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

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MISSILE DEFENSE

Alternate Approaches to Space Tracking and Surveillance System Need to Be Considered

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GAO-03-597

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Highlights

Highlights of GAO-03-597, a report to Subcommittee on Strategic Forces, Senate Committee on Armed Services

Why GAO Did This Study

The Department of Defense's Missile Defense Agency (MDA) is developing a ballistic missile defense system designed to counter a wide spectrum of ballistic missile threats. A future element of this system is the Space Tracking and Surveillance System (STSS). STSS will eventually be composed of a constellation of satellites that will work together to detect and track missiles throughout all phases of their flight. GAO was asked to analyze MDA's approach to demonstrate capabilities for STSS.

What GAO Recommends

To optimize MDA's approach to demonstrating space-based missile tracking capabilities, GAO recommends that MDA focus spending to assessing what needs to be done to complete work on existing satellite components so that it has a reasonable basis for its cost and scheduling estimates. GAO also recommends that MDA assess alternatives to its current strategy that may offer opportunities to reduce risks and gain more knowledge. In commenting on a draft of this report, DOD partially concurred with two of our recommendations and concurred with two others. In its comments, DOD stated that it would not be prudent to delay launching satellites given the need to make overall ballistic missile defense system sensor assessments.

www.gao.gov/cgi-bin/getrpt?GAO-03-597.

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

What GAO Found

MDA purposely adopted a strategy that would evolve STSS over time rather than trying to make a big leap in its capability, deferring some requirements, and calling for competition in the development of the sensors aboard the satellite. Recent decisions, however, will limit MDA's ability to achieve its original goals as well as the knowledge that could be gained from its satellite demonstrations. Specifically:

- MDA recently reduced its efforts to sustain competition by eliminating funds set aside to procure an alternative satellite sensor from a competing contractor. It now plans to fund only efforts to design an alternative sensor. If it chooses to pursue STSS as part of the missile defense system, STSS may end up being more expensive in the future because MDA could be locked into a single contractor for the design and production of the large constellation of satellites.

- MDA decided to delay development and launch of new demonstrators in order to focus on completing development of two legacy satellites. MDA already knows that it would like to pursue different designs and different technologies for its target system given that the legacy satellites do not support a producible design. As a result, delaying work on the next generation of satellites will delay work that could offer a better basis from which MDA could build an operational capability.

- MDA's decision to launch in 2007 lacks important knowledge. MDA has established a launch date before it has completed its assessment of the working condition of the equipment it needs to assemble in order to finish building the two satellites it would like to launch. As a result, it does not know the extent of work that must be done or how much it will cost because the number components found to be in working or non-working order have not yet been identified.

MDA has considered pursuing alternate approaches, but all are constrained by the need to participate in 2006-2007 missile defense tests. These approaches include (1) launching the legacy satellites in 2008 instead of 2007 and (2) stopping work on the legacy satellites and focusing instead on developing new demonstrators. Both of these approaches would enable MDA to inject more competition into the STSS program, reduce scheduling risks, and demonstrate more capabilities. However, they also have drawbacks; primarily, they would delay MDA's ability to make informed trade-offs on missile defense sensors.

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Abbreviations

AEHF	Advanced Extremely High Frequency
DOD	Department of Defense
MDA	Missile Defense Agency
MSX	Midcourse Space Experiment
SBIRS	Space-Based Infrared System
STSS	Space Tracking and Surveillance System
TRL	Technology readiness level

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Accountability * Integrity * Reliability
United States General Accounting Office
Washington, DC 20548

May 23, 2003

The Honorable Wayne Allard
Chairman
The Honorable Bill Nelson
Ranking Minority Member
Strategic Forces Subcommittee
Committee on Armed Services
United States Senate

The Department of Defense's (DOD) Missile Defense Agency (MDA) is developing a ballistic missile defense system designed to counter a wide spectrum of ballistic missile threats. A future element of this system is the Space Tracking and Surveillance System (STSS), formerly known as Space-Based Infrared System-low (SBIRS-low). STSS will eventually be composed of a constellation of an as yet undefined number of satellites that will work together to detect and track missiles throughout all phases of their flight—from launch through midcourse and finally into reentry phase—and pass that information to other missile defense elements. The satellites will orbit earth at a low altitude, and they will carry infrared sensors and supporting subsystems based on sophisticated technologies. DOD currently expects to spend about $3.1 billion on STSS through 2009.

DOD has initiated several programs and spent several billion dollars over the past 2 decades trying to develop a system to track missiles from space, but has not yet demonstrated certain critical capabilities. While some capabilities have been demonstrated through computer modeling and simulations, DOD believes all of the capabilities need to be proven in space before a large number of satellites can be acquired.

Given the challenges associated with the program, you requested that we determine which capabilities still need to be demonstrated for STSS, analyze MDA's approach for doing so, and identify alternative approaches for demonstrating the capabilities that may offer better outcomes.

Results in Brief

To be able to track missiles from space, MDA still needs to demonstrate that:

- tracking information can be passed between sensors within a satellite;
- tracking information can be passed between satellites;
- missiles can be tracked in the midcourse phase of their flight;
- data from two satellites at different locations and angles can be successfully integrated, processed, and analyzed;
- data from the satellites can be successfully passed to other space-, air-, land-, and sea-based platforms;
- satellites can operate and make some decisions autonomously; and
- satellites can discriminate warheads from decoys.

Achieving these capabilities is technically challenging given the difficulties associated with tracking cool objects against the cold background of space as well as the harsh space environment and the short time frames required to successfully identify, track, and intercept an incoming warhead. Yet MDA believes most of these capabilities are needed to have a system that can play a useful role in the overall missile defense system. Two capabilities—autonomous operation and discrimination—do not need to be demonstrated as quickly, but they would significantly enhance a space-based missile tracking system.

MDA purposely adopted a strategy that would evolve STSS over time rather than trying to make a big leap in capability, as had been the strategy in the past. It deferred requirements that were too technically challenging or beyond its immediate missile defense mission. MDA also called for competition in the development and production of the sensors aboard the satellite that would detect a missile launch (acquisition sensor) and track a missile flight (tracking sensor) so that costs could be contained in the future and the best technical solution could be pursued. In addition, MDA opted to launch "demonstration" satellites before developing and producing them in large numbers. This strategy helps to reduce risks because it ensures technology is sufficiently mature and capabilities have been demonstrated before a greater investment is made.

Recent decisions, however, will limit MDA's ability to achieve its original goals as well as the knowledge that could be gained from its satellite demonstrations.

- In order to take part in broader missile defense tests scheduled for 2006 and 2007, MDA decided to retrieve satellites and ground components that were partially built in a previous effort and put into storage 4 years ago, complete the assembly of this equipment, and launch two satellites in 2007. Using these satellites in the 2007 test will help MDA to make trade-off decisions among missile defense systems. To be able to launch both satellites in 2007, however, MDA eliminated its plans to have two contractors compete in the production of satellite acquisition sensors. Instead, the program office now plans to fund the separate development of an alternative sensor design, but if the funds available do not allow for a meaningful design effort, it will be canceled. By choosing this approach, overall program costs could be higher because MDA could be locked in to using a single contractor for the production of a larger constellation of satellites.

- In order to complete the development of the legacy satellites for launch in 2007, MDA also decided to delay the development and launching of new demonstrators. While MDA could learn a great deal about missile tracking capabilities from the legacy satellites, MDA already knows that it would like to pursue different designs and different technologies for its target system given that the legacy satellites do not support a producible design. As a result, delaying work on the next generation of satellites will delay work that could offer a better basis from which MDA could build operational capability.

