United States Government Accountability Office

GAO

Testimony

Before the Subcommittee on Strategic Forces, Committee on Armed Services, U.S. Senate

For Release on Delivery
Expected at 2:30 p.m. EST
Tuesday, March 4, 2008

SPACE ACQUISITIONS

Major Space Programs Still at Risk for Cost and Schedule Increases

Statement of Cristina T. Chaplain, Director
Acquisition and Sourcing Management

March 4, 2008

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Highlights

Highlights of GAO-08-552T, a testimony before the Subcommittee on Strategic Forces, Committee on Armed Services, U.S. Senate

Why GAO Did This Study

Each year, the Department of Defense (DOD) spends billions of dollars 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 2009 alone, DOD expects to spend over $10 billion to develop and procure satellites and other space systems.

At the same time, 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.

This testimony relies on the extensive body of work GAO has produced reviewing DOD space acquisitions. It comments on

- the persistent problems affecting space acquisitions,
- the actions DOD has been taking to address these problems, and
- what remains to be done.

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. Along with the increases, many programs are experiencing significant schedule delays—as much as 7 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.

Our past work has identified a number of causes behind the cost growth and related problems. These include: optimistic cost and schedule estimating; the tendency to start programs with too many unknowns about technology; inadequate contracting strategies; contract and program management weaknesses; the loss of technical expertise; capability gaps in the industrial base; tensions between labs that develop technologies for the future and acquisition programs; divergent needs in users of space systems; and diffuse leadership.

DOD has taken a number of actions to address the problems that GAO has reported on. These include initiatives at the department level that will affect all major weapons programs, as well as changes in course within specific Air Force programs. Most notable, the Air Force has sustained its commitment to reduce technology risks in programs and acted to restructure new programs so that its space portfolio can be more affordable. These actions are a step in the right direction and will be effective, particularly if they are complemented by more accurate cost estimating; continued prioritization of investments; actions to address capacity shortfalls, such as low-cost launch and shortages of staff in program offices; and changes to acquisition policies to reflect the best practices the Air Force is committing to.

To view the full product, including the scope and methodology, click on GAO-08-552T. For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

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 of dollars 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 2009 alone, DOD expects to spend over $10 billion to strengthen space-based capabilities and $7.6 billion of this amount is targeted for selected major space acquisition efforts. At the same time, 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. Today, we are here to comment on what problems affecting space acquisitions still persist, what actions DOD has been taking to address these problems and what remains to be done. In general, we found this year that space programs that have been troubled in recent years still face problems that are driving up costs and schedule. At the same time, senior leadership has remained committed to reducing technology risks and ensuring newer programs are more affordable. Investment prioritizing, realistic cost estimating, policy changes, and other actions we identify can help this commitment take further hold.

Space Acquisition Problems Persist

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 7 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.

As figures 1 and 2 below indicate, five programs that were begun in the late 1990s / early 2000s to replenish aging constellations of satellites have incurred substantial cost growth and schedule delays, including the (1) the Advanced Extremely High Frequency (AEHF) communications satellite

program, (2) the National Polar-orbiting Operational Environmental Satellite System (NPOESS), which DOD is jointly developing with the National Oceanic and Atmospheric Administration, (3) the Space Based Infrared System (SBIRS), which detects missile launches, (4) the Wideband Global SATCOM (WGS), another communications satellite, and (5) the Global Positioning System (GPS) IIF program. Last year we reported that AEHF and WGS had worked through the bulk of their technical problems. Since our testimony, the first WGS satellite was launched, but the AEHF program experienced technical problems with hardware components that have pushed back its first launch date by 6 months. Also, this year, as described below, we found that NPOESS and SBIRS still face very high risks, even after recent acquisition replanning efforts. Further, GPS IIF has experienced additional technical problems.

