or design, problems in managing contractors, and more broadly, funding shifts needed to sustain the larger space portfolio. Such setbacks—common among all weapons acquisitions—continue to hamper the Air Force's ability to provide resources and support needed to deliver capabilities within cost, schedule, and performance targets. My testimony today will highlight our findings on space acquisitions as well as actions needed to address persistent acquisition problems and to build on best practice approaches being adopted in Space Radar and TSAT.

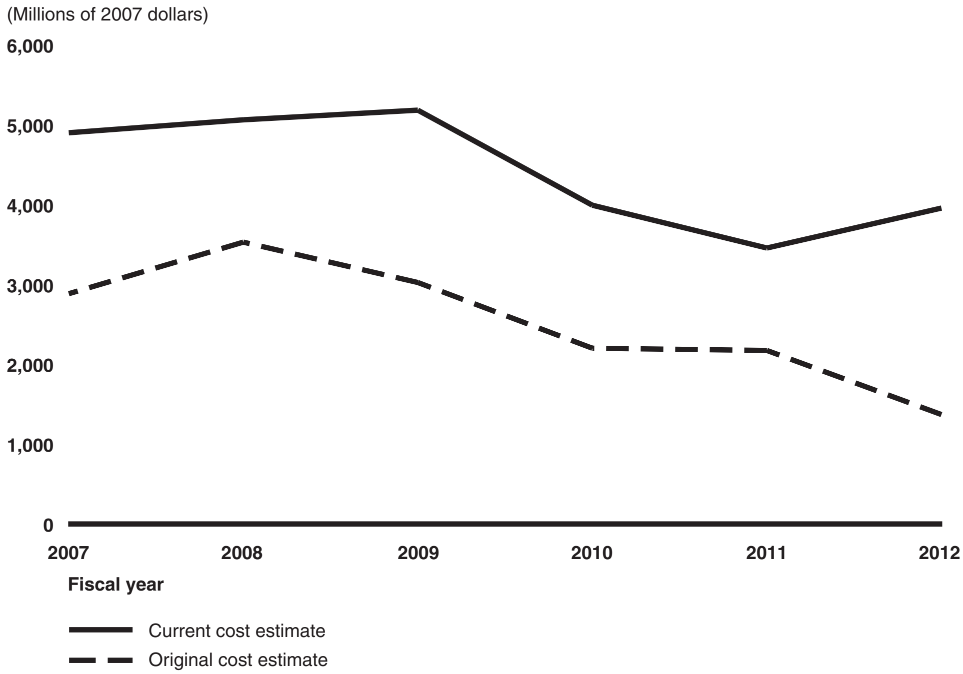
[1]Estimates of fiscal year 2008 spending on procurement and research, development, test and evaluation, are based on DOD's Fiscal Year 2007 Future Years Defense Program (FYDP) plan. The fiscal year 2008 FYDP plan was not available to us at the time we developed this testimony.

Space Acquisitions Continue to Face Cost and Schedule Increases

The majority of major acquisition programs in DOD's space portfolio have experienced problems during the past two decades that have driven up cost and schedules and increased technical risks. Several programs have been restructured by DOD in the face of delays and cost growth. At times, cost growth has come close to or exceeded 100 percent, causing DOD to nearly double its investment in the face of technical and other problems without realizing a better return on investment. Along with the increases, many programs are experiencing significant schedule delays—as much as 6 years—postponing delivery of promised capabilities to the warfighter. Outcomes have been so disappointing in some cases that DOD has had to go back to the drawing board to consider new ways to achieve the same, or less, capability. Some programs have been able to work through the bulk of technical problems they were facing and are on track to meet revised targets, albeit at higher costs and with delayed deliveries. Others, however, continue to face setbacks.

The following chart compares original cost estimates and current cost estimates for the broader portfolio of major space acquisitions for fiscal years 2007 through 2012. The wider the gap between original and current estimates, the fewer dollars DOD has available to invest in new programs.

Figure 1: Comparison between Original Cost Estimates and Current Cost Estimates for Selected Major Space Acquisition Programs[a] for Fiscal Years 2007 through 2012

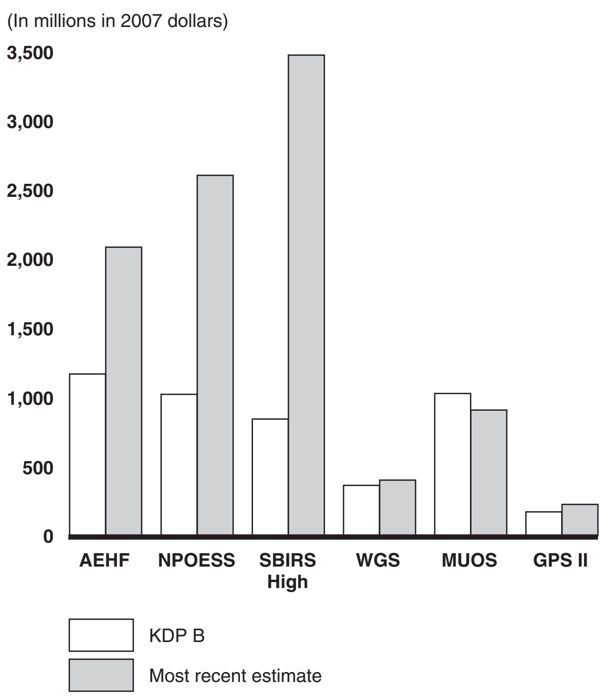


Source: GAO analysis of DOD data.

[a]Includes: Advanced Extremely High Frequency (AEHF) satellites, Evolved Expendable Launch Vehicle (EELV), Global Broadcast Service (GBS), Global Positioning System II (GPS) , Mobile User Objective System (MUOS), National Polar-orbiting Operational Environmental Satellite System (NPOESS), Space Based Infrared System (SBIRS)High, and Wideband Global SATCOM (WGS).