- MDA's decision to launch in 2007 was based on limited knowledge. MDA established a launch date before it had completed its assessment of the working condition of the equipment it needs to assemble in order to finish building the two satellites it would like to launch. As a result, it does not know the extent of work that must be done or how much it will cost. More specifically, while MDA may know the cost to test the satellite component hardware, it does not know how many components will be found in nonworking order, nor the costs to fix these components. Moreover, MDA has identified a number of activities that will pose scheduling risks, such as (1) completing development of software for the ground segment and the infrared sensor software and (2) integrating the payload hardware and software. Though MDA has set aside funds to cover the risks, it will not have the knowledge it needs to really know if it can meet its target date until early 2004—when its assessment of the working condition of the existing equipment will be complete.

MDA has considered alternative approaches, but has not pursued any that would not allow STSS to participate in 2006-2007 testing. Alternative approaches not considered include (1) launching the legacy satellites in 2008 instead of 2007, which would allow another year to complete development of the legacy satellites and procure a sensor of different design, and (2) stopping work on the legacy satellites and focusing instead on developing new technology, which would enable MDA to demonstrate and eventually field an operational capability sooner than its current approach. Both of these approaches would enable MDA to inject more competition into the STSS program, reduce scheduling risks, and demonstrate more capabilities. However, they also have drawbacks; primarily, they would delay MDA's ability to make informed trade-offs among missile defense systems.

We are making recommendations in this report that are intended to guide MDA in selecting the best approach for demonstrating missile tracking capabilities from space. DOD partially concurred with two of our recommendations and concurred with two others. In its comments, DOD stated that it would not be prudent to delay launching satellites given the need to make overall ballistic missile defense system sensor assessments.

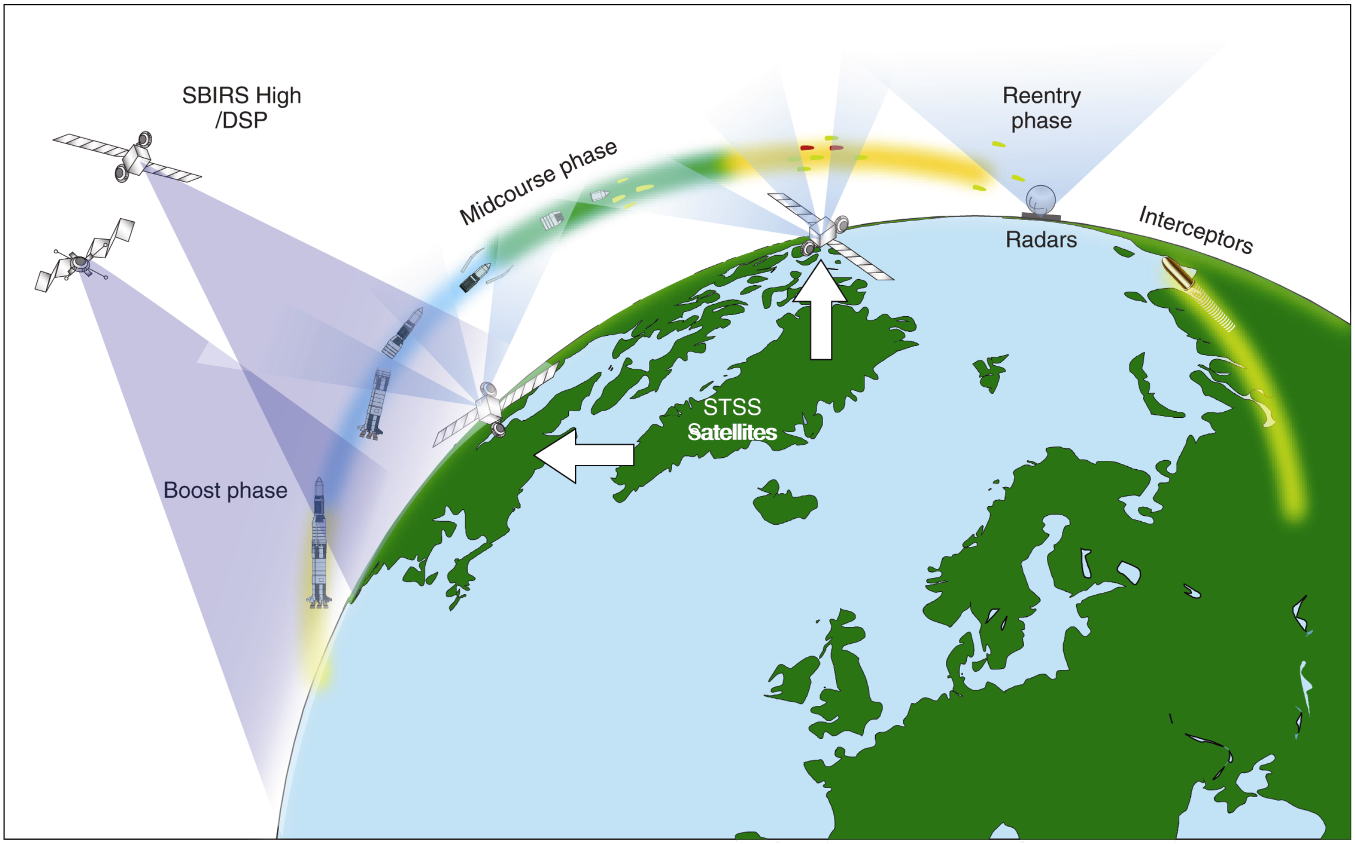
Background

DOD is developing a ballistic missile defense system designed, over time, to counter a wide spectrum of ballistic missile threats. It will rely on space and ground-based systems to detect and track missiles; ground-, sea-, and air-based systems to intercept missiles in all stages of flight (which includes boost, midcourse, and reentry); and an overarching command and control system to plan and execute actions to counter enemy attacks.

STSS will serve as the satellite network that will detect and track missiles throughout their flight and relay necessary cuing data to other elements in the missile defense system. The satellites will orbit the earth at low altitudes in order to allow for better missile viewing angles and high resolution.[1] Each satellite will contain two infrared sensors—one to watch for bright missile plumes during the boost phase (acquisition sensor) and one to follow the missile through midcourse and reentry (tracking sensor). To provide for worldwide coverage, STSS would consist of a large constellation of satellites (between 21 and 28) as well as a supporting ground infrastructure. MDA has decided that significantly fewer satellites could be used to provide a meaningful capability based on the contributions and configurations of the other elements in MDA's ballistic missile defense system. However, at this time MDA has not decided on the number of satellites that it plans to acquire.

[1] The satellites will operate about 1,350 kilometers above the earth. By comparison, satellites in geo-synchronous orbit operate at about 36,000 kilometers.

Figure 1: Notional Configuration of STSS and the Ballistic Missile Defense System



Source: Missile Defense Agency.

History of Problems in Developing a Missile Tracking System

DOD has had considerable difficulty for almost 20 years in developing a space-based missile tracking capability. Though it has spent several billion dollars through a series of development and acquisition programs since 1984, it has not launched a single satellite or demonstrated any space-based missile tracking capabilities from space using technologies similar to those to be used by STSS. This is partly due to the technical challenges associated with building a system like STSS. For example, the satellites' sensors need to be able to track missiles in the midcourse phase of their flight, when missiles can no longer be easily detected by their bright plume. To do this, detection sensors must be cooled to very low temperatures for very long periods of time to detect and track a cool warhead against the cold background of space. In addition, systems aboard the satellite and on the ground must send that data to other missile defense systems quickly enough to allow them to target and destroy incoming missiles and they must work under harsh environmental conditions of space. This requires fast data processing and communication links as well as materials that can withstand radiation and cold temperatures.