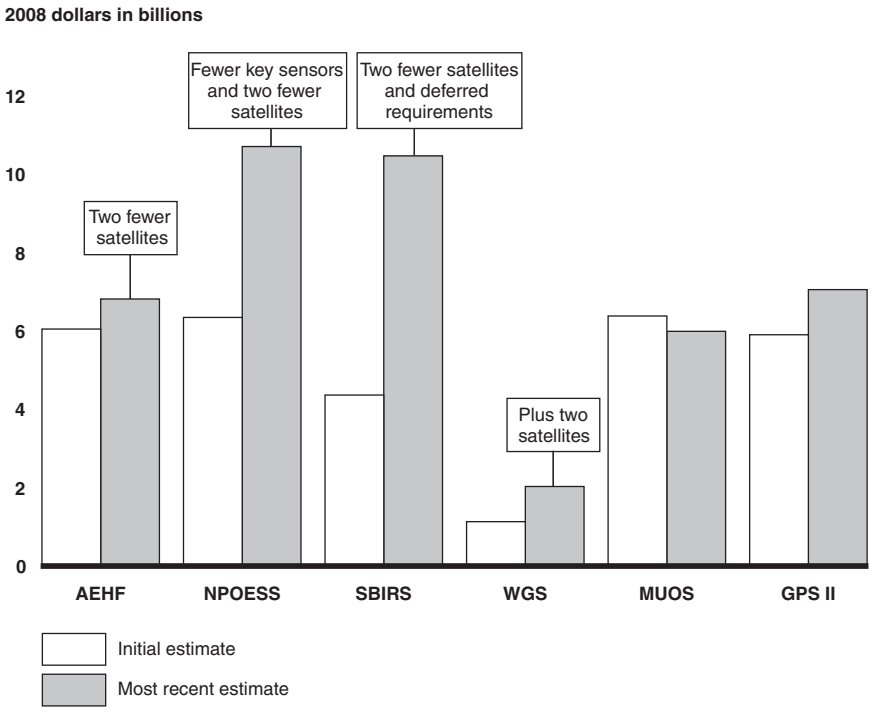
- SBIRS continues to face cost and schedule setbacks. Software problems have recently delayed the first satellite launch by about a year, which will likely increase the program's overall delay to roughly 7 years. Correcting the problems may necessitate hardware and software changes that could, according to the Air Force, also drive cost increases up to $1 billion, which would be in addition to the $6 billion cost growth already incurred. Management-reserves expenditure continues at an unsustainable rate. Program officials acknowledge that management reserves set aside to fix unexpected problems will likely be depleted in early 2009, even though the reserves were intended to last through 2012. Given the complexity of the SBIRS satellites, it is possible that further design flaws may be discovered, leading to more cost and schedule increases. If management reserves are depleted and not replenished, the program will likely experience further cost and schedule problems.

- In July 2007, the NPOESS program finalized its restructure in response to a Nunn-McCurdy (10 U.S.C. § 2433) program acquisition unit breach of the critical cost growth threshold. The restructure included about an additional $4.1 billion, or about a 49 percent, life-cycle cost increase for fewer satellites to be acquired, delays in satellite launches, and deletions or replacements of satellite sensors. The restructure also included removing 7 of the original 14 critical technologies from the program. Furthermore, 3 of the remaining technologies remain immature and the program continues to experience development problems, increasing risks of further problems. At this point, the program has seen a 153 percent unit cost increase.

- The GPS IIF program has faced technical challenges in completing development and production, causing another schedule delay in the launch of the first IIF satellite—over a 2-year slip from the original launch

date of December 2006 to February 2009. Moreover, the program continues to face cost increases due to these technical problems. Specifically, the program has requested over $100 million for fiscal years 2008 and 2009 to cover the estimated cost overruns to complete production of the first three space vehicles. In addition, program officials are concerned that additional funds may be needed to complete this program if additional delays are incurred—the program has already spent $1.2 billion to date, which represents about 77-percent of the total cost originally estimated for the program. (Note: The chart below reflects a larger cost because it includes estimates for the GPS IIR, IIR-M, and IIF blocks of the GPS program.)

