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TECHNOLOGY DEVELOPMENT

New DOD Space Science and Technology Strategy Provides Basis for Optimizing Investments, but Future Versions Need to Be More Robust

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GAO-05-155

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Highlights

Highlights of GAO-05-155, a report to congressional committees

TECHNOLOGY DEVELOPMENT

New DOD Space Science and Technology Strategy Provides Basis for Optimizing Investments, but Future Versions Need to Be More Robust

Why GAO Did This Study

The Department of Defense (DOD) is depending heavily on new space-based technologies to support and transform future military operations. Yet there are concerns that efforts to develop technologies for space systems are not tied to strategic goals for space and are not well planned or coordinated. In the National Defense Authorization Act for 2004, the Congress required DOD to develop a space science and technology (S&T) strategy that sets out goals and a process for achieving those goals. The Congress also required GAO to assess this strategy as well as the required coordination process.

What GAO Recommends

GAO is making recommendations that focus on assuring DOD has the right tools and measures in place to meet its goals for space S&T and to take steps needed to begin addressing barriers to effectively implementing the new strategic plan. In commenting on the report, DOD agreed with the recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-05-155.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Mike Sullivan at (937) 258-9715 or sullivanm@gao.gov.

What GAO Found

DOD's new strategy for space S&T met four of the nine requirements set out by the Congress and plans are in place to meet the remaining requirements. These included requirements for setting short- and long-term goals and a process for achieving those goals as well as requirements that focused on ensuring the strategy was developed with laboratories, research components, and other organizations involved in space S&T and ensuring the strategy would be reviewed by appropriate entities and revised periodically. In addition to meeting these requirements, GAO found that development of the strategy itself helped spur collaboration within the DOD space S&T community since it required diverse organizations to come together, share knowledge, and establish agreement on basic goals.

Since the strategy has only recently been issued, it is too early to assess whether the direction and processes outlined in the strategy will be effective in supporting and guiding future space S&T efforts. Moreover, DOD officials are still working out the details of some implementation mechanisms. However, in order to better position DOD for successful implementation, GAO believes that the plan should contain stronger linkages to DOD's requirements setting process, identify additional measures for assessing progress in achieving strategic goals, and explicitly cover all efforts related to space S&T.

Moreover, there are formidable barriers that stand in the way of optimizing DOD's investment in space S&T. For example:

- DOD does not have complete visibility over all spending related to space S&T, including spending occurring within some S&T organizations and acquisition programs. Without a means to see where funding is being targeted, DOD may not be able to assure all spending on technology development is focused on achieving its goals.
- The S&T community itself may not have resources critical to achieving DOD's goals. In recent years, funding and opportunities for testing for the space S&T community have decreased. And, concerns have grown about the adequacy of the space S&T workforce.
- DOD acquisition programs continue to undertake technology development that should be occurring within an S&T environment, which is more forgiving and less costly than a delivery-oriented acquisition program environment. Until this is done, cost increases resulting from technology problems within acquisitions may keep resources away from the S&T community.

By using the strategy as a tool for assessing and addressing these challenges, DOD can better position itself for achieving its goals and also strengthen the S&T base supporting space.

Contents

Figures

Abbreviations

BA	budget activity
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director of Defense Research and Engineering
DOD	Department of Defense
JCIDS	Joint Capabilities Integration and Development System
MDA	Missile Defense Agency
NASA	National Aeronautics and Space Administration
NRO	National Reconnaissance Office
RDT&E	research, development, test and evaluation
S&T	science and technology
TRL	technology readiness level

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Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

January 28, 2005

The Honorable John W. Warner
Chairman
The Honorable Carl Levin
Ranking Minority Member
Committee on Armed Services
United States Senate

The Honorable Duncan Hunter
Chairman
The Honorable Ike Skelton
Ranking Minority Member
Committee on Armed Services
House of Representatives

The Department of Defense (DOD) is looking to its space systems to play an increasingly pivotal role in future military operations. As such, it is developing several families of new, expensive, and technically challenging space systems, eventually including constellations of satellites that will employ laser optics to transport information over long distances in much larger quantities than radio waves; a new generation of global positioning technology; and advanced infrared sensors, radar sensors, and environmental monitoring sensors. At the same time, DOD is seeking to improve technologies and materials that are critical to enhancing satellite performance, such as propulsion systems, cooling systems, onboard and ground processing systems, and materials used to protect technologies and spacecraft in the harsh space environment.

A broad array of entities is charged with responsibility for developing the science and technology (S&T) supporting space systems, including research laboratories and test facilities belonging to the military departments and DOD as well as industry and academic organizations that perform research and development for these organizations or for specific DOD space acquisition programs. From fiscal years 2004 through 2009, DOD plans to spend about $3.8 billion on S&T efforts exclusive to space applications within its military laboratories and contracts through its laboratories. Considerably more money will be spent on projects that have space and terrestrial applications (for example, propulsion technologies and advanced materials) as well as on technology development that occur within acquisition programs. In addition, outside agencies, such as the National Aeronautics and Space Administration (NASA), also invest in

S&T efforts that can support DOD space systems and may benefit from S&T efforts being carried out by DOD.