Within this environment of significant technical challenges, DOD has not yet established a program that it could execute. As we have reported[2] over the years, DOD and the Air Force did not relax rigid requirements to more closely match technical capabilities that were achievable. Program baselines were set based on artificial time and/or money constraints. Over time, it became apparent that the lack of knowledge of program challenges had led to overly optimistic schedules and budgets that were funded at less than what was needed. Attempts to stay on schedule by approving critical milestones without meeting program criteria resulted in higher costs and more slips in technology development efforts. For example, our 1997 and 2001 reviews of DOD's $1.7 billion SBIRS-low program, STSS' immediate predecessor, showed that the program would enter the product development phase with critical technologies that were immature and with optimistic deployment schedules. In order to reduce costs, schedule, performance, and technical risks, we recommended that DOD restructure the program and analyze alternatives to satisfy critical ballistic missile defense requirements in case SBIRS-low could not be deployed according to the original acquisition strategy. DOD eventually restructured the SBIRS-low program because of the cost and scheduling problems, and it put the equipment it had partially built into storage. Table 1 further highlights problems affecting space-based missile tracking programs since 1990.

[2]U.S. General Accounting Office, *Defense Acquisitions: Space-Based Infrared System-low at Risk of Missing Initial Deployment Date*, GAO-01-6 (Washington, D.C.: Feb. 28, 2001) and *National Missile Defense: Risk and Funding Implications for the Space-Based Infrared Low Component* GAO/NSIAD-97-16 (Washington, D.C.: Feb. 25, 1997).

Table 1: DOD's Attempts to Demonstrate or Field Space-Based Missile Tracking Capabilities and Their Outcomes

Program start	Program title	Purpose/mission	Problems	Outcome
1990	Brilliant Eyes	Development program. Acquire and track missiles during late boost and midcourse phases and discriminate warheads from decoys.	Program funding was sharply reduced for Brilliant Eyes and other space-based systems. The lack of funding hindered the program from meeting its objectives.	No demonstration satellites launched. The Congress transferred the program from the Ballistic Missile Defense Organization (now MDA) to the Air Force in 1993.
1993	Space and Missile Tracking System	Development program. Acquire and track missiles and discriminate warheads from decoys during post-boost phases.	Technical, funding, and management problems delayed the scheduled launch of two demonstration satellites.	No demonstration satellites were launched. In 1994, DOD consolidated its infrared space requirements and selected the Space-Based Infrared System as a "system of systems" approach. Program was terminated.
1996	Space-Based Infrared System-low	Acquisition program. Support national and theater missile defense by tracking missiles over their entire flights and discriminating warheads from decoys in supporting the missile defense mission.	Negative trends in cost, schedule, and performance estimates for the SBIRS-low program resulted in DOD taking it off an acquisition track, and returning it to a sustained and deliberate technology development track.	Satellite demonstration effort canceled and the program development risk reduction phase restructured. Program subsequently transferred from the Air Force to MDA.
2002	Space Tracking and Surveillance System	Development program. Acquire, detect, and track ballistic missiles through a series of increasingly capable and interoperable satellites and ground infrastructure.	Not applicable. Program has just begun.	Not applicable. Program has just begun.

Source: GAO.

Congressional Actions

In October 2000, the Congress directed the Air Force to transfer the program to the Ballistic Missile Defense Organization (now MDA). The Senate Committee on Armed Services directed a study of alternatives to SBIRS-low as part of the fiscal year 2002 budget authorization process. These alternatives were to include ground-, sea-, and air-based sensors such as radar systems. MDA is currently expected to complete this study in 2003. The Committee directed that the report contain (1) an analysis of essential national missile defense requirements that SBIRS-low would fulfill and what alternative systems could also fulfill such requirements; (2) a quantitative assessment of national missile defense system performance without SBIRS-low or any alternative system; (3) a quantitative assessment of the national missile defense system performance with SBIRS-low and with each alternative system; (4) yearly cost estimates for SBIRS-low and of each alternative system beginning with fiscal year 2002, including all previous fiscal years and all fiscal years through deployment of a fully operational system; (5) a risk assessment of SBIRS-low and of each alternative system; and (6) a qualitative assessment of the strengths and weaknesses of SBIRS-low and each alternative system.

In addition, the Congress denied the $385 million DOD requested for the program for fiscal year 2002, but it provided $250 million for a satellite sensor technology effort, of which STSS would be a part. MDA was also directed by the House Appropriations Committee to take STSS out of the acquisition process and manage it as a sustained and deliberate technology development effort.

Capabilities Remain to Be Proven through Testing in Space

DOD believes the following capabilities are needed to have a space-based missile tracking system that can play a useful role in the overall missile defense system. These capabilities have not yet been demonstrated in space, although DOD has had successes in demonstrating some related on-orbit capabilities through experimental satellites.

- *Acquisition-to-track hand over*:
  The ability of one satellite to detect or "acquire" a missile launch and to transmit this data to its internal tracking sensor. The tracking sensor would then continue tracking the missile after the acquisition sensor has completed its detection function.

- *Satellite-to-satellite hand over*:
  The ability of two or more low-earth orbiting satellites to pass along missile tracking data through two-way cross-links. This is a challenging capability to demonstrate given the low orbits and flight path geometry of the satellites. DOD has no military flight experience linking two or more low-earth orbiting satellites through two-way cross-links. The Iridium System, a private network of low orbiting satellites, can establish cross-links, but it does not have the timeliness and low bit error rate requirement of STSS. Further, only voice data (versus analytical data) is transmitted from one fixed user to another (in comparison with a moving satellite's speed), there are ground stations to assist in the process, and dropped links are not mission-critical as they would be for STSS. DOD's Milstar communication satellites use cross-links, but they operate in a much higher orbit in fixed positions

relative to one another, so this experience also does not translate directly to STSS.[3]

- *Midcourse tracking*:
  The ability to (1) accurately track cool objects from thousands of kilometers away, which depends on sensitive sensors and accurate pointing capabilities, and (2) stereo tracking, which requires the capability to transfer and fuse data from multiple sensors in space while viewing the target missile from differing ranges and angles. Midcourse stereo tracking (two satellites reporting tracking information on one missile's flight) is more desirable because it results in more precise information on the missile's location. Some missile tracking capabilities were demonstrated during DOD's 1996 Midcourse Space Experiment (MSX), which launched a satellite that collected data on a missile launch using optical sensors. However, this satellite did not conduct the same kind of functions that STSS would be required to perform, nor did it demonstrate all of the same technologies.[4]

- *Dual mission data processing*:
  The ability to process and analyze data from two satellites that view one event from two different angles and locations.

- *Missile defense system integration*:
  The ability to transmit and fuse STSS data with data provided by other space-, air, land-, and sea-based sensors—including legacy and emerging systems belonging to DOD and U.S. allies—and to use the results effectively in missile defense operations.

[3] The Milstar satellite communications system provides secure, jam resistant, worldwide communications to meet essential wartime requirements for high-priority military users.

[4] The MSX spacecraft had 5 primary sensors with a total of 11 optical sensors, precisely aligned so that activity of various targets can be viewed simultaneously with multiple sensors. Four months after its launch, MSX successfully observed and tracked a 20-minute ballistic missile test flight. MSX collected more than 800 seconds of high-quality data on this missile test. MSX tracked missiles by relying on a sensor that was cooled using a passive technique whereas the sensor on-board STSS is to rely on an active and mechanical approach.

There are two capabilities that DOD believes do not need to be demonstrated as quickly, but they would significantly enhance a space-based missile tracking system. They are:

- *Autonomous operation*:
  The ability of each satellite to operate as a self-contained unit and to perform some decision-making functions before downlinking the results. Because satellites will be moving at speeds of more than 15,000 mph relative to one another and across different orbital planes, as well as moving in and out of the target missile's range, calculations and decisions must be made and data passed between sensors and satellites within seconds. This is a desired future capability.