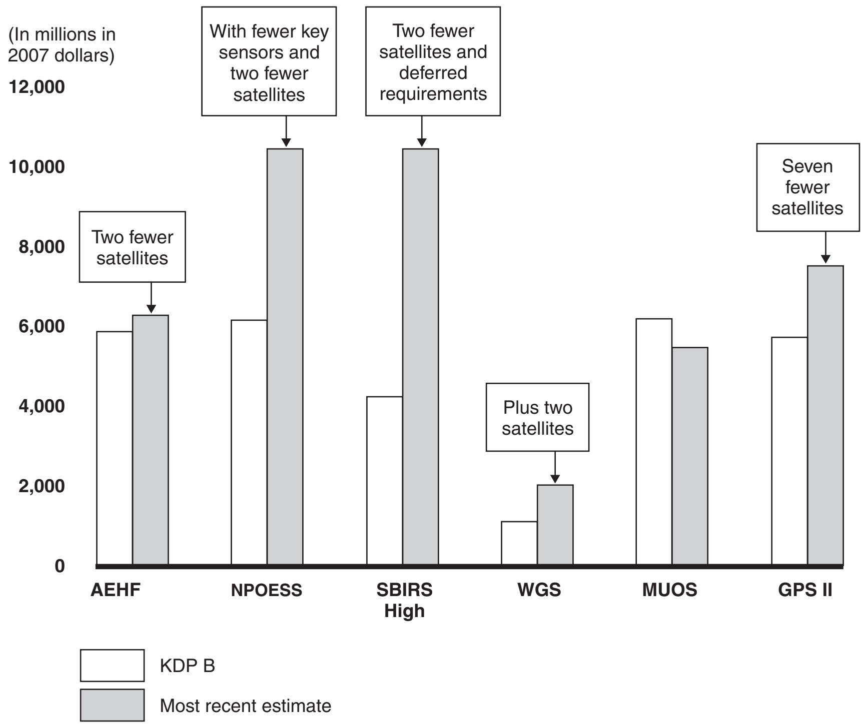
The next two figures reflect differences in unit costs and total costs for satellites from the time the programs officially began to their most recent cost estimate. As the second figure notes, in several cases, DOD has had to cut back on quantity and capability in the face of escalating costs. For example, two satellites and four instruments were deleted from National Polar-orbiting Operational Environmental Satellite System (NPOESS) and four sensors are expected to have fewer capabilities. This will reduce some planned capabilities for NPOESS as well as planned coverage. Likewise, the Space Based Infrared System (SBIRS) High missile detection program deferred capabilities, such as mobile data processors for the Air Force and the Army and a fully compliant backup mission control facility, and it pushed off a decision to procure the third and fourth satellites, which will not meet SBIRS High requirements for coverage. Despite such measures, unit costs for both programs are still considerably higher than originally promised. In addition to SBIRS High and NPOESS, the programs featured in the figures include the Advanced Extremely High Frequency (AEHF) satellites, the Wideband Global SATCOM (WGS) and the Mobile User Objective System (MUOS), which are all communications satellites, and the Global Positioning System (GPS) II.

Figure 2: Differences in Unit Life Cycle Cost from Key Decision Point (KDP) B (Program Start) and Most Recent Estimate



Source: GAO analysis of DOD data.

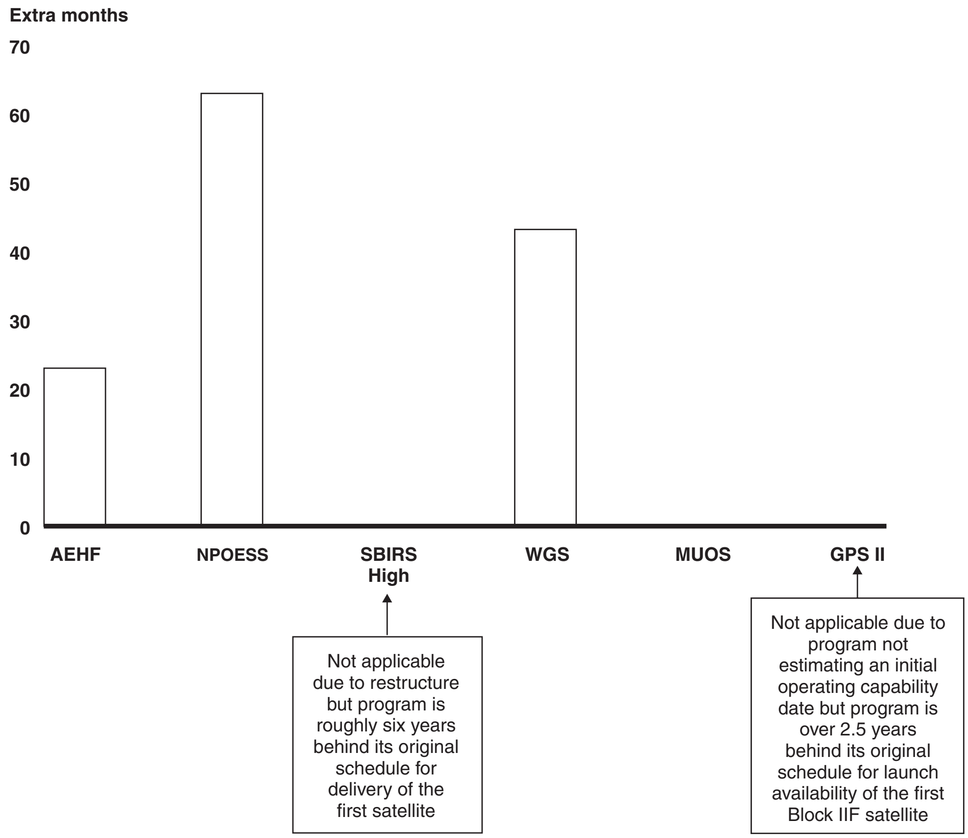
Figure 3: Differences in Total Program Costs from Key Decision Point (KDP) B and Most Recent Estimate



Source: GAO analysis of DOD data.

The next chart highlights the additional estimated months needed to complete programs. These additional months represent time not anticipated at the programs' start dates. Generally, the further schedules slip, the more DOD is at risk of not sustaining current capabilities. For this reason, DOD began an alternative infrared system effort, known as the Alternative Infrared Satellite System (AIRSS), to run in parallel with the SBIRS High program.

Figure 4: Additional Months Needed since Program Start



Source: GAO analysis of DOD data.

Some programs, such as AEHF and WGS, have worked through the bulk of technical and other problems that were causing large schedule increases and cost delays. For example, the AEHF program, which has been in the final stages of development for almost 3 years, resolved issues related to its cryptographic equipment and is on track to meet a revised date for first launch. The WGS program completed rework on improperly installed fasteners, and contractors have redesigned computers to rectify data transmission errors. The program expects a first launch in June 2007. As noted in our figures, the MUOS program, which began more recently than AEHF and WGS, is generally meeting its targets, though it has yet to enter into the more difficult stages of satellite production, integration and test.