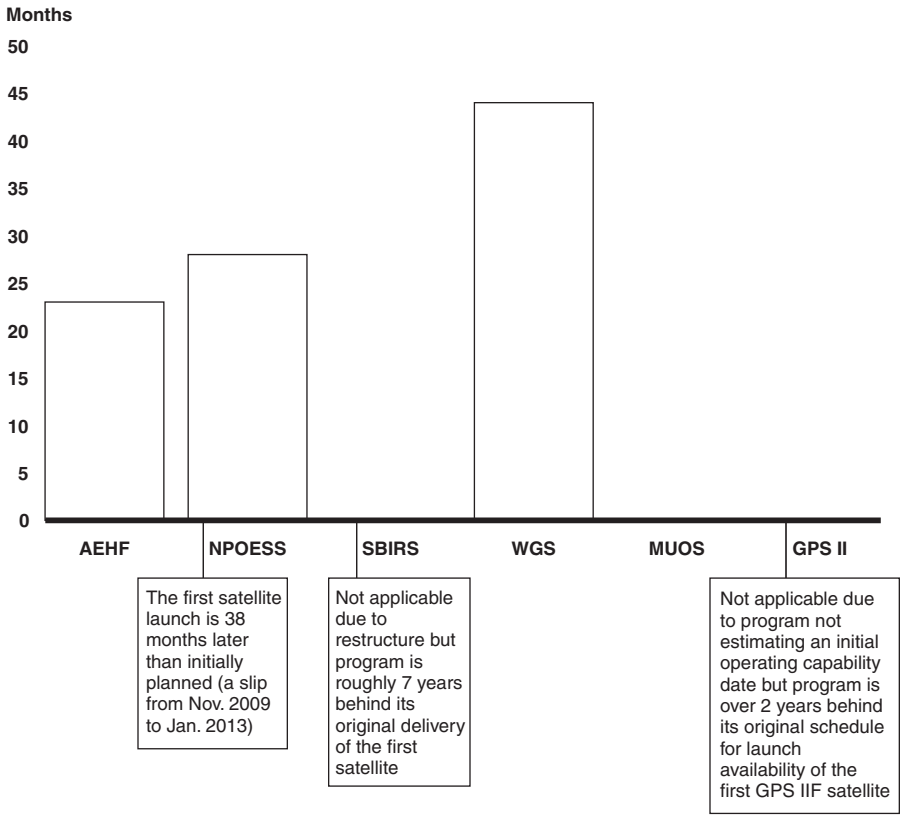
Figure 1: Differences in Total Program Costs from Program Start and Most Recent Estimates



Source: GAO analysis of DOD data.

Note: MUOS is the Mobile User Objective System.

Figure 2: Additional Months Needed since Program Start



Source: GAO analysis of DOD data.

Not all of DOD's space programs are facing the problems being experienced by GPS, NPOESS, and SBIRS. For example, the Navy's Mobile User Objective System (MUOS), another communications satellite program, is meeting cost and schedule goals. Further, as discussed later in this testimony, newer Air Force acquisition efforts such as the Transformational Satellite Communications System (TSAT) and Space Radar have been taking actions to ensure they can meet their cost and schedule goals, though their funding has been reduced in light of overall affordability of space acquisitions. These two efforts were highly complex and ambitious and were predicted to be the most expensive military satellite developments ever.

In addition, in December 2005, the Air Force was directed to begin efforts to develop competing capability in parallel with the SBIRS program; this

effort was previously known as the Alternative Infrared Satellite System (AIRSS). We reported in September 2007 that DOD had not positioned the AIRSS effort for success. DOD agreed, and revised the effort's development strategy to reflect best practices. The effort has a new name, the Third Generation Infrared Surveillance (Third Gen), and is now a follow on to the SBIRS program. The first sensor prototypes are expected later this month.