- *Discrimination*:
  Countering more advanced and sophisticated threats will require DOD to be able to detect and track multiple objects and differentiate the threatening warhead from decoys. Given technical challenges, DOD deferred plans to achieve this capability for STSS. However, it plans to achieve this capability for the missile defense system as a whole before 2015.

MDA's Approach to Demonstrate STSS Capabilities

MDA could demonstrate space-based missile tracking capabilities by either continuing earlier efforts or developing new satellites. At the beginning of the STSS program, MDA chose to combine both, focusing first on assembling and launching existing satellites and second on developing new satellites. MDA also sought to avoid the mistakes made in previous space-based missile tracking efforts by adopting a more flexible, knowledge-based development strategy and calling for competition in aspects of satellite development. Recently, MDA decided to launch the first two demonstration satellites in 2007 and launch the first next generation satellite in 2011.

Potential Approaches Available to MDA

MDA could demonstrate space-based missile tracking capabilities by either relying on legacy satellites or developing new satellites or a combination of both.[5] Specifically, MDA could complete work on satellite and ground components that were partially built during the Air Force's effort (SBIRS-low) and put into storage 4 years ago. The satellites were intended to serve as precursors to a constellation of operational satellites. The capabilities that were built into the legacy components include acquisition to track hand over, satellite-to-satellite hand over, stereo midcourse tracking, and a limited capability to discriminate the types of missiles launched.

MDA could also develop more capable and more robust satellites based on newer technology. The satellites could be equipped with more accurate sensors, faster data processing capacity, and longer lasting components. The new satellites could also be designed to include features not available to the existing satellites, such as adding an autonomous operations capability. As with any approach, a ground segment capable of supporting future demonstration satellites would be needed.

At the beginning of the STSS program, MDA decided it would pursue a combination of both approaches. Specifically, it would complete the assembly of satellite and ground components already in storage and launch them to coincide with broader missile defense tests that would take place in 2006-2007. This would allow MDA to establish a basis for making trade-off decisions between space-, sea-, and air-based missile defense sensors (for example, radar systems). MDA also decided to develop a newer design, including more robust technologies envisioned for the target system.

[5] MDA could supplement both approaches by incorporating knowledge from the results of tests of other satellites with missile tracking capabilities, though there are limitations to the knowledge that could be applied to STSS. These include past tests such as the 1996 MSX test discussed earlier and upcoming tests such as one MDA will be conducting in the near future with a satellite build by Spectrum Astro to collect infrared data on intercontinental ballistic missiles during the boost phase. Data to be collected under the contract will be used to verify MDA's future selection of a kill vehicle and tracking sensors for missile engagements during the boost and ascent phases. The data will also build the foundation for developing guidance and homing algorithms for MDA's ground-based, boost-, and ascent-phase interceptors. The satellite will be designed for an on-orbit lifetime of at least 1 year, with the objective of a 2-year on-orbit life, and is planned for launch into low earth orbit in June 2004.

MDA Sought to Avoid Past Mistakes with a More Flexible Strategy

At the onset of STSS, MDA adopted a more flexible product development approach that would maximize competition. For example:

- As with all missile defense elements, MDA called for a strategy that would evolve STSS over time, rather than trying to make a big leap in its capability. This means that new technology would be incorporated into subsequent increments so that the product's capability would evolve over time. Our work has shown this approach reduces risk because it introduces less new content and technology into a program's design and development effort. An evolutionary strategy also enables developers to deliver a series of interim capabilities to the customer more quickly.

- Under its evolutionary approach, MDA deferred requirements that were too technically challenging or beyond its immediate missile defense mission. For example, MDA deferred the requirement for a discrimination capability and has not decided whether the next STSS development block will perform discrimination. It also deferred requirements for STSS missions beyond missile defense, including technical intelligence and battlespace characterization. Instead, these missions would be addressed only to the extent that inherent or residual capabilities could satisfy them. Our work has also shown that programs are more successful when customers are willing to defer requirements that demand more time or unproven technologies to succeeding versions of the product. In essence, this flexibility helps to ensure the product can be developed within available resources.[6]

- MDA called for competition in the development and production of the sensors onboard the satellite that would detect a missile launch (acquisition sensor) and track a missile flight (tracking sensor) so that costs could be contained in the future and the best technical solution could be pursued. Specifically, one satellite would host sensors from one subcontractor and another satellite would host sensors from a competing subcontractor. Since contractors may use different materials to build the infrared sensors, different detector technologies, and different production methods, performance could vary considerably. In describing the STSS approach, the Director of MDA stated that injecting competition into sensor development was

[6] U.S. General Accounting Office, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes* GAO-01-288 (Washington, D.C.: March 8, 2001).

necessary to reduce risks, particularly since MDA planned to award a single contract to a prime contractor.

- MDA decided to fly "demonstration" satellites before developing and producing them in larger numbers. This practice enables MDA to see how components and subsystems work together as a system in a realistic environment before a greater investment of procurement funds is made. Our work has also shown this to be a practice used by successful programs.[7]

Recent Decisions on STSS Strategy Provide More Time to Learn from First Two Demonstration Satellites

After MDA laid the foundation for approaching STSS, it decided to complete development and testing of two satellites and ground station equipment it acquired under SBIRS-low; launch the first satellite in 2006 and the second in 2007. Then, beginning in 2003, MDA would pursue development of new demonstration satellites with more robust technology and launch them beginning in 2010. It would launch and demonstrate a series of satellites until it arrived at a design that could be used to support a bigger constellation of satellites for the missile defense system. The Air Force signed a contract with Northrop Grumman in August 2002 valued at $868.7 million to (1) design, manufacture, and deliver the satellites and test and check out the satellites on orbit; (2) develop a ground system; and (3) conduct preliminary engineering analyses on the new demonstration satellites.

In late 2002, MDA made significant changes to its strategy after it decided to allocate less funding to the STSS program in order to fund other missile defense elements. Specifically, it decided to continue the STSS program by integrating and testing the existing satellites, but launch them in tandem in 2007 instead of sequentially in 2006 and 2007. Work on a single new satellite would begin in 2003, instead of a pair of satellites as had been originally planned. The program office plans to define the capabilities for the follow-on satellite in mid-2003 and until then, the design, technologies, and specifications for the new satellite will not be known. Work on the new satellite will be stretched out, but MDA hopes to launch the new satellite in 2011, only 1 year later than planned. The STSS program office has programmed about $1 billion to complete work, launch, and operate

[7] U.S. General Accounting Office, *Best Practices: A More Constructive Test Approach Is Key to Better Weapon System Outcomes*, GAO/NSIAD-00-199 (Washington, D.C.: July 31, 2000).

the legacy satellites and $1.3 billion for fiscal years 2004 through 2009 for work on the new, follow-on satellite effort.

This change has some benefits in that certain capabilities could be demonstrated over a longer on-orbit period of time. Under the original strategy, satellite-to-satellite hand over, midcourse tracking, and dual mission data processing would only have been demonstrated for about 8 months since this would be the amount of time that the satellites would be fully operational together. By contrast, under the new strategy, these same capabilities could be demonstrated for as long as 2 years since the satellites will be launched in tandem. Moreover, under the previous strategy, only partial integration with the missile defense test bed could be demonstrated because data from the 2006 satellite would be processed off line. There could also be delays in processing data because the ground segment may not be fully integrated with the missile defense test bed until 2008. (The completion of ground connectivity between the STSS ground station and the missile defense system does not yet have a definitive schedule.) Since satellites are expected to be fully operable for 2 years, integration could be demonstrated during the latter part of the second satellite's life. But this would limit the extent to which MDA can assess STSS functions in the context of the overall system.