By contrast, the SBIRS High program still faces considerable risks. Recent GAO work for this subcommittee, for example, shows that the program is diverging from cost and schedule targets just months after rebaselining due to problems related to assembly, integration, and testing and that the contractor's estimates for addressing these issues are overly optimistic. Defense Contract Management Agency reports also show that software development efforts are behind schedule—by as much as 32 percent. In addition, the contractor has already spent about 28 percent, or $66 million, of its management reserve from April 2006 to November 2006. This reserve is designed to last until 2012, but at the current rate, is likely to be depleted by May 2008. If this trend continues, $500 million in additional reserve will be needed. As noted earlier, DOD initiated an alternative effort—AIRSS—to ensure it would have continued capabilities. However, we have questions as to whether AIRSS is being pursued as a "plan B" program, as originally envisioned. Rather than seek to maintain continuity of operations, the program is focused on advancing capabilities because program managers believe there are no viable alternatives. We also found that there was disagreement among DOD stakeholders as to whether there were alternatives or not, and there was concern that the AIRSS schedule may be too compressed. Our analysis also found that there was a high degree of concurrency in the program's schedule, which may be limiting DOD's ability to gain knowledge from planned demonstrations and increased the potential for costly rework further in the program.

The GPS Block IIF program is also at a high risk of cost increases and schedule delays. Since our last annual assessment of the GPS Block IIF program, the program has revised its acquisition program baseline to account for cost increases and schedule delays, and requested an additional $151 million to cover these costs. The number of IIF satellites to be procured was reduced from 19 to 12. Further, the launch date of the first IIF satellite continues to slip. The original baseline showed an initial launch availability date of December 2006, but DOD's current baseline shows July 2009—a slip of about 2.5 years. The program also learned that the contractor's earned value management reporting system was not accurately reporting cost and schedule performance data. A DOD report also recently found that development of user equipment has not been synchronized with the development of satellites and control system, increasing the risk of substantial delays in realistic operational testing and fielding of capabilities. GPS is taking measures to address these problems. For example, this year, it did not award its contractor $21.4 million in award fees. In December 2005, GAO recommended that DOD improve its use of award fees for all weapon system contracts by specifically tying them to acquisition outcomes. A review of a sample of programs, including SBIRS High, found that this was generally not done.

The NPOESS program is also still at risk of more cost increases and schedule delays. In June 2006, DOD certified the NPOESS program to Congress, and with agreement from its program partners, DOD restructured the program. Now the NPOESS program acquisition costs are estimated to be about $11.5 billion—an increase of about $3 billion over the prior cost estimate. Before the contract was awarded, in 2002, the life cycle cost for the program was estimated to be $6.5 billion over the 24-year period from the inception of the program in 1995 through 2018. The delivery of the first two NPOESS satellites has been delayed by roughly 4 and 5 years, and as noted earlier, the number of satellites to be produced has been reduced from six to four. In addition, the number of instruments was reduced from 13 (10 sensors and 3 subsystems) to 9 instruments (7 sensors and 2 subsystems), and 4 of the remaining sensors will have fewer capabilities. The NPOESS program will incorporate any number of the deleted instruments if additional funding is provided from outside the NPOESS program. The program restructure will result in reduced satellite data collection coverage, requiring dependence on a European weather satellite for coverage during midmorning hours. Although the program has reduced the number of satellites it will produce, the cost per satellite is more than 150 percent above the original approved program baseline. The NPOESS program is now updating the cost, schedule, performance baselines and acquisition strategy, and coordinating the changes with the three agencies. The program expects these documents to be approved later this year. While work is continuing on key sensors, the program still faces potential problems in their development.

The Space Based Space Surveillance System (SBSS) system—not featured on the charts above because it is not yet a formal acquisition program—is also encountering problems. The SBSS system is to replace an aging sensor on an orbiting research and development satellite and improve the timeliness of data on objects in geosynchronous orbit. As currently planned, the initial block will consist of a single satellite and associated command, control, communications, and computer equipment. Subsequent SBSS efforts will focus on building a larger constellation of satellites to provide worldwide space surveillance of smaller objects in shorter timelines. In late 2005, an independent review team found that the program's baseline was not executable; that the assembly, integration, and test plan was risky; and that the requirements were overstated. The SBSS program was restructured in early 2006 due to cost growth and schedule delays. The restructuring increased funding and schedule margin; streamlined the assembly, integration, and test plan; and relaxed requirements. The launch of the initial satellite was delayed to April

2009—a delay of about 18 months. Cost growth due to the restructure is about $130 million over initial estimates.

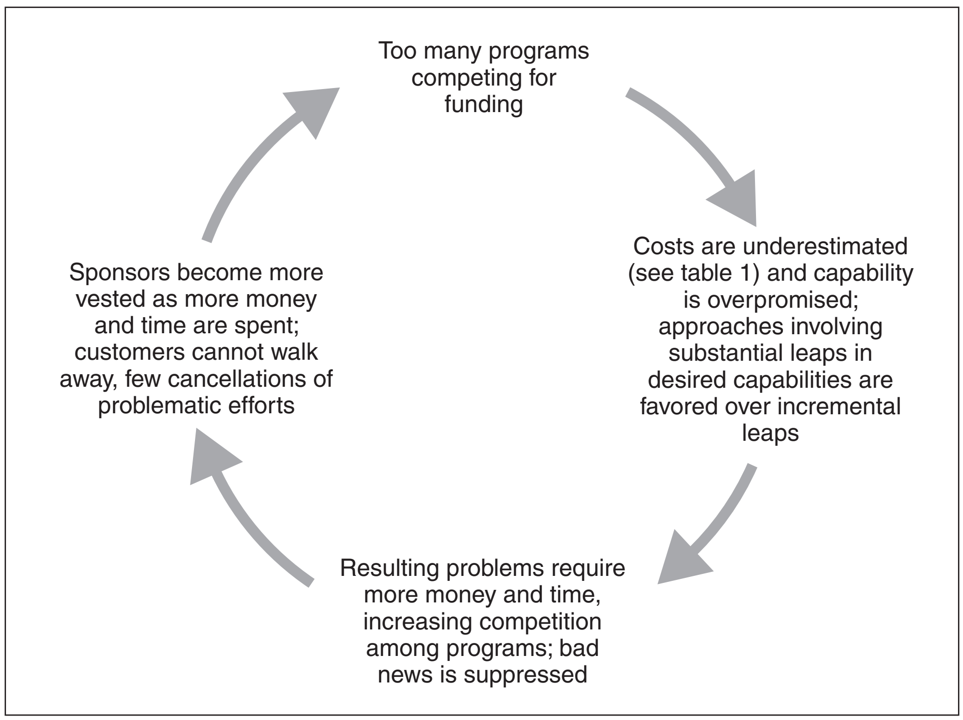
Last, additional cost increases are expected for the Evolved Expendable Launch Vehicle (EELV) program, but for reasons that are different than the ones being experienced on the satellite programs. In recent years, program cost has risen 79 percent, with a cost per unit increase of 135 percent. A chief reason for cost increases is a decline in the commercial launch market upon which the program's business case was based. Cost increases are also a result of additional program scope, including mission assurance, assured access to space, and earned value management systems reporting. In addition, satellite vehicle weight growth and satellite launch delays have contributed to cost increases. In December 2006, Boeing and Lockheed Martin initiated a joint venture (United Launch Alliance, or ULA) that will combine the production, engineering, test, and launch operations associated with U.S. government launches of Boeing Delta and Lockheed Martin Atlas rockets. Though the EELV program office expects long-term savings to be achieved through this arrangement, the cost per launch under a recently negotiated Buy III acquisition strategy will be higher than under Buy I. According to the Air Force, this is because the contractors will incur additional costs to allow the government to perform the necessary oversight not required under Buy I. (Exact estimates of the new cost per launch have not been finalized by the program office yet.) Under the new strategy, EELV will be transitioning from a fixed-price arrangement, where launches were essentially procured as a service, to a combination of a cost-plus and fixed-price contracts. The arrangement will allow the government to exercise more oversight and to incentivize contractors through the use of award fees. But to realize these benefits, the Air Force will need to ensure it has resources (skills, expertise, and tools) to begin accumulating and analyzing detailed cost, schedule, performance, design, and technical data. In addition, it will be important to assess progress in achieving longer-term savings envisioned under ULA as well as to ensure that the combined assets of the contractors are adequately protected.