Though there are many diverse organizations carrying out S&T efforts related to space and a considerable amount being invested, DOD has not had an overarching strategy for space S&T in recent years that sets goals for these efforts, helps direct how investments should be spent, and tracks the overall progress of DOD's investment in space S&T. Moreover, there have been concerns that the level of collaboration and coordination among all DOD S&T organizations involved in space has not been adequate, leading to redundant or unnecessary investments in some areas or even too little investment in areas where it is critical for the United States to maintain a lead over other nations. There has also been concern that technologies have difficulty transitioning from the laboratories to DOD's acquisition programs. In addition, our previous reports have shown that weapon system acquisition programs have taken on technology development that should occur in an S&T environment. In doing so, acquisition programs have not been able to align customer expectations with resources, and therefore minimize problems that could hurt the program in its design and production phases. In fact, many of the space programs we have reviewed over the past several decades have incurred unanticipated cost and schedule increases because they began without knowing whether technologies could work as intended and invariably found themselves addressing technical problems in a more costly environment.

The National Defense Authorization Act for Fiscal Year 2004 (the act) required DOD's Executive Agent for Space and its Director of Defense Research and Engineering (DDR&E) to develop and implement a space S&T strategy. The act required us to review and assess the S&T strategy and the effectiveness of the coordination process among DOD S&T elements and to report our findings by September 1, 2004. As discussed with committee staff, our objectives were to (1) assess whether the strategy meets the act's requirements, (2) identify additional criteria above and beyond the act that could enhance the usefulness of the strategy, and (3) identify barriers that may hamper DOD's ability to successfully enhance S&T efforts for space. We provided a briefing on our review to your committees on our findings on September 1, 2004. This report details our findings.

In conducting our work, we reviewed DOD and military department policy documents on S&T activities, as well as pertinent S&T reports and related material, to determine DOD's progress in achieving program mission objectives. We assessed the DOD space S&T strategy for compliance with the 2004 Defense Authorization Act. We developed additional criteria with which to assess the space S&T strategy and identified barriers that may influence DOD's ability to successfully implement S&T efforts for space. In doing so, we consulted with subject matter experts and reviewed our previous best practice reports. We reviewed documents from and conducted interviews with officials in DOD, the Army, the Navy, the Air Force, the Defense Advanced Research Projects Agency (DARPA), the Missile Defense Agency (MDA), NASA, and military department research laboratories. We also analyzed the fiscal year 2004 virtual Major Force Program for Space and unclassified DOD budget documents to identify the amount of space research, development, test and evaluation (RDT&E) funding for fiscal years 2003 to 2009 and confirmed with DOD officials responsible for maintaining this information that our analysis was correct. Our review was conducted from November 2003 to November 2004 in accordance with generally accepted government auditing standards.

Results in Brief

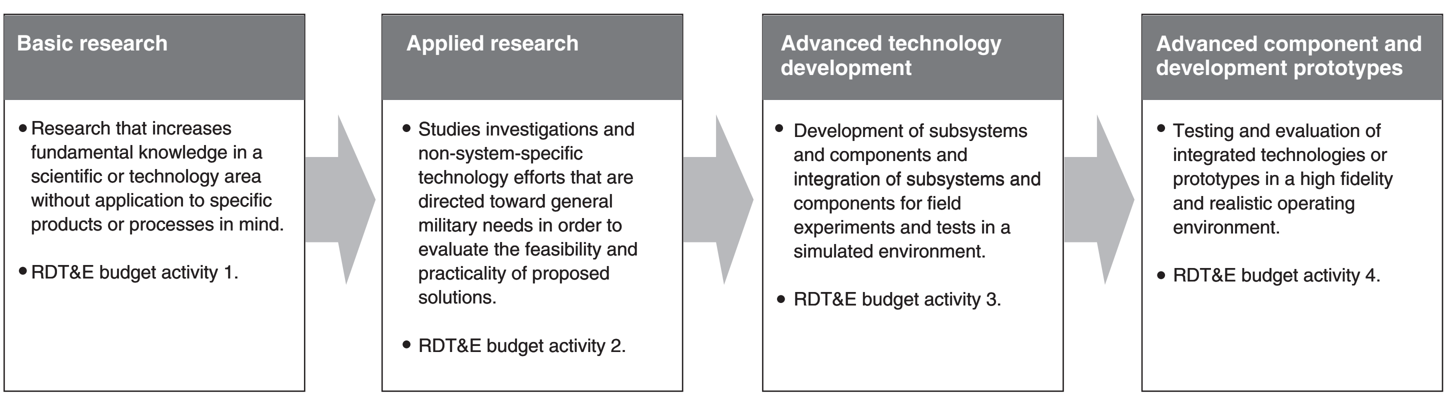
The 2004 National Defense Authorization Act required DOD to develop a strategy for space S&T that identified short- and long-term space S&T goals; a process for achieving the goals, including an implementation plan; and a process for assessing progress made toward achieving the goals. The act also required DOD to coordinate its efforts with various organizations and agencies involved in space. The strategy met four of nine specific requirements in the act, and plans are in place to meet the remaining five requirements. We found that the strategy provides a foundation for enhancing coordination among space S&T efforts since it does specify overall goals and it establishes several mechanisms to help senior leaders gauge whether investments are focusing on those goals. Moreover, the development of the strategy itself helped spur collaboration within the DOD space S&T community since it required diverse organizations to come together, share knowledge, and establish agreement on basic goals.