MDA is using tools to measure the maturity of critical technologies on the legacy satellites. Specifically, as the table below shows, MDA has assessed critical technologies for the legacy satellites using technology readiness levels (TRL). TRLs measure maturity along a scale of one to nine. TRL 1 characterizes the least mature technologies representing the point where scientific research begins to be translated into technologies basic properties. A TRL 9 represents the most mature, an actual application of the technologies in its final form under mission conditions. DOD guidance states that a TRL 7, which means the system has been demonstrated in an operational environment, is desired but that a TRL 6 represents acceptable risk for a space-related technology to enter product development. At a TRL 6, the subsystem or system has been demonstrated in a relevant environment. MDA expects critical technologies on the legacy satellites to be at a TRL 6 by June 2006. Moving from a TRL 5 to a TRL 6 to a TRL 7 represents a significant investment.

Table 2: TRL Assessment for Critical Technologies for Legacy Satellites

Technology area	TRL at fall 2002	Projected TRL at June 2006
Acquisition sensor	5	6
Tracking sensor	5	6
Single-stage cryocooler	5	6
Two-stage cryocooler	5	6
Satellite communication cross-links	6	6
On-board processor	6	6

Source: Air Force.

Table 3 highlights the main activities that must be done to complete work on the legacy satellites. MDA developed a schedule to support the original plan to launch in 2006 and 2007. It is in the process of establishing the dates that these activities would need to be done by in order to support the new tandem launch date of 2007.

Table 3: Work That Must Be Done on Legacy Satellites

Area	Work
Systems engineering and assessment	This includes validating specifications and configurations, establishing performance baselines, and assessing and integrating ground test data analyses. Work under this component also includes analyzing the performance of the satellites after launch.
Sensor development	This includes redesign efforts to the track sensor, along with assembly, and integration and test. The track sensor is on the critical path, and all work on this sensor needs to be completed in time to allow for integration onto the spacecraft. Under the original strategy, this meant the work should be done by July 2004. While work progresses on the sensor, software in support of the sensor will also be developed.
Spacecraft development	Efforts include developing the spacecraft test bed, harness, and software. Activities also include integration and test of the satellite before and after launch. Satellite integration and test is on the critical path and was to begin in February 2005 and be completed in November 2005 under the original strategy. At that time the satellite will be shipped for launch.
Ground segment development	Activities include designing and developing the ground systems, installing hardware in the ground facilities, and integrating and testing the systems. The ground segment will involve more software development than the other satellite segments. Also, operational procedures will be developed and training on ground systems is to take place.
System test and operations planning	This includes developing the system and flight test plans. Readiness reviews are to be complete by September 2005, under the original strategy. Other activities planned include training and rehearsals, operations crew test training, test operations, and site and satellite operations.

Source: Air Force Space and Missile Systems Center.

MDA May Not Be Able to Achieve Original Goals With Its Revised Strategy

MDA's approach to STSS will limit its ability to achieve its original goals for the program as well as the knowledge that could be gained from its satellite demonstrations.

- First, the program office decided to forego pursuing production of on-board sensors from competing contractors, as originally planned. As a result, MDA will not have the ability to benefit from competition.
- Second, to stay within its budget, the STSS program office made a trade-off decision to develop only one new satellite rather than two and to delay work on the new satellite. This decision will delay MDA's ability to learn about new satellite designs and technologies needed for an operational capability.
- Third, MDA's decision to launch in 2007 is not knowledge-based. At this point, it does not know the extent of work that needs be done on the legacy satellites since it has not completed its assessment of the condition of the components that have been in storage for 4 years. Moreover, it is uncertain as to whether some of the activities it does know it must undertake in order to integrate and test legacy satellite systems can be completed in time for the 2007 launch. To its credit, MDA has set aside extra funds for tasks that present particular scheduling risk. But until it knows more about the working condition of the satellite hardware and software, it cannot be sure of its ability to deliver on time.

Limiting Competition Could Increase Long-term Costs and Risks

MDA's decision to tentatively fund the design, but not the production, of a sensor from a competing contractor as part of the first effort will potentially increase long-term costs and risks. Specifically, it will preclude MDA from gaining knowledge about competing sensors and selecting the one that offers the best capability. Moreover, it precludes another contractor from gaining experience in building infrared sensors, potentially hampering MDA's ability to compete work in the future and making the system more costly over the long term.

We recently reported, for example, that DOD's effort to develop a new generation of communication satellites (the Advanced Extremely High Frequency (AEHF) satellite program) incurred significant cost and scheduling problems partly because of its decision to consolidate contractors into one team. In commenting on our findings, DOD admitted that its major failing with the program was the acceptance of this team's proposed approach of an overly optimistic performance, schedule, and profit baseline. Part of the reason DOD chose to limit competition was to launch a new satellite as soon as possible. In hindsight, it recognized that this worsened the situation because the contracting team could not follow through on its original promises, and DOD had nowhere else to turn to for a better solution.

Also, under the SBIRS-low program, the Air Force awarded a contract in 1995 for the development of two technology demonstration satellites to the same contractor. It later recognized the need for competition for the demonstration to lower costs and reduce schedule and technical risks because otherwise only one contractor would gain the experience and knowledge needed to build the full constellation of satellites. To prevent similar problems, in 1996, the Air Force requested offers for an alternative system concept from one or more contractors to demonstrate and validate critical design issues. The goal of this effort was to stimulate competition, resolve key technical and production risks, and create a plan to ensure SBIRS-low deployment schedules can be executed.

Delaying Work on New Design Will Delay Work Toward Operational Capability

The decision to launch the two existing satellites in tandem in 2007, instead of 2006 and 2007, will provide MDA with more time to assess the working condition of the satellites' components and to complete work on assembling the satellites. It will also offer more time for MDA to assess capabilities such as satellite-to-satellite hand over since the two satellites will be operating as a pair for a longer period of time. However, MDA already knows that it would like to pursue different designs and different technologies for its target system as the legacy system is based on technologies that are more than a decade old. Its recent decision to delay work on a new satellite will merely delay the opportunity to learn more about a design that could offer a future operational capability and a better basis for making trade-off decisions among missile defense sensors. In fact, for the next few years, resources will largely be devoted to work on the legacy satellites versus the new satellites. In 2004, about 92 percent of STSS funds will go to the legacy satellites versus 8 percent to the new ones.

Decision to Launch in 2007 Is Not Knowledge-Based

MDA has not yet completed its assessment of the working condition of satellite hardware and software, so it does not know the full extent of work that needs to be done on the legacy satellites. Moreover, MDA officials recognize that through the process of testing, assembling, and integrating the hardware and software components, unforeseen problems could arise that may make it more difficult to complete the satellites in time for the 2007 launch. These problems could include completing ground segment software and the infrared sensor software as well as integrating payload hardware and software. Table 4 highlights these and other activities MDA believes have costs and scheduling risks.

MDA and the STSS program office have set aside $47.2 million in funding to address these potential problems and also drafted risk mitigation plans, which are to be updated in 2003. This money will be used for independent review teams that can help the program office assess what work needs to be done as well as other resources (for example, more personnel) and activities (for example, contingency planning) needed to prevent scheduling delays. The program office has also identified the need for $26 million in additional funding to more fully address the risks involved with hardware and software issues, which has been funded from the contractor's management reserves. Program officials said that if the costs prove to be too high after the assessment of the working condition of the satellites, they will terminate the legacy effort and move onto the new demonstrators.