Underlying Reasons for Cost and Schedule Growth

Our past work has identified a number of causes behind the cost growth and related problems, but several consistently stand out. First, on a broad scale, DOD starts more weapon programs than it can afford, creating a competition for funding that encourages low cost estimating, optimistic scheduling, overpromising, suppressing of bad news, and, for space programs, forsaking the opportunity to identify and assess potentially better alternatives. Programs focus on advocacy at the expense of realism and sound management. Invariably, with too many programs in its portfolio, DOD is forced to continually shift funds to and from programs—particularly as programs experience problems that require additional time and money to address. Such shifts, in turn, have had costly, reverberating effects.

Figure 5 illustrates the negative cycle of incentives that come when programs compete for funding. Table 1 highlights specific areas where we found the original cost estimates of programs to be optimistic in their assumptions.

Figure 5: Pressures Associated when Too Many Programs Are Competing for Funding



Source: GAO.

Table 1: Areas where Space Programs Were Too Optimistic in Their Cost Estimate Assumptions

	Space programs affected					
Optimistic assumptions	**AEHF**	**EELV**	**GPS IIF**	**NPOESS**	**SBIRS**	**WGS**
Industrial base would remain constant and available		×	×	×	×	×
Technology would be mature enough when needed	×		×	×	×	×
Acquisition reform efforts (implemented via Total System Performance Responsibility policy) would reduce cost and schedule		×	×	×	×	
Savings would occur from experience on heritage systems	×			×	×	×
No weight growth would occur	×			×	×	×
Funding stream would be stable	×		×	×	×	
An aggressive schedule could be met	×			×	×	×
No growth in requirements	×		×		×	

Source: GAO analysis.

Note: This table was developed as part of a larger review on DOD's space cost-estimating function. Information was derived from discussions with program and contractor officials and GAO analysis. In some cases, programs may have ultimately experienced problems related to one of the categories, but we did not have evidence to show that the original assumptions were optimistic.[2]

Second, as we have previously testified and reported, DOD has tended to start its programs too early, that is before it has the assurance that the capabilities it is pursuing can be achieved within available resources and time constraints. This tendency is caused largely by the funding process, since acquisition programs attract more dollars than efforts concentrating solely on proving technologies. Nevertheless, when DOD chooses to extend technology invention into acquisition, programs experience technical problems that require large amounts of time and money to fix. Moreover, when the approach is followed, cost estimators are not well positioned to develop accurate cost estimates because there are too many unknowns. Put more simply, there is no way to estimate how long it would take to design, develop, and build a satellite system when critical technologies planned for that system are still in relatively early stages of discovery and invention.

A companion problem for space systems is that programs have historically attempted to satisfy all requirements in a single step, regardless of the design challenge or the maturity of the technologies necessary to achieve

[2]GAO, *Space Acquisitions: DOD Needs to Take More Action to Address Unrealistic Initial Cost Estimates of Space Systems*, GAO-07-96, (Washington, D.C.: Nov. 17, 2006).

the full capability. Increasingly, DOD has preferred to make fewer but heavier, larger, and more complex satellites that perform a multitude of missions rather than larger constellations of smaller, less complex satellites that gradually increase in sophistication. This has stretched technology challenges beyond current capabilities in some cases and vastly increased the complexities related to software—a problem that affected SBIRS High and AEHF, for example.

In addition, several of the space programs discussed above began in the late 1990s, when DOD structured contracts in a way that reduced government oversight and shifted key decision-making responsibility onto contractors. This approach—known as Total System Performance Responsibility, or TSPR—was intended to facilitate acquisition reform and enable DOD to streamline a cumbersome acquisition process and leverage innovation and management expertise from the private sector. However, DOD later found that this approach magnified problems related to requirements creep and poor contractor performance. In addition, under TSPR, the government decided not to obtain certain cost data, a decision that resulted in the government having even less oversight of the programs and limited information from which to manage the programs. Further, the reduction in government oversight and involvement led to major reductions in various government capabilities, including cost-estimating and systems-engineering staff. The loss of cost-estimating and systems-engineering staff in turn led to a lack of technical data needed to develop sound cost estimates.

DOD Is Implementing Best Practices on Two New Efforts

Over the past decade, GAO has examined successful organizations in the commercial sector to identify best practices that can be applied to space and weapon system acquisitions. This work has identified a number of practices, which we have recommended that DOD adopt. Generally, we have recommended that DOD separate technology discovery from acquisition, follow an incremental path toward meeting user needs, match resources and requirements at program start, and use quantifiable data and demonstrable knowledge to make decisions to move to next phases. DOD is making efforts to instill these practices on two programs reviewed this year: the Transformational Satellite Communications System and the Space Radar program. Specifically:

- *Successful organizations we have studied ensure that technologies are mature, that is, proven to work as intended before program start.* Both TSAT and Space Radar are attempting to do this. According to their plans, critical technologies should reach at least a Technology

Readiness Level (TRL) 6 by program start, meaning the technologies have been tested in a relevant environment. This stands in sharp contrast to previous programs, which have started with immature technologies, such as SBIRS and NPOESS, and it reflects the implementation of a "back to basics" policy advocated this past year by the Under Secretary of the Air Force. If these programs adhere to the TRL 6 criteria, they will greatly reduce the risk of encountering costly technical delays, though not completely. There are still significant inherent risks associated with integrating critical technologies and with developing the software needed to realize the benefits of the technologies. Moreover, the best practice programs we have studied strive for a TRL 7, where the technology has been tested in an operational environment, that is, space.