However, the strategy lacks details in key areas needed to achieve its goals. For example, measures for gauging success have not been fully defined. In addition, the strategy does not specifically address how S&T efforts within space acquisition programs will be covered, even though considerable money is being spent by acquisition programs on technology development. Also, the strategy does not address how long-standing barriers to optimizing DOD's investment in space S&T will be addressed, including incomplete visibility over funding for space-related S&T as well as testing and workforce deficiencies. Concentrating on these issues would help ensure that DOD has the right tools and measures in place to meet its goals for space. As such, we are making recommendations focused on addressing these issues in future versions of the strategy. In addition, there are barriers outside of the space community that may hamper effective implementation of the space strategy, including a lack of a DOD-wide investment strategy. Such a strategy could be useful in guiding and directing S&T investments, funding, and organizational incentives, which have been encouraging technology development in acquisition programs rather than the S&T community. DOD has initiated actions to address these issues, but it is too early to assess their effectiveness.

Background

Generally, DOD's S&T community (which includes DOD laboratories and testing facilities as well as contractors and academic institutions that support these facilities) conducts research and develops technologies to support military applications, such as satellites or weapon systems. Like the acquisition community in DOD, the S&T community uses RDT&E funds, but the S&T community's work precedes the acquisition cycle. Weapon system program managers, who receive most of DOD's RDT&E budget, apply generic technologies to specific systems. Figure 1 highlights activities the S&T community is involved in along with the RDT&E budget categories, or "activities," which are used to fund these efforts. More details on both are provided in appendixes I and II.

Figure 1: DOD S&T Activities within the RDT&E Appropriations



Source: Department of Defense.

The S&T community carries out its work within the first three categories of research and development listed above. DOD has specified that the work within the fourth category—testing and evaluation of prototypes of systems or subsystems in a high fidelity or realistic environment—involves efforts before an acquisition program starts product development. However, according to DOD officials, it is assumed that either the S&T community or an acquisition program may carry out this work, and traditionally, weapon system acquisition programs have taken on technology development within this stage. After this point, any additional development is to be completed as part of a formal acquisition or product development phase under the authority of the weapon system manager and apart from the S&T community.

The DOD DDR&E is responsible for the overall direction, quality, and content of the agency's S&T efforts. Each of the military departments—Army, Air Force, and Navy—has its own S&T programs, as do DOD organizations such as DARPA, Defense Threat Reduction Agency, MDA, and the National Reconnaissance Office (NRO). The DOD Executive Agent for Space—who is also the space milestone decision authority for all space major defense acquisition programs, the Under Secretary of the Air Force, and the Director of the NRO—also influences S&T efforts for space since he decides whether significant investments in space systems are to move forward in the development process.

There are mechanisms within the space community and DOD designed to ensure S&T efforts are coordinated and are focused on achieving broader goals and that redundancy is minimized. Within the space community, a forum called the Space Technology Alliance was established in 1997 to coordinate the development of space technologies with an eye toward achieving the greatest return on investment. Its membership includes the Air Force, the Army, the Navy, MDA, DARPA, and NRO. At the DOD-wide level, there is a Defense Science and Technology Strategy, which lays out goals for DOD-wide S&T efforts based on goals set by higher-level documents, such as the Quadrennial Defense Review. This strategy is used, in turn, to develop a DOD-wide basic research plan, which reflects DOD's objectives and planned investments for basic research conducted by universities, industry, and laboratories and a DOD-wide technology area plan, which does the same for applied research and advanced technology development. There is also a Joint Warfighting S&T Plan, which ties S&T projects to priority future joint warfighting capabilities identified by higher-level documents. These overall plans, in turn, are used by DOD laboratories to direct investments in S&T. They are also used by the Office of the Secretary of Defense to provide guidance to the military departments and the defense agencies as they develop and vet their proposed budgets. In addition, DOD puts together teams of outside experts in 12 technology areas to assess whether particular investments across DOD's S&T community are redundant or unnecessary. These are known as Technology Area Reviews and Assessments. The teams make recommendations to a board comprised of senior DOD S&T officials and chaired by the DDR&E for action to terminate, adjust, and/or enhance investments to better align the S&T program to comply with the planning document guidance. The DDR&E, which reports to the Under Secretary of Defense (Acquisition, Technology and Logistics), has oversight of the RDT&E budget activities used to research and develop new technologies, specifically, RDT&E budget activities 1 (basic research), 2 (applied research), and 3 (advanced technology development). Recently, the DDR&E was given oversight of RDT&E budget activity 4 (advanced component development and prototypes) in an effort to ensure this development had sufficient oversight from the S&T community.

DOD's Space S&T Strategy Addresses the Act's Requirements

The act required DOD to develop a strategy for its space S&T efforts that identified short- and long-term space S&T goals; a process for achieving the goals, including an implementation plan; and a process for assessing progress made toward achieving the goals. The act also required DOD to coordinate its strategy development efforts.[1] The strategy, yet to be delivered to the Congress at the time of our review, met four of nine requirements, and plans are in place to meet the remaining five. We found that the strategy provides a foundation for enhancing coordination among space S&T efforts since it does specify overall goals and that it establishes several mechanisms to help senior leaders gauge whether investments are focusing on those goals. However, since the strategy has only recently been issued, it is too early to assess whether the direction and processes outlined in the strategy will be effective in supporting and guiding future space S&T efforts.

[1] The act's requirements for the strategy have been codified at 10 U.S.C. § 2272 (2004).

Table 1: Requirements Met or Planned

Requirement	Requirement met?
Identify short- and long-term goals.	Yes
Address a process for achieving the goals, including an implementation plan.	Yes
Address a process for assessing progress made toward achieving the goals.	Yes
Strategy developed in consultation with DOD laboratories, research components, and other organizations.	Yes
Strategy to be reviewed and, as appropriate, revised annually.	Planned
Strategy to be made available for review by the congressional defense committees.	Planned
Strategy to be included as part of the annual National Security Space Plan.	Planned
Strategy to be provided to DOD components and DOD S&T entities to support DOD's planning, programming, and budgeting processes.	Planned
In carrying out the space S&T strategy, DOD laboratories, research components, and other organizations shall each (1) identify research projects that contribute directly and uniquely to the development of space technology and (2) inform the DDR&E and the DOD Executive Agent for Space of the planned budget and schedule for those projects.	Planned

Source: GAO.