Table 4: Potential Risks for the Current STSS Strategy

Risk		Description	Potential effect	Risk mitigation funding (millions)
1.	Condition of the satellite hardware and software	Hardware and software must be tested to determine their working condition after being in storage for 4 years.	If hardware and software do not test as expected, launch delays could be significant, particularly for the first launch.	$ 9.9
2.	Completion of the ground segment software	The schedule to design, develop, and test the ground software is aggressive and requires these tasks to be done concurrently. Also, the requirements for the ground segment software were significantly increased.	If the 31-month schedule does not play out, software costs could increase, and the ground segment might not meet the scheduled launches for the existing satellites.	$ 5.0
3.	Uncertainty of the STSS Block 2006 performance	Integrated flight test scenarios and targets have not been defined or analyzed; STSS performance analyses are incomplete; and infrared sensor tests will not be completed for 2 more years.	If problems surface, costs could increase, schedules could be delayed, and STSS could provide less on-orbit performance and utility for the ballistic missile defense system test bed.	$14.1
4.	Completion of the infrared sensor software	Software requirements are undefined and software interface issues could require software redesign.	If the issues are not resolved, costs could increase, and payload testing and delivery could be delayed, which would delay the launch(es).	$14.6
5.	Integration of the payload hardware and software	Many integration and test activities conducted in serial must be successful. The schedule has little slack for test equipment or component failures.	If this work does not proceed as planned, costs would increase and delivery of the payloads would be late, which could delay the launch(es).	$ 2.9
6.	Thermal modifications to the infrared sensor payload	Thermal performance and its impact on long-wave infrared performance will not be known until the sensor has been built and tested.	If lower than expected thermal performance occurs, costs would increase and satellite-tracking capabilities would be reduced.	$ 0.8

Source: Air Force Space and Missile Systems Center.

Risk 1: Working Condition of Satellite Hardware and Software Has Not Been Assessed

MDA will not know the extent of work needed on satellite hardware and software until late 2004. When the Air Force canceled the flight demonstration system satellites in 1999, the development of hardware and software was not completed, and the problem areas that had been identified had not been fully documented, leaving a knowledge gap that will need to be closed before MDA proceeds with further development. The legacy components have been retrieved from storage; however, they still need to be tested to determine their working condition. In November 2002, testing started on the first satellite's payload components (including the acquisition and tracking sensors). As part of the SBIRS-low effort, the tracking sensor was tested last year and found to be in working order. This testing should be completed in October 2003. The satellite's spacecraft hardware has been visually inspected, and it will be tested from May 2003 to September 2003. The spacecraft hardware for the second satellite has also been visually inspected. Under MDA's schedule for its original strategy, testing for the second satellite was planned for September 2003 through November 2003, and payload testing was planned for December 2003 to August 2004.

Risk 2: Time for Completing Ground Segment Software May Be Insufficient

MDA expects that many tasks needed to design, develop, and test the ground software will need to be done concurrently to meet the new schedule. The effort will also be complicated by the fact that the requirements for the ground software significantly changed in 2002, at the time of the program restructure. Specifically, the software will need to support the future generation and eventual larger constellation of satellites, whereas the ground software associated with the legacy satellites was originally supposed to support two demonstration satellites. Program officials acknowledged that they would not have a high level of confidence in the software cost estimate or software schedule until the preliminary design review for the software occurred, which occurred in March 2003.

Risk 3: Critical Tests for Assessing Whether Performance Is Acceptable Will Not Be Done Until Shortly Before Launch Preparations

Critical tests for assessing preflight performance will not be done and analyzed until MDA is close to the point where it needs to begin launch preparations. For example, integrated flight test scenarios and targets have not yet been defined or analyzed and, as originally scheduled, infrared sensor performance tests will not be completed until mid-calendar year 2005—a few months before MDA would need to stop work on the satellites and begin launch preparations. Program officials pointed to other factors that will make preparing for performance tests difficult, including the fact that MDA had not yet identified interfaces with other missile defense elements or integrated test plans and schedules.

Our reports have shown that pushing such testing to the latter stages of a development program is very risky. Specifically, it prevents programs from using test results to improve design. It also raises the risk that problems will not be discovered until a point where it becomes very costly and time-consuming to fix them. Moreover, our reports have also shown that when testing occurs at latter stages, the amount of testing that is actually conducted is significantly less than planned.[8]

Risks 4, 5, and 6: Considerable Work Remains to Be Done on Infrared Sensors and Software

Considerable work needs to be done on the infrared sensors and software within a short period of time. Three activities are particularly critical: (1) completing software development for the acquisition sensor, (2)

[8] GAO/NSIAD-00-199.

integrating payload hardware and software, and (3) modifying the tracking sensor to accommodate requirements for long-wave infrared performance.

- Software development for the infrared sensors is on the critical path and must be completed in time to support integration and testing of the sensors. Software originally developed for the legacy satellites' sensors was never completed, and the sensors' software requirements are not completely defined, which may delay software development. According to the program office, the lack of time scheduled to perform early software testing on sensors could result in a delay in detecting and resolving errors. Most of the $14.6 million risk mitigation funding in this area has been earmarked to address the lack of early software testing. Also, software interface issues could require a redesign of the software.

- Integration of the payload hardware and software will be complex because many serial integration and test activities must be successful, and the schedule has little slack for test equipment or component failures, according to the program office.

- The tracking sensor needs additional modifications to accommodate long-wave infrared performance requirements. However, the impact of the modifications will not be known until the sensor has been built and tested. (The sensor was originally designed for mid-wave infrared performance. In the middle of the SBIRS-low program, the long-wave infrared requirements were imposed on the program. While modifications were made to meet this requirement, the sensor still generates more heat than the satellite coolers were designed to handle. As such, the sensor still needs thermal modifications to improve its long-wave infrared performance.)

Software Development Schedules Tend to Be Optimistic

Since software development is a risk in many areas of the STSS program, MDA faces an overriding challenge in accurately predicting what work will need to be done in developing software related to the program. Reports show that this is a significant problem for many space and other weapon system programs—commercial and military. For example, in a series of studies completed in the 1990s, the Standish Group[9] found that the average cost overrun was 189 percent, the average schedule overrun was 222 percent of the original estimate, and, on average, only 61 percent of the projects were delivered with originally specified features or functions

[9] *The CHAOS Report*, the Standish Group International, Inc. (West Yarmouth, Mass.: 1995).

attributable to software development. In November 2000, the Defense Science Board reported that the majority of problems associated with DOD software development programs are a result of undisciplined execution. The Board found that troubled programs lacked well thought-out, disciplined program management and/or software development processes. Meaningful cost, schedule, and requirement baselines were also lacking, making it virtually impossible to track progress against them.[10]

We have stated in previous reports that software development schedules were optimistic for DOD's AEHF satellite system and SBIRS-high program. For example, the Air Force originally estimated that the AEHF payload and spacecraft bus required approximately 257,000 lines of software code, but as the requirements and capabilities of the satellite system were better understood, the estimate grew to approximately 466,000 lines of software code. AEHF's ground segment also increased from about 1.1 million lines of software code to nearly 1.7 million. In early 2002, during the last SBIRS-high program restructure, Air Force officials estimated that the amount of ground segment software had grown 48 percent, while the amount of space segment software had grown 28 percent.

MDA and the prime contractor recognize that software presents a risk across the board for STSS. The prime contractor has decided to manage the work on the STSS program based on milestones that are 6 months earlier than the contractual satellite launch date milestones. This means that delays attributable to software development up to 6 months will not directly affect the satellite launch schedule.

[10] Report of the Defense Science Board Task Force on Defense Software, Office of the Under Secretary of Defense for Acquisition and Technology (Washington, D.C.: Nov. 2000).