- *Successful organizations defer more ambitious technology efforts to corporate research departments (equivalent to science and technology (S&T) organizations in DOD) until they are ready to be added to future increments.* Both programs have deferred more ambitious technology development efforts to the science and technology environment. TSAT, for example, deferred the wide-field of view multi-access laser communication technology, and is contributing about $16.7 million for "off-line" maturation of this technology that could be inserted into future increments. It has laid out incremental advances in other capabilities over two increments. Space Radar has deferred lithium-ion batteries, more efficient solar cells, and onboard processing for its first increment, and like TSAT, is contributing toward their development by S&T organizations. At this time, Space Radar has not defined details of an increment beyond the first one.

- *Successful organizations extensively research and define requirements before program start to ensure that they are achievable, given available resources, and that they do not define requirements after starting programs.* Both programs have also employed systems engineers to help determine achievability of requirements. The TSAT program has reached agreement on requirements with its users—primarily in terms of what will be included in the first several blocks of the program and what will not be included. The Space Radar program has instituted several processes designed to achieve consensus on requirements across a range of diverse users. It still needs to formalize agreements related to these processes and also identify key performance parameters. This is important because Space Radar is to be shared by the military and intelligence communities—each with different specific needs for the system and very specific roles and responsibilities with regard to the data being produced by Space Radar and its users. It has been reported recently that conflicts in roles and responsibilities have arisen on dissemination of data being produced by a small tactical satellite (TacSat 2) recently launched by DOD for use by military commanders.

It remains to be seen whether TSAT and Space Radar will take additional steps that successful organizations take to position programs for success. For example:

- *The organizations we have studied do not go ahead with program start milestone decisions if there are still gaps between requirements and resources.* TSAT and Space Radar have indicated that they intend to do the same, but there are external pressures on both programs to provide needed capabilities.

- *The organizations we have studied hold program managers accountable for their estimates and require program managers to stay with a project to its end.* We have made recommendations to DOD to instill similar practices departmentwide, but these have yet to be implemented. Further, there are still incentives in place to keep program managers' tenures relatively short. Promotions, for example, often depend on having varied management experience rather than sustained responsibility for one program.

- *The organizations we studied have developed common templates and tools to support data gathering and analysis and maintain databases of historical costs, schedule, quality, test, and performance data. Cost estimates themselves are continually monitored and regularly updated through a series of gates or milestone decisions that demand programs assess readiness and remaining risk within key sectors of the program as well as overall cost and schedules.* We saw indications that TSAT and Space Radar were using more robust tools to analyze risks, costs, and schedule than programs have done in the past. However, it remains to be seen how these practices will be reflected in official cost estimates. In the past, we have found space program estimates were simply too optimistic and that independent estimates produced by DOD's Cost Analysis Improvement Group were not being used. DOD agreed with our findings and asserted it was taking actions to address them.

Actions Needed to Sustain Commitment to Improvements

The Air Force's continued efforts to instill best practices on Space Radar and TSAT are good first steps toward addressing acquisition problems in the space portfolio. They represent significant shifts in thinking about how space systems should be developed as well as commitment from senior leadership. But sustaining these reforms will not be easy. The programs are not immune to funding pressures that have encouraged too much optimism. They are also being undertaken as DOD is addressing shortfalls in critical technical, business, and program management skills. Further, processes and policies key to sustainment and broader use of best practices have not been changed to further reflect the kinds of changes taking place on Space Radar and TSAT.

First, new programs still must compete for limited funding. As DOD seeks to fund Space Radar and TSAT, it will be (1) undertaking other new, costly efforts, including GPS III, SBSS, and AIRSS; (2) addressing cost overruns associated with programs like SBIRS High and GPS; and (3) facing increased pressures to increase investments in assets designed to protect space systems. In total, these efforts will increase DOD's investment for all major space acquisitions from $6.31 billion to $9.22 billion, or about 46 percent over the next 3 years. More may be needed if technical, software, and other problems on current programs worsen. At the same time, investment needs for other weapon systems are also on the rise, while long-term budget forecasts indicate that considerably fewer dollars will be available for discretionary spending in coming years rather than more.

In prior reports, we have stated that as long as too many programs compete for too few dollars in DOD, programs will be incentivized to produce optimistic estimates and suppress bad news. They will view success as securing the next installment of funds versus delivering capability within cost and schedule goals. We have recommended that DOD guide its decisions to start space and other weapons acquisition programs with an overall investment strategy that would identify priorities for funding so that space systems that are expected to play a critical role in transformation, such as Space Radar and TSAT, could be prioritized along with other legacy and transformational systems.

Let me take a moment to illustrate why an investment strategy is critical. We have reported in the past that DOD and the Air Force have waited too long to establish priorities or make trade-off decisions. We have also reported that frequent funding shifts have hurt programs that were performing well or further damaged troubled programs. We have also reported cases where DOD and the Air Force have walked away from opportunities to save costs in lot buys or leverage knowledge already gained in legacy programs in favor of starting new programs that promise much more advanced capability but have little knowledge to back up that promise. Today, DOD is on track to cut short the AEHF program in order to pursue TSAT. It has stated it may also do the same for SBIRS to pursue AIRSS. In both cases, DOD would be forgoing savings that it had already negotiated for lot buys and in effect, paying significantly more for nonrecurring engineering. While these decisions have the potential to enable DOD to obtain advanced capability sooner (provided best practices are followed on the new programs), they should have been made much earlier and more strategically in order to stem investment losses.

DOD's own reports recognize that investment planning needs to be instilled in weapon acquisitions. A February 2007 report, in response to a requirement in the John Warner National Defense Authorization Act for Fiscal Year 2007, outlines steps that DOD is taking to better prioritize and fund programs.[3] The initiatives include (1) establishing a new concept decision review to provide decision makers with an early opportunity to evaluate trade-offs among alternative approaches to meeting a capability need, (2) testing portfolio management approaches in selected capability areas to facilitate more strategic choices about how to allocate resources across programs, and (3) capital budgeting as a potential means to stabilize program funding. While these developments are promising, we recently reported that such initiatives do not fundamentally change DOD's existing service-centric framework for making weapon system investment decisions.[4] Moreover, it will take some time to determine their success in enabling more effective funding prioritization.