The strategy identified goals for space S&T along six main areas—assured access to space, responsive space capability, assured space operations, spacecraft technology, information superiority, and S&T workforce. Except for the goal of enhancing the workforce, the strategy laid out short-term goals (within 5 years) and long-term goals (in the year 2020 or beyond). Under spacecraft technology, for example, the strategy identified a short-term goal of on-orbit assessment of satellite servicing and repair and long-term goals of on-orbit assembly, deployment, repair, and upgrades. Under assured space operations, the strategy identified a short-term goal of detecting, identifying, and characterizing natural and man-made objects in space and a long-term goal of complete space situational awareness. According to S&T community officials we spoke with, the mere identification of goals should be useful in helping DOD laboratories and other S&T facilities to direct their investment as this type of guidance had not been provided for space previously.

The strategy also establishes several mechanisms for implementation. Primarily, it calls for semiannual space S&T summit meetings to coordinate user expectations, highlight technologies, provide guidance, and establish priorities.[2] DDR&E officials, agency S&T executives as well as Service Program Executive Officers for Space who will ultimately transition new capabilities, and major command leadership will attend these meetings. The strategy also implements an Industry Independent Research and Development coordination conference, where industry and government officials can come together to collaborate in their S&T planning activities. Details on both of these mechanisms are still being worked out, according to the developers of the strategy.

The strategy also identifies some tools and measures that will be used to track progress in meeting goals. These tools and measures include "technology roadmaps," which identify timelines, milestones, and transition dates for specific projects as well as interdependencies with other projects and "technology readiness level" (TRL), an analytical tool that assesses the maturity level of technology. Our prior work has found TRLs to be a valuable decision-making tool since it can presage the likely consequences of incorporating a technology at a given level of maturity into a product development. [3] Appendix III details criteria for each TRL.

In addition, DOD has plans in place to ensure that the strategy is reviewed and revised, as necessary, annually and that it be made publicly available for review by congressional defense committees. Other DOD S&T entities will be provided the strategy to support the planning, programming, and budgeting processes. DOD also plans to include the strategy as an annex to the National Security Space Plan, even though the plan is thought to be a lower-level tactical document and not a strategic document.

The developers of the strategy worked with a wide range of organizations in establishing goals, measures, and implementation plans. These include military department laboratories, DARPA, intelligence agencies, MDA, the Air Force Space Command, NASA, the Space and Missile Systems Center, the U.S. Strategic Command, the National Security Space Office, and others.[4] Officials within the space community we spoke with commented

[2] The DDR&E and the DOD Executive Agent for Space signed a Memorandum of Understanding to conduct organized reviews of the S&T enterprise as outlined in the space S&T strategy.

[3] See *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

[4] Appendix IV lists the organizations that participated in developing the space S&T strategy.

that it has historically been difficult to gain agreement from these organizations. Even though they all have ties to space, these organizations have different views as to what overall goals the space community should strive for and how they should be achieved. According to officials within the space community we spoke with, just getting these organizations to work together and to gain agreement was a significant benefit to the community at large since it helped foster more collaborative working relationships and greater knowledge sharing.

Additional Criteria Are Not Included in the Act That May Enhance the Strategy

In addition to the requirements specified by the act, we found that optimizing space S&T efforts also depends on whether (1) the strategy is clearly linked to other strategies and plans; (2) all DOD space S&T efforts are covered by the strategy; and (3) the strategy identifies metrics beyond TRLs that focus on success. Linkage to other strategies and plans is important to providing clear guidance to S&T laboratories and other organizations making investments since there are a number of DOD-wide "strategies" for S&T as well as a number of space-related higher level strategic plans as well as tactical plans relating to S&T. Coverage of all space S&T efforts is important since S&T is carried out not only by DOD laboratories but also by large acquisition programs and other agencies that have a large stake or investment in space S&T. For example, NRO develops new satellites for the intelligence community and could potentially leverage its S&T efforts with DOD's. Lastly, having additional measures beyond TRLs is important to gauging the success of the implementation of the strategy as well as the relevancy and feasibility of specific progress toward achieving DOD's overall goals for space. We found that the strategy clearly identified linkages to some, but not all, key plans and strategies, and it did not provide coverage over all S&T efforts or establish additional measures.

Links to Other Strategies and Plans

The space S&T strategy identifies links to higher-level documents, such as the National Security Space Strategy, which sets overall strategic goals for DOD space and identifies capabilities to be pursued, and the Defense S&T Strategy, which provides overall goals for DOD S&T based on higher-level strategic documents. The strategy also references lower-level plans including the National Security Space Plan discussed earlier and DOD-wide S&T plans, such as the Basic Research Plan, the Defense Technology Area Plan, and the Joint Warfighting S&T Plan. However, the strategy did not provide links to other documents and assessments that impact the space S&T community. For example, it is unclear how the document will link to DOD's Space Technology Guide, which describes the current state of space and space-related technology activities underway, including key enabling technologies, that is, those that "must be done right" since they play a pivotal role in making revolutionary advancements in space applications. The guide is being revised and could serve as a useful implementation tool for the new space S&T strategy. It is also unclear how the strategy links to architectures in areas such as responsive space operations, protection for space mission assurance, and integrated intelligence, surveillance and reconnaissance being developed by the National Security Space Office. These architectures are to define the future desired state for DOD's space assets. It is important that DOD reflect these other documents in the new space S&T strategy so that the space community clearly understands where the strategy fits in relation to other plans and guides and can ensure decision making is consistent. Moreover, by establishing closer links with the Space Technology Guide and architectures under development, DOD may have more avenues to implement its short- and long-term goals.