Lastly, our annual weapons system assessment this year will be reporting on challenges faced by the Evolved Expendable Launch Vehicle (EELV) program, as the two providers—Boeing and Lockheed Martin—undertake a joint venture that will provide U.S. government launches of medium- to heavy-lift rockets. The consolidation of production, engineering, test, and launch operations under the joint venture, called the United Launch Alliance or ULA, is expected to yield cost savings in the future, but when and how much remains unknown. ULA expects the consolidation to be nearly complete by the end of 2010, but there are preliminary indications that some elements of the consolidation are falling behind schedule.

Furthermore, the Air Force revised its acquisition and contracting strategy for EELV in 2005, which among other things increased program office oversight responsibilities. The change in contracting strategy created new data analysis activities for the program and expanded the types of expertise needed by the program office to utilize the new information provided by contractors. Despite its increased responsibilities, the program office is experiencing staff reductions and expects staffing vacancies to continue in the near term. The current military staff lacks some of the technical expertise needed to fully analyze contractor performance data now being collected under the new contracting strategy.

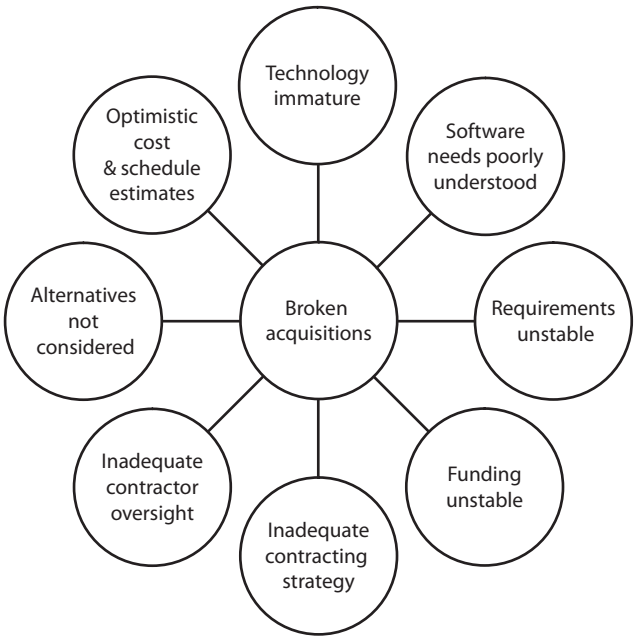
Causes of Acquisition Problems in Space Programs

Our work has identified a variety of reasons for this cost growth, most notably that weapons programs are incentivized to produce and use optimistic cost and schedule estimates in order to successfully compete for funding. We have also found that DOD starts its space programs too early, that is, before it has assurance that the capabilities it is pursuing can be achieved within available resources and time constraints.

We have also tied acquisition problems in space to inadequate contracting strategies; contract and program management weaknesses; the loss of technical expertise; capability gaps in the industrial base; tensions between labs that develop technologies for the future and current acquisition programs; divergent needs in users of space systems; diffuse

leadership; and other issues that have been well documented in DOD and GAO studies.

Figure 3: Key Underlying Problems



Source: GAO.

Many of these underlying issues affect the broader weapons portfolio as well, though we have reported that space programs are particularly affected by the wide disparity of users, who include DOD, the intelligence community, other federal agencies, and in some cases, other countries and U.S. business and citizens. Moreover, problematic implementation of an acquisition strategy in the 1990s, known as Total System Performance Responsibility, for space systems resulted in losses of technical expertise and weaknesses in contracting strategies that space programs are still dealing with the effects of.

Actions Needed to Address Space and Weapon Acquisition Problems

Over the past decade, we have identified best practices that DOD space programs can benefit from. DOD has taken a number of actions to address the problems that we have reported on. These include initiatives at the department level that will affect its major weapons programs, as well as changes in course within specific Air Force programs. Although these actions are a step in the right direction, additional leadership and support are still needed to ensure that reforms that DOD has begun will take hold.