Second, space programs are facing capacity shortfalls. These include shortages of staff with science and engineering backgrounds as well as staff with program management and cost estimating experience. During our review this year, the TSAT program cited shortages of space acquisition personnel as a key challenge that increases risk for the program. Due to broader Air Force cuts in workforce, the program did not expect to be able to fill technical positions needed to accompany plans to

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[3]Department of Defense, *Defense Acquisition Transformation Report to Congress* (Washington, D.C., 2007).

[4]GAO, *Best Practices: An Integrated Portfolio Management Approach to Weapon System Investments Could Improve DOD's Acquisition Outcomes*, GAO-07-388 (Washington, D.C.: March 30, 2007).

ramp up spending. During our review of DOD's space cost estimating function, Air Force space cost estimating organizations and program offices said that they believed their cost-estimating resources were inadequate to do a good job of accurately predicting costs. Because of the decline in in-house cost-estimating resources, space program offices and Air Force cost-estimating organizations are now more dependent on support contractors. At 11 of 13 program offices we informally surveyed, contractors accounted for 64 percent of cost-estimating personnel. This reliance raised questions from the cost-estimating community about whether numbers and qualifications of government personnel were sufficient to provide oversight of and insight into contractor cost estimates. In addition to technical and cost estimating skills, DOD and GAO studies have also pointed to capacity shortfalls in program management. According to DOD's Young Panel report, government capabilities to lead and manage the space acquisition process have seriously eroded, in part because of actions taken in the acquisition reform environment of the 1990s. During our 2005 review of program management, we surveyed DOD's major weapon system program managers and interviewed program executive officers, who similarly pointed to critical skill shortages in program management, systems engineering, and software development. The Air Force and DOD recognize these shortfalls and are taking actions to address them, but these will take time to implement. It is important that in the interim, the Air Force identify and take steps to grow or retain skill sets that should be organic, such as highly specialized knowledge of certain military space technologies. During both our cost estimating and space system reviews, program officials noted that it can take several years for new technical staff to build knowledge and skills unique to military space.

Our past work has also pointed to capacity shortfalls that go beyond workforce. For example, in 2006, we reported that cost estimation data and databases are incomplete, insufficient, and outdated. And in our testimony last year, we pointed to limited opportunities and funding for space technologies, and the lack of low-cost launch vehicles. It is our understanding that the Air Force and DOD are working to address all of these shortfalls. Budget plans show, for example, an increase of nearly $11 million in funding for the space test program beginning in 2009—about 23 percent.

Last, policies that surround space acquisition need to be further revised to ensure best practices are instilled and sustained. For example, DOD's space acquisition policy does not require that programs such as TSAT and Space Radar achieve a TRL 6 or higher for key technologies before being formally started (KDP B). Instead, it is suggested that TRL 6 be achieved at preliminary decision review (KDP C) or soon after. Given that there are many pressures and incentives that are driving space and other weapon programs to begin too early and to drive for dramatic rather than incremental leaps in capability, DOD needs acquisition policies that ensure programs have the knowledge they need to make investment decisions and that DOD and Congress have a more accurate picture of how long and how much it will take to get the capability that is being promised. In addition, although the policy requires that independent cost estimates be prepared by bodies outside the acquisition chain of command, it does not require that they be relied upon to develop program budgets. Officials within the space cost estimating community also believed that the policy was unclear in defining roles and responsibilities for cost estimators. We continue to recommend changes be made to the policy—not only to further ingrain the shift in thinking about how space systems should be developed, but to ensure that the changes current leaders are trying to make can be sustained beyond their tenure.

In closing, we support efforts to instill best practices on programs like Space Radar and TSAT. They are critical to enabling DOD to break the cycle of space acquisition problems by matching resources to requirements before program start. We encourage DOD to build on this momentum by extending a best practice approach to its entire space portfolio. For newer efforts, such as AIRSS, this means reexamining requirements and alternative means of satisfying those requirements and clarifying the true purpose of the program. For current programs, such as SBIRS, this means continuing to track risks and dedicating resources necessary to mitigate those risks, leveraging management tools such as earned value management analyses, and finding ways to incentivize contractors to perform well. For the broader portfolio, this means ensuring programs have all the right resources to enable success. These include adequate levels of funding accompanied by short- and long-term investment plans, adequate skills and capabilities, as well as data, policy, and processes, accountability and leadership support.

Appendix I: Scope and Methodology

In preparing for this testimony, we relied on previously issued GAO reports on assessments of individual space programs, common problems affecting space system acquisitions, and DOD's space acquisition policy. We also relied on our best practices studies, which have examined pressures and incentives affecting space system acquisition programs, the optimal levels of knowledge needed to successfully execute programs, and complementary management practices and processes that have helped commercial and DOD programs to reduce costs and cycle time. In addition, we analyzed DOD's Selected Acquisition Reports to assess cost increases and investment trends. We conducted our review between March 19 and April 13, 2007 in accordance with generally accepted government auditing standards.

Appendix II: Contacts and Acknowledgments

For in information, please contact Cristina Chaplain at 202-512-4841 or chaplainc@gao.gov. Individuals making contributions to this testimony include, Art Gallegos, Jeff Barron, Tony Beckham, Noah Bleicher, Greg Campbell, Maricela Cherveny, Claire Cyrnak, Jean Harker, and Rich Horiuchi.