Alternate Approaches May Garner More Knowledge

There are other approaches MDA could pursue, but they have not been considered because they would not allow STSS to participate in 2006-2007 missile defense testing. These include (1) planning the launch of the legacy satellites for 2008 and (2) canceling work on completing the existing satellites and focusing solely on developing new satellites. These approaches would enable MDA to inject competition into the STSS program, reduce scheduling risks, and demonstrate more capabilities. Both approaches also have drawbacks, primarily, they would delay MDA's ability to make informed trade-offs between STSS and other competing surveillance and tracking capabilities, such as ground-, sea-, and air-based radar systems. Table 5 compares these alternatives in terms of achieving capabilities to MDA's original and current strategies.

Table 5: Comparison of MDA's Strategy and Alternatives Not Being Considered

Approaches	Acquisition to track hand over	Satellite-to-satellite hand over	Stereo midcourse tracking	Dual mission data processing	Missile defense system integration	Autonomous operation	Discrimination
Original: Launch legacy satellites in 2006 and 2007 and new satellites in 2010	●	◉	◉	◉	◉	○	◉
Current: Launch legacy satellites in tandem in 2007 and a single new satellite in 2011	●	●	●	●	◉	○	◉
Alternative not considered: Launch existing legacy satellites in tandem in 2008 and new satellites in 2010	●	●	●	●	●	○	◉
Alternative not considered: Focus on new technology and eliminate effort to launch legacy satellites. Launch before 2010.	●	●	●	●	●	●[a]	●[a]

● Capability would be demonstrated

◉ Capability would be demonstrated, but only partially or for a limited period of time

○ Capability would not be demonstrated

●[a] As long as design incorporated this capability

Source: GAO.

Delaying Launches of Existing Satellites Could Reduce Scheduling Risk and Offer More Knowledge

One approach not being considered involves delaying the launch of the legacy satellites until 2008. This approach offers several advantages over the current strategy.

- First, it would reduce program risks by allowing more time to complete the development and testing of satellite hardware and software that have been in storage for 4 years, and to complete software development and testing for the ground segment.

- Second, it would allow time to complete integration of the ground segment with the missile defense test bed (scheduled for 2008) and ensure that both satellites would have enough on-orbit life remaining so that the satellites and ground segment could be tested together while fully integrated into the ballistic missile defense system test bed.
- Third, it would allow MDA to fund both the design and production of a competing contractor's acquisition sensor. This would ensure that competition remains viable for the development of future series of satellites, and it is key to MDA getting the best prices and technical solution.
- Fourth, satellites launched in 2008 will likely still have some residual capability when the new satellite is launched in 2010, allowing them to interact together to provide increased knowledge.

One drawback is a potential delay in demonstrating capabilities and technologies, since MDA's current plan would begin to demonstrate some capability in 2007. But more importantly, this approach will delay the benefit of incorporating on-orbit lessons learned into the upgraded design, because this newer design will be well underway by the time the satellites are launched. Instead, MDA will have to wait for a future effort before it can incorporate these lessons learned.

Focusing Solely on Developing New Demonstration Satellites Can Allow MDA to Develop More Robust Satellites Quicker

MDA is also not considering focusing solely on developing and demonstrating new satellites that can offer operational capability once a limited or full constellation is fielded. However, this approach could demonstrate most capabilities needed for an operational system with at least two satellites in orbit at the same time for some duration. Specifically, satellite-to-satellite hand over could be demonstrated since the new satellites would be designed to be compatible. Additionally, the new satellites could be fully integrated with the missile defense test bed. Midcourse stereo tracking and STSS mission dual data processing would also be demonstrated. Discrimination capability could be demonstrated, depending on the design selected.

There are other benefits of pursuing the newer technologies beyond meeting these capabilities. The newer technology satellites would have increased lifetimes. In addition, the satellites' sensors would likely be more sensitive and able to detect cooler targets. Software upgrades would continue to evolve to meet a newer generation of needs with the new technology satellites. Moreover, this approach would allow more time to test with the longer on-orbit life expected from these newer satellites.

Finally, MDA could reach a decision to field an operational capability sooner than with any other approach.

There are also drawbacks to this approach. There could be at least a 2-year delay in demonstrating capability. In addition, the technology risk would be greater because the critical technology for the new satellites is less mature. For example, the TRLs for the new satellites currently range from 4 to 5, whereas the TRLs for the existing satellites, according to the Air Force, range from 5 to 6.[11]

Conclusions

Over about the last 20 years, DOD has invested billions of dollars to develop a missile tracking capability from space. Past efforts show that a heavy focus on meeting schedules can debilitate an effort to the point of failure. Yet DOD is at risk of repeating past mistakes because it has made decisions that are largely focused on meeting its 2007 launch date rather than making sure the satellites and ground station can work as intended and that it can gain the maximum knowledge at the lowest cost. Given the research and development nature of the program at this point, MDA has the ability to study and consider alternative ways of moving forward with the existing satellite components with greater emphasis on gaining knowledge from its demonstration satellites. If research and development is not the primary goal and operational capability is, MDA should stop its investment in completing the existing satellites and concentrate on developing new satellites.

Recommendations for Executive Actions

To better ensure the Missile Defense Agency's approach to validate space-based sensors and technologies for missile acquisition, tracking, and discrimination, we recommend that the Secretary of Defense direct the Director, MDA to take the following actions.

- Focus spending on its STSS contract to assessing the working condition of the legacy satellites and what additional work is necessary to develop, test, and launch the existing satellites so that MDA has more knowledge on which to build cost and schedule estimates.

[11] This means that for the new satellites, components are testable but do not exist in their final assembled configuration. For the existing satellite hardware, prototypes are available that are very close in their final form, fit, and function, and performance has been demonstrated in a relevant environment.

- Use this assessment to conduct a broader analysis of alternative approaches, including the possibility of delaying launches to 2008 as well as dropping the development of the existing satellite components and focusing instead on developing demonstration satellites based on later generation technology.
- Further, use this assessment to find ways to ensure that competition at the sensor level is part of all efforts to develop missile tracking capabilities.
- If this assessment concludes that MDA should follow a different path for STSS, renegotiate the STSS contract to account for this change.

Agency Comments and Our Evaluation

We received written comments on a draft of this report from the Director of Defense Systems within the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics. DOD partially concurred with our first two recommendations and concurred with our third and fourth recommendations. In response to the first two recommendations, DOD noted that efforts to develop, test, and launch the legacy satellite hardware is well understood and on contract, and that a delay in launching the first STSS satellites is not prudent, given the overall missile defense sensor assessments that are to be made. In response to the third and fourth recommendations, DOD agreed that the sensor payload competition is central for risk mitigation and that if DOD pursued a different strategy, contract adjustments would be warranted. DOD also offered additional corrections and suggestions to clarify our draft report, which we have incorporated as appropriate. DOD's comments appear in appendix I.

In responding to our first recommendation, DOD agreed with the need to assess the working condition of the legacy satellite hardware, but did not explicitly concur with the need to focus spending on this assessment. DOD further commented that its efforts to develop, test, and launch the legacy hardware is well understood. This comment, however, is based on the assumption that all of the hardware will be found in working condition and performing within acceptable technical parameters. Our point is that the condition of the legacy hardware will not be known until after all of the hardware checks have been conducted. Because its knowledge of the condition of the legacy satellites is not complete, MDA's decisions to develop older technology versus pursuing new technology and to launch legacy satellites in 2007 may not have the expected results. If key satellite components are found to be in unacceptable working condition, MDA may be forced to spend more time and money than currently estimated to execute its strategy.