In addition, the Joint Chiefs of Staff did not participate in the development of the strategy, including offices responsible for DOD's new Joint Capabilities Integration and Development System (JCIDS). JCIDS is replacing DOD's requirements generation process for major acquisitions in an effort to shift the focus to a more capabilities-based approach for determining joint warfighting needs rather than a threat-based approach focused on individual systems and platforms. Under JCIDS, boards comprised of high-level DOD civilians and military officials are to identify future capabilities needed around key functional concepts and areas, such as command and control, force application, and battlespace awareness, and to make trade-offs among air, space, land, and sea platforms in doing so. Although the JCIDS officials were not required to participate in developing the strategy, it is important that they do so in the future since their work could have a significant impact on the direction of investments for space S&T projects.

Coverage of All S&T Efforts

The space S&T strategy does not explicitly address technology development efforts within DOD acquisition programs. According to DOD officials, space acquisition programs are typically using RDT&E funds from budget activity 4 to mature technology and build the first two satellites. Our analysis showed that space acquisition programs plan to spend as much as $16 billion from fiscal years 2004 through 2009 on budget activity 4. Our annual assessments of space systems have shown that the portion of the $16 billion that is to be spent on maturing technology (which we could not readily separate from the portion spent building the first two satellites) is often being used to carry out activities that should be carried out in an S&T environment. For example, the Transformational Satellite program, which is focused on building advanced communication satellites, entered system development in early 2004 with only one of seven critical technologies matured to a point of being tested in a relevant environment. Most of the technologies were at a TRL 3, meaning analytical studies and some laboratory tests had been conducted, but components had not yet been demonstrated to work together. If DOD does not explicitly include acquisition programs in the space S&T strategy, it will not be able to ensure the S&T community has oversight over a considerable amount of ongoing technology development.

We were not provided access to NRO to discuss how it collaborated with the DDR&E and the Executive Agent for Space in developing the space S&T strategy and how they intended to work with the DDR&E and the Executive Agent for Space in implementing the strategy. However, DOD officials stated that NRO had participated in the development of the strategy and would participate in all S&T coordination activities identified by the space S&T strategy. Moreover, according to DOD officials, NRO and other intelligence agencies already participate in some DOD space S&T coordination and review efforts, such as the Space Technology Alliance. In addition, the DDR&E and the DOD Executive Agent for Space are continuing to work on increasing coordination between DOD and the intelligence community. DOD officials also noted that the current Executive Agent for Space also serves as the Director of NRO, which has helped to increase coordination between the intelligence community and DOD. While these efforts may be helping to increase coordination between DOD and the intelligence S&T communities, it is still important to specifically include the DOD intelligence agencies in the strategy itself and to identify protocols that can help foster greater knowledge sharing between both communities.

Success Measures

While the strategy identifies TRLs as a measure for tracking progress, it does not prescribe metrics that focus on the value of S&T projects relative to specific goals or knowledge being gained from projects. Such metrics would help provide a foundation for assessing progress in achieving strategic goals. Strategy developers stated that technology development organizations are better suited to develop and use their own specific metrics to measure success because different technologies may require different types of metrics. The developers stated that by design, the strategy sets the direction but leaves it up to the laboratories and other S&T entities to establish their own metrics. However, they acknowledged that some of the organizations they worked with did not have adequate metrics. It is important that DOD attempt to identify and use metrics that help assess progress, since these will enable DOD to evaluate investments against its short- and long-term goals and make informed investment decisions.

Barriers May Hamper Strategy Implementation

Though the new space S&T strategy takes important first steps toward optimizing investments, there are significant barriers that will make it difficult to make advancements in the way S&T efforts are planned, managed, and transitioned into acquisition programs. Some barriers relate specifically to the space community—principally, incomplete RDT&E funding visibility, inadequate testing resources, and workforce deficiencies. These can potentially be addressed through further study, resource shifts, increased management attention, and/or changes to how funding is captured. Other barriers are more systemic and require more difficult management and cultural changes to be made throughout DOD. Nevertheless, until barriers are largely removed, the impact of a new strategy for space S&T may be limited. The developers of the strategy agreed that the barriers we identified were important and needed to be addressed through efforts beyond the development of the strategy.

Visibility over S&T Spending on Space Is Incomplete

The current budget process does not readily capture all RDT&E funding for space S&T efforts. In 2001, DOD established a "virtual" Major Force Program for space to increase the visibility of resources allocated for space activities. This is a programming mechanism that aggregates most space-unique[5] funding by military department and function. However, the mechanism does not align funding with RDT&E budget activities, making it more difficult for DOD to assess the balance of funding among basic research, applied research, and advanced technology development.[6] In working with DOD officials to categorize the virtual Major Force Program by RDT&E budget activity, we identified about $3.8 billion from fiscal years 2004 through 2009 for budget activities 2 (applied research) and 3

[5] Space unique means the virtual Major Force Program that was designed to include program elements that represent space activities only. In other words, land, sea, and air platforms with space components, and work on sensors or propulsion, are not included in the virtual Major Force Program for space.