Our work—which is largely based on best practices in the commercial sector—has recommended numerous actions that can be taken to address the problems we identified. Generally, we have recommended that DOD separate technology discovery from acquisition, follow an incremental path toward meeting user needs, match resources and requirements at program start, and use quantifiable data and demonstrable knowledge to make decisions to move to next phases. We have also identified practices related to cost estimating, program manager tenure, quality assurance, technology transition, and an array of other aspects of acquisition program management that space programs could benefit from. Table 1 highlights these practices; appendix II provides more detail.

Table 1: Highlights of Commercial Best Practices Identified in GAO Reports That Space Programs Can Benefit From

Before Undertaking New Programs
• Prioritize investments so that projects can be fully funded and it is clear where projects stand in relation to the overall portfolio.
• Follow an evolutionary path toward meeting market needs rather than attempting to satisfy all needs in a single step.
• Match requirements to resources—that is time, money, technology, and people—before undertaking a new development effort.
• Research and define requirements before programs are started and limit changes after they are started.
• Ensure cost estimates are complete, accurate, and updated regularly.
• Commit to fully fund projects before they begin.
• Ensure critical technologies are proven to work as intended before programs are started.
• Assign more ambitious technology development efforts to research departments until they are ready to be added to future generations (increments) of a product.
• Use systems engineering to close gaps between resources and requirements before launching the development process.
During Program Development
• Use quantifiable data and demonstrable knowledge to make go/no-go decisions, covering critical facets of the program such as cost, schedule, technology readiness, design readiness, production readiness, and relationships with suppliers.

• Do not allow development to proceed until certain thresholds are met—for example, a high proportion of engineering drawings completed or production processes under statistical control.
• Empower program managers to make decisions on the direction of the program and to resolve problems and implement solutions.
• Hold program managers accountable for their choices.
• Require program managers to stay with a project to its end.
• Hold suppliers accountable to deliver high-quality parts for their product through such activities as regular supplier audits and performance evaluations of quality and delivery, among other things.
• Encourage program managers to share bad news, and encourage collaboration and communication.

Source: GAO.

Constructive Actions Are Being Taken

DOD is attempting to implement some of these practices for its major weapons programs. For example, we recently reported that DOD released a strategy to enhance the role of program managers in carrying out its major weapon system acquisitions. As part of this strategy, DOD established a policy that requires formal agreements among program managers, their acquisition executives, and the user community intended to set forth common program goals. In addition, DOD plans a variety of actions to enhance development opportunities, provide more incentives, and arrange knowledge-sharing opportunities for its program managers. Within this strategy, the department also acknowledged that any actions taken to improve accountability must be based on a foundation from which program managers can launch and manage programs toward greater performance, and must include an overarching strategy and decision-making processes that prioritize programs based on a match between customer needs and available resources. DOD highlighted several initiatives that, if adopted and implemented properly, could provide such a foundation. Some of these include establishing an early decision gate to review proposed programs at the concept stage, testing portfolio management approaches in selected capability areas and using capital budgeting accounts for programs in development.

Additionally, as we reported previously, the Air Force adopted a "back to basics" approach for space designed to reduce technology risk and ensure programs were more executable. Specifically, for its TSAT and Space Radar acquisition efforts, the Air Force committed to delaying product development until critical technologies could be demonstrated to work in a relevant environment. This stood in sharp contrast to previous programs, started with immature technologies, such as NPOESS and SBIRS.

The Air Force also committed to deferring more ambitious technology efforts associated with these efforts to science and technology organizations until they are ready to be added to future increments. TSAT, for example, deferred the wide-field of view multi-access laser communication technology, and contributed about $16.7 million for "off-line" maturation of this technology that could be inserted into future increments. It 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, contributed toward their development by space and technology organizations. Further, both efforts have used systems engineers to help determine achievability of requirements.