In responding to our second recommendation, DOD asserted that it had already conducted a broader analysis of alternative approaches to development of space-based sensor support to the missile defense system. As noted in our report, however, this analysis did not include the alternative of launching legacy satellites in 2008 instead of 2007 or focusing solely on development of new technology. We also disagree with DOD's comment that a delay in launching the first STSS satellites is not prudent, given the overall ballistic missile defense system sensor assessments that are to be made. First, MDA is striving to launch the STSS satellites in 2007 to support the 2007 test bed in order to allow DOD to make informed decisions about the composition of the missile defense sensor architecture. However, launching both legacy satellites in 2007 also has some long-term affordability consequences. For example, to be able to fund a launch in 2007, MDA has decided not to fund the procurement of a satellite sensor from a competing contractor. Instead, MDA plans to fund the development of an alternative sensor design from a competing contractor, if the funds available are sufficient for meaningful design work. By reducing competition, MDA may well face higher long-term costs to develop STSS because it may have to rely on a single contractor. Moreover, competition will enable MDA to pursue the best technical solution for STSS. Second, a primary goal of the initial STSS satellites is to demonstrate key capabilities that have never before been demonstrated from space. By adopting a strategy designed to meet the target launch date, however, MDA will be constrained in its ability to learn about these capabilities. For example, it will not be able to fully assess how well STSS will interact with other missile defense systems because the legacy systems will only be partially integrated with the missile defense test bed. Third, the history of the STSS program warrants a broader assessment of alternative investment approaches. The legacy satellites that MDA is relying on experienced technical and schedule difficulties as well as significant cost growth when they were developed under the SBIRS-low program, STSS's precursor. The SBIRS-low program as a whole was also schedule driven, it faced technical challenges, and although almost $2 billion was spent on this program, not a single satellite was launched. The demonstration portion of the program was eventually canceled in 1999. To avoid similar problems, we believe that MDA should examine approaches that offer ways to maximize competition and reduce cost and scheduling risks even if that means a delay in its assessment of STSS's participation in the missile defense test bed.

Scope and Methodology

To determine what capabilities DOD still needs to demonstrate in support of a missile tracking capability from space, we reviewed briefings of program goals, acquisition and test plans, management reports, and internal memoranda relevant to the development of STSS. Specifically, we reviewed the system element reviews, MDA's Director Guidance, and the element capability specification, from MDA and the Air Force's Space and Missile Systems Center. We also held discussions on STSS capabilities with officials at MDA, the Space and Missile Systems Center in Los Angeles, California, and Northrop-Grumman Space Technology in Redondo Beach, California. We also reviewed documentation from the Director, Operational Test and Evaluation, Office of the Secretary of Defense, regarding the SBIRS-low program and its risks.

To identify and assess DOD's prior and current approaches for demonstrating missile-tracking capabilities, we reviewed the STSS September and December 2002 System Element Reviews, program briefings, and the STSS contract. We also held discussions with officials at the Space and Missile Systems Center. In deriving the different approaches, we relied on program briefings and supplemented this information with our own institutional knowledge and experience in reviewing space systems. Through trial and error for estimation purposes, we extended launch dates, launched satellites in tandem, or both, to see which could result in increased knowledge to the program. Through briefings with officials from the Space and Missile Systems Center and our own assessments, we determined what the advantages and disadvantages would be to each approach.

To determine the risk areas involved with the different alternatives for accomplishing the STSS mission, we reviewed our prior work on the STSS program and the STSS System Element Review and launch schedules and discussed with officials at the Missile Defense Agency, the Air Force Space and Missile Systems Center, and Northrop-Grumman Space Technology, the work needed to finish development and testing of the existing demonstration satellites. We reviewed schedule and funding information for developing both hardware and software for the demonstration satellites, to include whether components can be fully integrated, tested, and validated before launch. We also reviewed our prior reports and testimonies on practices characterizing knowledge-based acquisition processes.

We performed our work from July 2002 through March 2003 in accordance with generally accepted government auditing standards.

We plan to provide copies of this report to the Chairmen and Ranking Minority Members of the Senate Committee on Armed Services; the Senate Committee on Appropriations, Subcommittee on Defense; the House Committee on Armed Services; and the House Committee on Appropriations, Subcommittee on Defense; the Secretary of Defense; and the Director, Missile Defense Agency. We will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov/.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841. Key contributors to this report were Cristina Chaplain, Art Gallegos, Tony Beckham, Joseph Dewechter, Dave Hubbell, Sigrid McGinty, Karen Sloan, Jim Solomon, Hai Tran, and Randy Zounes.

Katherine V. Schinasi
Director, Acquisition and Sourcing Management

Appendix: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE

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ACQUISITION,
TECHNOLOGY
AND LOGISTICS

1 MAY 2003

Ms. Katherine Schinasi
Director, Acquisition and Sourcing Management
U. S. General Accounting Office
441 G. Street, N.W.
Washington, DC 20548

Dear Ms. Schinasi:

This is the Department of Defense's (DoD's) response to the GAO Draft Report, GAO-03-597, "MISSILE DEFENSE: Alternative Approaches to Space Tracking and Surveillance System Need to be Considered" dated April 3, 2003 (GAO Code 120156).

The DoD concurs with some recommendations in the report and partially concurs with the others. Specific comments on each recommendation, and proposed corrections, are enclosed. My action officer for this effort is Lt Col Mark Arbogast, (703) 695-7328, mark.arbogast@osd.mil.

We appreciate the opportunity to comment on the draft report.

Sincerely,

Glenn F. Lamartin
Director
Defense Systems

Attachments:
As Stated

GAO DRAFT REPORT – DATED APRIL 3, 2003
GAO CODE 120156/GAO-03-597

"MISSILE DEFENSE: Alternative Approaches to Space Tracking and Surveillance System Need to be Considered"

DEPARTMENT OF DEFENSE COMMENTS TO THE RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommended that the Secretary of Defense direct MDA to focus spending on its STSS contract to assessing the working condition of the legacy satellites and what additional work is necessary to develop, test, and launch the existing satellites so that MDA has more knowledge on which to build cost and schedule estimates. (p. 23/GAO Draft Report)

DOD RESPONSE: Partially concur.
The assessment described in this report is part of the Department's ongoing Space Tracking and Surveillance System (STSS) activity. The efforts required to develop, test, and launch the Flight Demonstration System hardware are well understood and on contract. The assessments of the status of the flight 1 and flight 2 legacy satellite hardware are expected to be complete by September 2003, and February 2004, respectively.

RECOMMENDATION 2: The GAO recommended that the Secretary of Defense direct MDA to use this assessment to conduct a broader analysis of alternative approaches, including the possibility of delaying launches to 2008 as well as dropping the development of the existing satellite components and focusing instead on developing demonstration satellites based on later generation technology. (p. 23/GAO Draft Report)

DOD RESPONSE: Partially concur.
The Department already conducted an initial assessment of the Flight Demonstration System (FDS) satellites and used this assessment to conduct the analysis of alternative approaches to development of space-based sensor support to Ballistic Missile Defense. We believe the current Block 2006 STSS program will yield critical data which will expand our understanding of the effectiveness of a space-based infrared system. Data acquired through the launch and operation of these satellites will allow the Department to make informed decisions about the composition of the Ballistic Missile Defense System sensor architecture. A delay in launching the first STSS satellites is not prudent. The Department is now conducting a more thorough assessment of the satellites and preparing them for a 2007 launch as part of the Block 06 Ballistic Missile Defense System.

RECOMMENDATION 3: The GAO recommended that the Secretary of Defense direct MDA to use this assessment to find ways to ensure that competition at the sensor level is part of all efforts to develop missile-tracking capabilities. (p. 23/GAO Draft Report)

DOD RESPONSE: Concur.
Competition in the area of sensor payloads is central to the Department's risk mitigation strategies on STSS.

RECOMMENDATION 4: If this assessment concludes that MDA should follow a different path for STSS, the GAO recommended that the Secretary of Defense direct MDA to renegotiate the STSS contract for this change. (p. 23/GAO Draft Report)

DOD RESPONSE: Concur.
If the Department decides that a different strategy is in order for STSS, appropriate adjustments to the contract will be made.

(120156)

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