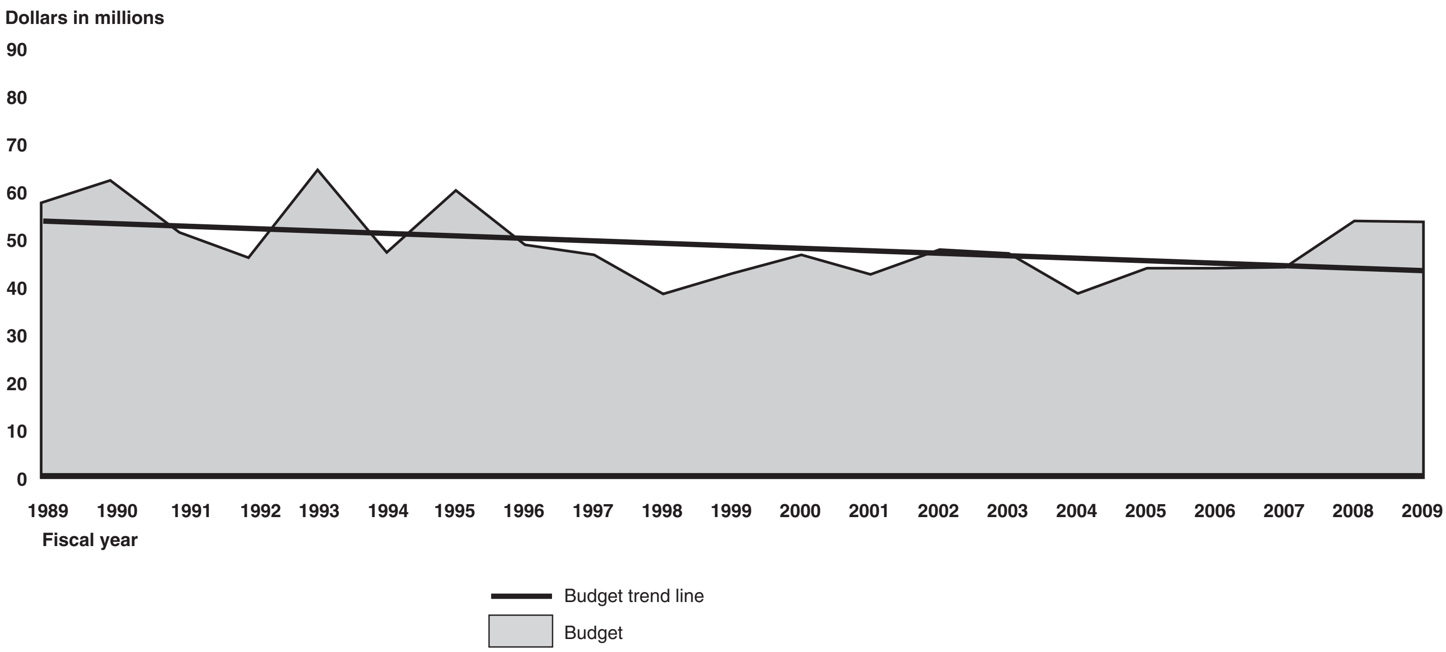
[6] Instead, funding is categorized by program element, the smallest aggregation of resources controlled by the Office of the Secretary of Defense.

(advanced technology development). However, funding for budget activity 1 (basic research) cannot be specifically associated to either space or terrestrial platforms, and therefore does not appear in the virtual Major Force Program, which is focused on space-unique funding. Funding in RDT&E budget activities 2 and 3 that is not space unique is also not captured. In addition, some DOD agencies develop space assets but have primary missions that are not associated with space and are therefore, not included in the virtual Major Force Program. For example, MDA's space efforts are not included in the virtual Major Force Program for space even though MDA is developing a new generation of missile tracking satellite systems using advanced infrared sensors. MDA plans to spend about $4.12 billion on this system from fiscal years 2004-2009, and a considerable portion of this funding is expected to be used to mature technologies for future satellites. Moreover, DARPA reports its space funding by project so space S&T efforts cannot be readily identified without additional knowledge of whether these projects are space related. Currently, DARPA has funded about $200 million annually on projects that are space unique and considerably more on projects that have both space and terrestrial applications. Until the virtual Major Force Program or some other tool can capture and categorize the total amount of RDT&E dollars supporting space-unique S&T projects at a minimum, DOD will be limited in guiding and directing all space investments.