In our experience, the Navy has tended to follow good acquisition practices for its space programs, especially in relation to keeping technology risks out of programs. The Navy's Mobile User Objective System (MUOS) is an example. Specifically, the MUOS acquisition effort began development with almost all of its critical technologies mature. Additionally, about 95 percent of design drawings had been completed at the critical design review milestone in March 2007. Since MUOS's development start in September 2004, the program has been meeting its overall cost and schedule goals, with the first satellite expected to become operational in March 2010.

Furthermore, the Air Force, U.S. Strategic Command, and other key organizations have made progress in implementing the Operationally Responsive Space (ORS) initiative. This initiative encompasses several separate endeavors with a goal to provide short-term tactical capabilities as well as identifying and implementing long-term technology and design solutions to reduce the cost and time of developing and delivering simpler satellites in greater numbers. ORS provides DOD with an opportunity to work outside the typical acquisition channels to more quickly and less expensively deliver these capabilities. In performing a review of ORS for this committee, we found that DOD has made progress in putting a program management structure in place for ORS as well as executing ORS-related research and development efforts, which include development of low-cost small satellites, common design techniques, and common interfaces.

Other parts of DOD are also moving towards space programs with less risk and that have a greater chance of being more successful. The Missile Defense Agency's Space Tracking and Surveillance System (STSS) program office is seeking an operational constellation that would be easier

to produce than originally envisioned for the constellation. The new development approach for the constellation would involve no technology breakthroughs or scientific discovery, and the program office wants to scale the system design so that it will only require only a 5- to 6-year build cycle.

DOD has also pushed back the decisions to start the TSAT and Space Radar acquisitions so it could reformulate their acquisition schedules and approaches to make them more affordable within DOD's overall space portfolio. For example, TSAT is currently being assessed by the Office of the Secretary of Defense (OSD) to better ensure that proposed future funding levels for TSAT are affordable in the near term. In the meantime, the program office is continuing to fund risk-reduction efforts between two separate contractors to further reduce overall risk in TSAT. Similarly, the Space Radar program office told us that it is adjusting its acquisition approach to better balance affordability through incremental evolution of the Space Radar capability. In both of these cases, DOD will likely be better positioned with acquisition programs that are more affordable and executable in terms of meeting cost, schedule, and performance goals.

Additional Actions Needed

The actions that the Air Force and OSD have been taking to address acquisition problems are good first steps. The back to basics policy and ORS, in particular, represent significant shifts in thinking about how space systems should be developed as well as commitment from senior leadership. But, there are still more, significant changes to processes, policies, and support needed to ensure reforms can take hold.

First, while DOD pilot initiatives related to portfolio management are targeted at addressing funding pressures, there has not been a real commitment to prioritizing investments across DOD. For the past several years, we have emphasized that DOD starts more space and 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. This year, significant cuts were made to several major space programs including TSAT, Space Radar, and STSS largely in light of the realization that new,

expensive programs were not affordable at a time when DOD was attempting to upgrade other capabilities and still contending with problematic programs like SBIRS. In the case of TSAT, resulting delays in capability could have a dramatic effect on other new programs, such as the Army's Future Combat System, which were counting on TSAT-like capabilities to enhance their performance.

Second, as we have testified before, 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. Several of our reviews of major space programs have cited shortages of personnel as a key challenge that increases risk for the program, specifically in technical areas. In addition, 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. We recognize that there are actions being taken to strengthen the space acquisition workforce, but we have not yet seen the condition get much better at the individual program office level.

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 previous testimonies, we pointed to limited opportunities and funding for space technologies, and the lack of low-cost launch vehicles. The ORS initiative is designed to help alleviate shortfalls in launch and testing resources, but one concern raised in interviews with launch providers was that there was still not enough investment being directed toward low-cost launch.