Appendix III

Table 1: Highlights of Recent Findings for Current and Planned Space Programs

Description	Recent findings
Current programs	
Space Based Infrared System High (SBIRS-High): Ballistic missile detection system being developed by the Air Force to replace its legacy detection system. **Development** **Start:** October 1996[a]	With unit cost increases of more than 315 percent, the program has undergone four Nunn-McCurdy reviews. Total program costs have increased from $4 billion to more than $10 billion. The launch schedule has slipped at least 6 years; the first satellite is currently scheduled to launch not earlier than October 2008. Several program elements that were problematic before the restructure continue to pose risks for the program. SBIRS High faces challenges in software development and remains at risk of failing to meet cost and schedule goals. The total program cost is still not accounted for, in part because of deferred capabilities, and the contractor management reserve funds are not sustainable at the current rate of expenditure. In all likelihood, management reserve dollars will need to be increased. DOD officials recently began efforts to develop a viable competing capability in parallel with the SBIRS High program, known as the Alternative Infrared Satellite System (AIRSS). AIRSS is being designed in part to provide an alternative to the SBIRS GEO 3 satellite. DOD awarded contracts to Raytheon and Science Applications International Corporation for sensor assembly development for AIRSS.
Global Broadcast Service (GBS): Part of the overall military satellite communication architecture developed by the Air Force for one-way transmission of video, imagery, and other high-bandwidth information to the warfighter. **Development** **Start:** November 1997	Program funding increased by over $100 million for fiscal years 2008 through 2013 as a result of a decision to implement a new GBS architecture. The new architecture is to be implemented beginning in fiscal year 2008, and will use existing defense programs and computing centers to host GBS broadcast content. A revised acquisition program baseline is being developed to address the unit cost increase. GBS currently uses broadcast payloads on two Ultra-High Frequency Follow-on (UFO) satellites and three leased commercial satellite transponders, and starting in fiscal year 2008, the constellation of five Wideband Global SATCOM (WGS) satellites will also carry GBS.
Evolved Expendable Launch Vehicle (EELV): Acquisition of commercial launch services and associated infrastructure from two competitive families of launch vehicles. **Development** **Start:** October 1998	The program cost has risen 79 percent, with a cost per unit increase of 135 percent, and triggered a Nunn-McCurdy breach. A chief reason for cost increases is a decline in the commercial launch market upon which the program's business case was based. In December 2006, Boeing and Lockheed Martin initiated a joint venture (United Launch Alliance, or ULA) that will combine the production, engineering, test, and launch operations associated with U.S. government launches of Boeing Delta and Lockheed Martin Atlas rockets. The EELV program office is budgeting for ULA savings (estimated at $150 million per year) that are to appear starting in fiscal year 2011. The cost per launch under the new Buy III acquisition strategy will likely be higher than under Buy I because the contractors will incur additional costs to allow the government to perform the necessary oversight not required under Buy I. The contractors will incur additional costs due to added program scope (mission assurance, assured access to space, and earned value management systems reporting) and necessary government oversight not required under Buy I. The program office is revising the life cycle cost estimate and acquisition program baseline to reflect the transition from Milestone II to Milestone III (production) and incorporate the Buy III strategy and contract structure. The expected completion is summer 2007.

Description	Recent findings
Global Positioning System (GPS) Modernization: A space-based radio-positioning system that nominally consists of a 24-satellite constellation providing navigation and timing data to military and civilian users worldwide. **Development** **Start:** February 2000	Total costs of the GPS II modernization program have increased by over 20 percent, largely due to adding requirements after the contract award and using a contracting approach that gave the contractor for the IIF satellites and control system full responsibility for the life cycle of the program and allowed parallel development and production efforts. The program requested approximately $151 million in funds to be reprogrammed this year and did not award the contractor $21.4 million in 2006 available award fees. The first IIF satellite available for launch date has slipped about 2.5 years. The original program baseline had the available for launch date of December 2006, but DOD's recent approval of a revised baseline now shows July 2009 as the latest available date. That baseline also calls for the procurement of only 12 IIF satellites, rather than the planned 19. The reduced number of IIF satellites and a possible increase in reprogrammed funding will increase unit cost.
Wideband Global SATCOM (WGS): Previously known as Wideband Gapfiller Satellites and originally conceived to augment the near-term bandwidth gap in warfighter communications needs. The Air Force is considering a three-block approach for fielding WGS, which is to provide high data-rate military satellite communication services. Block 1 includes the first three satellites. **Development** **Start:** November 2000	Total program costs have increased by more than 80 percent—increasing from $1.10 billion in late 2000 to $2.01 billion in 2005 and reflect the purchase of two additional satellites. In October 2006, the Air Force awarded a $1.07 billion fixed price incentive fee with firm target contract to Boeing Satellite Systems for developing the Block 2 WGS satellites, or satellites 4 and 5, with an unfunded option for WGS 6. Satellites 4 and 5 will have enhanced capacity for supporting airborne intelligence, surveillance, and reconnaissance users and will complete the currently planned WGS constellation. The program has made progress in integrating and testing the first satellite. For example, rework on improperly installed fasteners is complete, and the contractor redesigned computers to correct data transmission errors. The program office conducted low-level signal testing associated with satellite launch and completed interoperability testing on the first satellite, in preparation for a June 2007 launch.
Advanced Extremely High Frequency (AEHF): Communications satellite system being developed by the Air Force to replace its legacy protected communications satellites. **Development** **Start:** September 2001	Unit cost has increased by 78 percent. In 2004, the program experienced cost increases of more than 15 percent, which required a Nunn-McCurdy notification to Congress. The program was restructured in 2004 when key cryptographic equipment was not delivered to the payload contractor in time to meet the launch schedule. Although the AEHF program has overcome hurdles that plagued the program through development, it still has to complete first-time integration and testing of a very complex satellite. The program expects to conduct thermal vacuum testing in the fall of 2007. Current plans are to meet full operational capability with three AEHF satellites and the first Transformational Satellite Communication System (TSAT) satellite.
Space Tracking and Surveillance System (STSS): Two satellites to be launched in 2007 as technology demonstrations for missile defense tests to assess whether missiles can be effectively tracked from space. **Development** **Start:** Restructured April 2002	Total program costs have increased by 35 percent due to the addition of funds for designing and developing the program's operational constellation. As of 2006, total program cost is estimated at almost $4.7 billion. The initial increment of this program, which started in 2002, is composed of two demonstration satellites that were built under the previous Space Based Infrared System-Low (SBIRS-Low) program. SBIRS-Low had incurred cost increases and schedule delays and other problems that were so severe, DOD abandoned the effort. The program office completed thermal vacuum testing on the first demonstration satellite's space vehicle. Test results show performance of the integrated space vehicle within specifications. However, the STSS program has experienced quality issues at the payload subcontractor, and technical difficulties encountered by the prime contractor during payload integration and testing contributed to STSS's unfavorable cost and schedule variances of $163.7 million and $104.4 million respectively. A portion of the unfavorable cost and schedule variance is related to work that does not contribute to the demonstration satellite effort. The program office expects to launch both satellites in 2007. The Missile Defense Agency (MDA) plans to initiate an effort to build the next generation of satellites, and the program office intends to award a contract for the follow-on constellation in the fall. If the contract is awarded in the fall, the follow-on satellites are to be launched in 2016 or 2017, resulting in a potential coverage gap of 5 to 6 years.