Testing Resources Declining

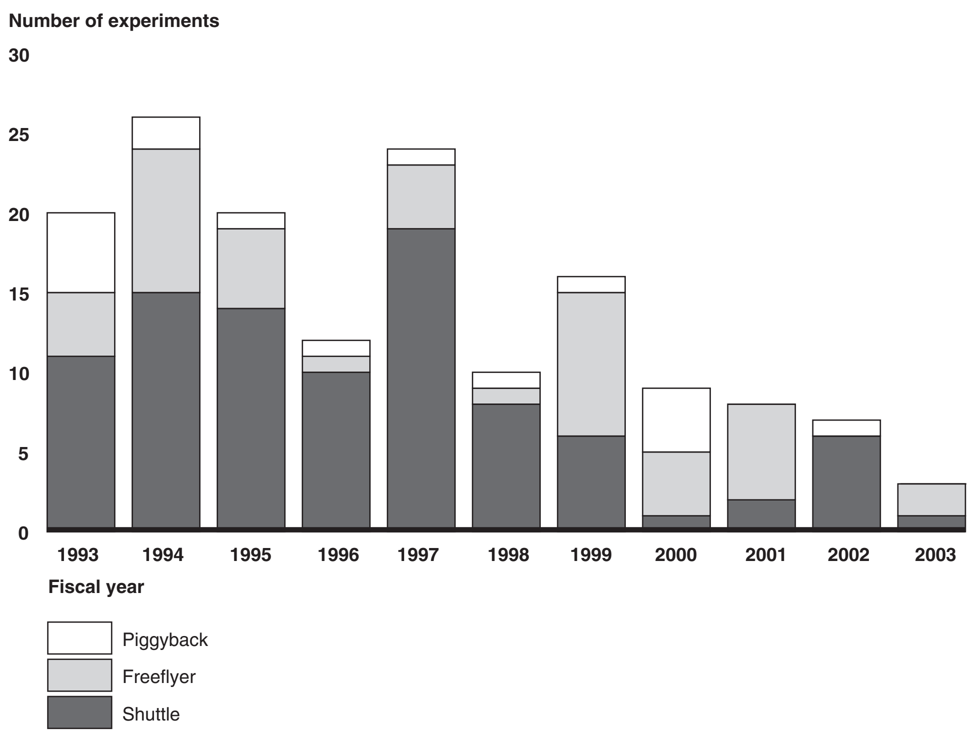
Testing resources for space technologies are on the decline. In particular, funding for testing has decreased, costs to launch experiments have increased, and opportunities have been reduced with the loss of the space shuttle, which had been partially used for DOD-related technology experiments. DOD's Space Test Program, which is designed to help the S&T community find opportunities to test in space relatively cost-effectively, was funded at $62.3 million in fiscal year 1990 but only $38.6 million in fiscal year 2004 (see fig. 2). And because the cost to launch experiments has increased, the program has only been able to launch an average of seven experiments annually in the past 4 years (see fig. 3). According to Space Test Program officials, demand for testing has not diminished. S&T officials cited dwindling testing resources as a barrier to their efforts. While the strategy states that appropriate resources need to be allocated for on-orbit testing, it does not address how this can or will be done.

Figure 2: Funding for Space Test Program



Source: U.S. Air Force.

Figure 3: Number of Experiments Carried Out by Space Test Program



Source: U.S. Air Force.

Note: This does not include funding for testing that occurs within acquisition programs. Chart is in FY 04 constant dollars.

Space S&T Workforce Facing Shortages

The workforce needed to carry out S&T for space is facing shortages. DOD officials cited staff shortages with science and engineering backgrounds and had more concerns about the future since their workforces were reaching retirement age. These concerns were echoed by DOD and industry studies. A 2002 study on the space research and development industrial base conducted by Booz Allen Hamilton, for example, found that over half of the current space R&D workforce is over 45 years old and that departure of key talent could be especially worrisome in 10 years, as scientists and engineers now in the 45- to 49-year-old group begin to retire from the workforce and are replaced by a smaller pool of less experienced personnel.[7] In its report, the Space Commission noted that both industry and the U.S. government face substantial shortages of scientists and engineers and that recruitment of new personnel is difficult since the space industry is one of many sectors competing for the limited number of trained scientists and engineers.[8] Booz Allen noted that areas in which either recruitment efforts are difficult or a critical mass is lacking include systems engineering and software engineering. The 2004 National Defense Authorization Act[9] directed the Secretary of Defense to promote the development of space personnel career fields within each of the military departments. However, we recently reported that the military services vary in the extent to which they have identified and implemented initiatives to develop and manage their space cadres.[10] Moreover, the space S&T strategy itself merely lays out goals for workforce without identifying actions or resources needed to achieve those goals.

In recognizing that more needs to be done to develop, attract, and retain staff with critical skills, the Defense Authorization Act for Fiscal Year 2005 Conference Report[11] directed DOD to develop detailed implementation plans for enhancing the space cadre and to study the ability of academia, industry, and government to educate and train a community of space professionals and to address the definition and development of key competencies and skill levels in the areas of systems engineering, program management, financial management, operations, and tactics. We believe that S&T skill areas should also be included in the strategy given the importance of advancing space technologies and potential future workforce shortages.

[7] Booz, Allen, Hamilton, *Space Research and Development Industrial Base Study Phase One Final Report*, McLean, Va., February 2002, and *Phase Two Final Report* in August 2002.

[8] *Report of the Commission to Assess United States National Security Space Management and Organization*, Washington, D.C., January 11, 2001.

[9] National Defense Authorization Act for Fiscal Year 2004, Public Law 108-136.

[10] See *Defense Space Activities: Additional Actions Needed to Implement Human Capital Strategy and Develop Space Personnel* GAO-04-697 (Washington, D.C.: Aug. 11, 2004).

[11] H.R. Conference Report Number 108-354, at 281 (2004).

Investment Strategy Needed to Support S&T Planning

DOD does not yet have a departmentwide investment strategy that could provide a good foundation for space S&T planning. While desired capabilities are regularly identified by military commanders and are vetted through strategic reviews, such as the Quadrennial Defense Review, DOD has limited ability to make trades among space, air, land, and sea platforms in deciding how best to meet those capabilities, document those decisions, and follow through on those decisions. For example, DOD would like to achieve persistent surveillance to enhance military operations. But it has not been decided how much of the earth needs to be covered and the extent to which air-based assets, such as unmanned reconnaissance aircraft, can achieve this capability versus space-based assets, such as the planned space-based radar system. If DOD conducted thorough and independent analyses of alternatives weighing the pros and cons of using different combinations of both assets and made trade-off decisions that could be enforced across the military services, the S&T community could have a better basis for deciding how much S&T dollars should go toward space-based radar technologies versus technologies supporting air platforms.