Furthermore, 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 acquisition efforts such as TSAT and Space Radar achieve a technology readiness level (TRL) 6 (that is, testing in a relevant environment) or higher for key technologies before being formally started—key decision point B (KDP B). Instead, the policy suggests that TRL 6 be achieved later—at preliminary decision review (KDP C) or soon after. In fact, the back to basics approach that was adopted by the Air Force has not been incorporated into DOD's space acquisition policy. 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 extended beyond their tenure.

Last, while DOD is planning many new practices that will provide program managers with more incentives, support and stability, the overall environment within which program managers perform their work is very difficult to change simply with policy initiatives. Policies similar to the one DOD issued in 2007 to increase accountability of program managers have existed for some time, but according to DOD and Air Force officials, they have not always been practiced. For example, while DOD policy provides for program managers of major defense acquisition programs to serve as close to a 4-year tenure as practicable,[1] many serve for only 2 years. One example is the SBIRS program, which has had six program managers in 12 years. In fact, our work has shown that rather than lengthy assignment periods between key milestones as suggested by best practices, many of the programs we have reviewed had multiple program managers within the same milestone.

Conclusions

In conclusion, senior leaders managing DOD's space portfolio are clearly working in a challenging environment. There are pressures to deliver new, transformational capabilities, but problematic older satellite programs continue to cost more than expected, constrain investment dollars, pose risks of capability caps, and thus require more time and attention from senior leaders than well-performing efforts. To best mitigate these

[1]DOD policy provides for the tenure of program managers of major defense acquisition programs to last until the completion of the major milestone that occurs closest in time to the date on which the person has served in the position for 4 years.

circumstances and put future programs on a better path, DOD needs to continue with the actions it has begun undertaken. However, these measures should be complemented by realistic estimating of what it will take to complete space programs, prioritizing programs for investment, and strengthening DOD acquisition policy for space. At the same time, DOD should ensure its ORS program is well-supported and focused on alleviating capability gaps as well as developing longer-term solutions for space programs. Taken together, such actions, with the support of Congress, should help senior leaders negotiate acquisitions in a challenging environment and ensure their commitments to reform can be sustained into the next administration.

Mr. Chairman, this concludes my statement. I will be happy to answer any questions that you have.

Appendix I: Scope and Methodology

In preparing this testimony, we relied on our body of work in space programs, including previously issued GAO reports on assessments of individual space programs, common problems affecting space system acquisitions, and the Department of Defense's (DOD) space acquisition policy. We relied on our best practices studies, which comment on the persistent problems affecting space acquisitions, the actions DOD has been taking to address these problems, and what remains to be done. We also relied on work performed in support of our 2008 annual weapons system assessment. The individual reviews were conducted in accordance with generally accepted government auditing standards. We conducted this performance audit from February 26 to March 4, 2008, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Commercial Best Practices Identified in GAO Reports from Which Space Programs Can Benefit