Description	Recent findings
National Polar-orbiting Operational Environmental Satellite System (NPOESS): Weather and environmental monitoring satellites being developed by the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, and DOD to replace those in use by the agencies. **Development** **Start:** August 2002	Unit costs increased by about 34 percent, triggering a Nunn-McCurdy review in January 2006. The revised program acquisition cost estimate is about $11.5 billion despite the reduction of total satellites. As part of the mandatory certification process, the program was restructured and will only include the development of four satellites, down from six, and the deletion of a critical sensor. However, the program now includes the development of a competition for a new replacement sensor that will coincide with the second developmental satellite. The launch of the first satellite has been delayed by at least 45 months from contract award, and is now planned for early 2013.
Mobile User Objective System (MUOS): Navy effort to develop a family of unprotected, narrow-band satellites that can support mobile and fixed-site users worldwide. **Development** **Start:** September 2004	In June 2004, DOD delayed the first MUOS satellite launch by 1 year to fiscal year 2010 due to a delay in awarding the development contract and to mitigate schedule risk. MUOS development has become time-critical due to the failures of two UHF Follow-On satellites, one in June 2005 and another in September 2006. In June 2008, narrow-band communications capabilities are expected to drop below those required and may remain degraded until the first MUOS satellite is available for operations in March 2010. According to the program manager, accelerating the MUOS schedule is not an option because of the production, integration and test activities that must take place prior to launch. DOD is examining options for addressing a communications capability gap. Additionally, development problems encountered under the Joint Tactical Radio System (JTRS) program have resulted in deferrals of requirements and the increased risk of underutilization of MUOS capabilities until MUOS-compliant JTRS terminals are fielded. According to the program office, MUOS must maintain its schedule each spacecraft will help mitigate the UFO availability gap until JTRS terminals are fielded.
Planned programs	
Alternative Infrared Satellite System (AIRSS): The Air Force's AIRSS effort is to provide a missile warning capability while also supporting missile defense, battlespace awareness, and technical intelligence. **Planned development start date:** Early third quarter fiscal year 2008	As a result of the Nunn-McCurdy certification for the SBIRS High program, the Under Secretary of Defense for Acquisition, Technology, and Logistics directed the DOD Executive Agent for Space to plan for a new program for space-based infrared capabilities that will pursue an approach with acceptable technical risk and can ensure a launch availability date of fiscal year 2015. However, AIRSS is not being pursued as a "plan B" for the SBIRS program, as originally envisioned. Rather than seeking to maintain continuity of operations, the effort is focused on advancing capabilities under highly compressed time-frames. There is disagreement within DOD about the likelihood of meeting the target delivery date of 2015. Results from the on-orbit demonstration satellite will not be ready in time to fully inform the development of the first AIRSS satellite, and AIRSS officials plan to award system contracts before data from key on-orbit testing is completed. The latest cost estimate for the effort through fiscal year 2013 is over $3.3 billion; there is no full estimate because the system is still undefined.
GPS III: Next generation of GPS satellites and a new control system (OCX) is to be acquired using the block approach. **Planned development start date:** First quarter of 2008 for satellites and fiscal year 2007 for OCX	Initial plans were to develop a new version of GPS that would add advanced jam-resistant capabilities and provide higher- quality and more secure navigation capabilities. However, the first block of GPS III satellites will have baseline capabilities, with a launch date of 2013 for the first satellite; second and third blocks will introduce new capabilities. Ongoing cost increases and schedule delays with the control system for the GPS modernized satellites (IIR-M and IIF) resulted in reallocating requirements to the OCX. If the first GPS III does not launch by 2013, constellation sustainment will be at risk.

Description	Recent findings
Space-Based Space Surveillance (SBSS): Optical sensing satellites being developed to search, detect, and track objects in Earth orbit. **Planned development start date:** Second quarter of fiscal year 2010	The SBSS system is to replace an aging sensor on an orbiting research and development satellite and improve the timeliness of data on objects in geosynchronous orbit. As currently planned, the initial block (Block 10) will consist of a single satellite and associated command, control, communications, and computer equipment. Subsequent SBSS efforts, referred to as Block 20, will focus on building a larger constellation of satellites to provide worldwide space surveillance of smaller objects in shorter timelines. In early 2006, the effort was restructured due to schedule delays and cost growth on Block 10 development efforts. The restructuring increased funding and schedule margin; streamlined the assembly, integration, and test plan; and relaxed requirements. The launch date for the Block 10 satellite has been delayed about 18 months—to April 2009. Cost has increased by about $130 million over initial estimates.
Space Radar (SR): Satellites being developed to provide global, persistent, all-weather, day- and -night, intelligence, reconnaissance, and surveillance capabilities. **Planned development start date:** April 2009	Program estimates for total funding range from $20 billion to $25 billion. In November 2006, the program revised its critical technologies, and although the technology readiness levels—or TRLs—are low (between TRL 3 and TRL 4), the program expects critical technologies to be mature when the product development phase begins in 2009. The program has strived to close knowledge gaps between requirements and resources in part by following an iterative approach, but key performance parameters are yet to be finalized. Furthermore, the program may not have planned enough time for design, integration, and production activities. For example, program start to initial launch capability for SR is shorter than what DOD has achieved or estimated for some other complex satellite systems that have had major replan activities. Although there is a cost sharing agreement in the FYDP, a long-term cost-share agreement (beyond FYDP) between DOD and the intelligence community has not been established, which adds to uncertainty about DOD's ability to afford expensive programs such as SR. SR has transferred its fiscal year 2008 budget estimate into the Defense Reconnaissance Support Activities budget, and it is now classified.
Transformational Satellite Communications System (TSAT): Communication satellites being developed by the Air Force to employ advanced technologies in support of DOD's future communication architecture. **Planned development** **Start:** First quarter fiscal year 2008	The latest cost estimate for TSAT is $17.7 billion (adjusted for inflation), and the launch of the first satellite has slipped from 2011 to 2015. DOD rescinded approval to begin preliminary design activities and restructured the program to follow an incremental development approach. Early tests have revealed challenges in laser communication and limited analyses of the scalability of TSAT raises integration risks. Final test results of Phase II testing will not be available until late fiscal year 2007.The program may not have planned enough time for networking activities between TSAT and other DOD systems, and the schedule for the TSAT Mission Operations System software code development may be too optimistic. Even with TSAT and other DOD satellites assets, gaps between bandwidth needs and resources are expected to continue to grow, requiring continued dependence on commercial bandwidth. Program officials said they will need additional government personnel to carry out oversight and management functions in the long run.

Source: GAO analysis of DOD data and previous GAO reports.

[a]The National Security Space Acquisition Policy specifies that key decision point B (also referred to as Milestone B by the DOD 5000 series or Development Start by GAO best practice work) is the official program initiation point when programs submit Selected Acquisition Reports (SAR) to Congress and develop a formal Acquisition Program Baseline (APB).

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