Practices That Can Reduce Acquisition Risk	
Prioritizing investments	Because there are more product ideas than there is funding to pursue them, successful organizations we have studied ensure that decisions to start new product developments fit within an investment strategy. The investment strategy determines project priority as well as providing a basis for trade-off decisions against competing projects. Program managers find their company's use of investment strategies helpful because it gives them confidence that their project has commitment from their organization and from their top leaders and managers, and clearly identifies where their project stands within the company's overall investment portfolio and funding priorities.
Evolutionary development	Organizations we have studied generally follow an evolutionary path toward meeting market needs rather than attempting to satisfy all needs in a single step. In effect, the companies evolve products, continuously improving their performance as new technologies and methods allow. These evolutionary improvements to products eventually result in full desired capability, but in multiple steps, delivering enhanced capability to the customer more quickly through a series of interim products. The approach permits program managers to focus more on design and manufacturing with a limited array of new content and technologies in a program.
Matching resources to requirements	The organizations we have studied are able to achieve their overall investment goals by matching requirements to resources—that is time, money, technology, and people—before undertaking a new development effort. Any gaps that existed are relatively small, and it is the program manager's job to quickly close them as development begins.
Defined requirements	As part of the effort to build a business case, requirements are researched and defined before programs start to ensure that they are achievable given available resources.
Cost estimating	Successful organizations ensure cost estimates are complete and accurate. They hold program managers accountable for their estimates. They also develop common templates and tools to support data gathering and analysis and maintain databases of historical cost, schedule, quality, test, and performance data. Cost estimates themselves are continually monitored and regularly updated through a series of numerous gates or milestone decisions that demand programs assess readiness and remaining risk within key sectors of the program as well as overall cost and schedule issues.
Funding	Once cost estimates are complete, the organization commits to fully funding projects before they begin.
Technologies	As part of the effort to build a business case, critical technologies are matured by the start of a program, that is, proven to work as intended. More ambitious technology development efforts are assigned to research departments until they are ready to be added to future generations (increments) of a product. In rare instances when less mature technologies are being pursued, the organization accepts and plans for the additional risk.
Systems engineering	Systems engineering is used to close gaps between resources and requirements before launching the development process. As our previous work has shown, requirements analysis, the first phase of any robust systems engineering regimen, is a process that enables the product developer to translate customer wants into specific product features for which requisite technological, software, engineering, and production capabilities can be identified.
Knowledge-driven development decisions	Once a new product development begins, program managers and senior leaders use quantifiable data and demonstrable knowledge to make go/no-go decisions. These cover critical facets of the program such as cost, schedule, technology readiness, design readiness, production readiness, and relationships with suppliers. Development is not allowed to proceed until certain thresholds are met, for example, a high proportion of engineering drawings completed or production processes under statistical control. Program managers themselves place high value on these requirements, as it ensures they are well positioned to move into subsequent phases and are less likely to encounter disruptive problems.

Program manager authority	The organizations we have studied empower program managers to make decisions on the direction of the program and to resolve problems and implement solutions. The program managers can make trade-offs among schedule, cost, and performance features, as long as they stay within the confines of the original business case. When the business case changes, senior leaders are brought in for consultation—at this point, they could become responsible for trade-off decisions.
Accountability	Program managers are held accountable for their choices. Sometimes this accountability is shared with the program team or senior leaders, or both. Sometimes, it resides solely with the program manager on the belief that the company provides the necessary levels of support. In all cases, the process itself clearly spells out what the program manager is accountable for—the specific cost, performance, schedule, and other goals that need to be achieved. In a recent study, we also noted that successful organizations hold their suppliers accountable to deliver high-quality parts for their product through such activities as regular supplier audits and performance evaluations of quality and delivery, among other things.
Program manager tenure	To further ensure accountability, program managers are also required to stay with a project to its end. Sometimes senior leaders are also required to stay. At the same time, program managers are incentivized to succeed. If they meet or exceed their goals, they receive substantial bonuses or salary increases, or both. Awards can also be obtained if the company as a whole meets larger objectives. In all cases, companies refrain from removing a program manager in the midst of a program. Instead, they chose first to assess whether more support is needed in terms of resources for the program or support and training for the program manager.
Other noteworthy practices	• Use of common tools and templates to support data gathering and analysis. • Implementation and adherence to formal lessons-learned processes. • Senior leaders stay committed to projects, mentor program managers, instill trust with their program managers, encourage program managers to share bad news, and encourage collaboration and communication.

Source: GAO.

Appendix III: Contact and Acknowledgments

For further information, please contact Cristina Chaplain at 202-512-4841or chaplainc@gao.gov. Individuals making contributions to this testimony include Art Gallegos, Greg Campbell, Claire Cyrnak, Anne Hobson, Rich Horiuchi, Sigrid McGinty, Angela Pleasants, Josie Sigl, and Alyssa Weir.

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