The need for an investment strategy DOD-wide or for particular functional areas has been cited in a variety of recent studies, including a 1999 Defense Science Board study on tactical battlefield communications and a 2004 study by the Center for Strategic and International Studies. The recently established JCIDS process is designed to identify future capabilities by functional areas and to make trades between space and other platforms. However, it is unknown as to how this work will translate into an investment strategy that could be used to enhance S&T planning. And it is unknown how effectively decisions made through JCIDS will be enforced. DOD has also made changes to its Planning, Programming, Budgeting, and Execution[12] process to provide higher-level guidance to the budgeting process. However, it is also unclear as to how effectively these changes will be implemented over time and whether they can serve as a foundation for directing science and technology investments.

[12]The process was established in 2003 and evolved from the Planning, Programming, and Budgeting System. DOD uses the Planning, Programming, Budgeting and Execution process to determine priorities, allocate resources, and evaluate actual output against planned performance and adjust resources as necessary.

Funding Process Encourages Technology Development to Occur within Acquisition Programs

We have previously reported that an S&T environment is more forgiving and less costly than a delivery-oriented acquisition program environment. Events such as test "failures," new discoveries, and time spent in attaining knowledge are considered normal in this environment, while they are seen as a negative event in an acquisition program. Moreover, separating technology development and product development enables organizations to align customer expectations with resources, and therefore minimize problems that could hurt a program in its design and production phases. Budget realities within DOD, however, make it more advantageous to fund technology development in an acquisition program. Historically, S&T organizations receive about 20 percent of DOD's research and development budget, while weapon system programs receive about 80 percent. The money going toward S&T is spread over several thousand projects, while the money going toward weapons systems is spread out over considerably fewer projects. This "distribution of wealth" makes it easier to finance technology development within an acquisition program. In addition, even though more money is distributed to weapon systems, there is still considerable competition for funding. Such competition makes it advantageous for programs to include in their design immature technologies that offer significant performance gains. Within the space community, there is also a perception that the length of time it takes to develop space systems (which have only "one shot" at incorporating technologies) demands that DOD push for continual advancement of technologies, even after starting an acquisition program.

The impact of acquisition programs taking on technology development that should be done in an S&T environment is considerable. Our work over the past several decades has shown that this practice invariably leads to unanticipated cost and schedule increases for space and other weapon system programs since technical problems occurring within acquisition require more time and money to fix. For some large programs for space, cost increases have amounted to billions of dollars and delayed schedules by years. Aside from removing technology development from a more protective environment and from S&T oversight processes, problematic acquisitions may also rob the S&T community and other acquisition programs of investment dollars.

Some actions have been taken recently to address this dilemma. In particular, DOD issued a revised directive in November 2003 expanding the DDR&E's oversight authority to include efforts to develop advanced components and prototypes—RDT&E budget activity 4.[13] According to DDR&E officials, this authority was intended to keep technology development out of the acquisition programs and within the S&T community, but it will take at least 2 years to determine its success. In addition, DOD's revised acquisition policy for weapon systems encourages programs not to commit to undertaking product development until technologies are matured, that is, at a minimum tested in a relevant environment (TRL 6) and preferably in an operational environment (TRL 7). However, in October 2003, DOD also issued a separate acquisition policy for space, which allows technology development to continue into product development up until a decision is made to build the first product. At the time of our review, DOD was revising the space acquisition policy and reexamining how long technology development should continue within an acquisition program.

Conclusions

DOD has taken an initial positive step in optimizing investments in space S&T projects by establishing short- and long-term goals, which can be used to direct spending by S&T organizations, and by establishing a forum by which senior leaders can assess whether spending is going in the right direction. However, there will be significant challenges ahead for DOD in implementing the strategy. Namely, DOD must maintain momentum toward greater collaboration, which began under this effort. This will not be an easy task, given the varied and competing interests of organizations with a stake in DOD's space S&T investment and the fact that the strategy does not explicitly cover organizations that fall outside the realm of traditional DOD S&T oversight. Moreover, there are formidable barriers that stand in the way of achieving and measuring progress, including inadequate funding visibility, decreased testing resources, workforce deficiencies, and long-standing incentives that encourage technology development to take place within acquisition programs rather than the S&T community. By using the strategy as a tool for assessing and addressing these challenges, DOD can better position itself for achieving its goals and also strengthen the S&T base supporting space.

[13] Department of Defense Directive, Number 5134.3, "Director of Defense Research and Engineering (DDR&E)," November 3, 2003.

Recommendations for Executive Action

We recommend that the Secretary of Defense direct the (1) Executive Agent for Space and (2) the Under Secretary of Defense (Acquisition, Technology and Logistics) (to whom the DDR&E reports) to make the following improvements to space S&T strategic planning.

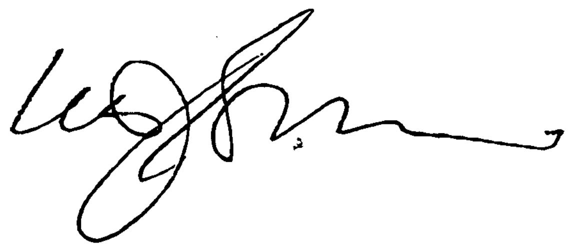
- Establish protocols and mechanisms for enhancing coordination and knowledge sharing between the DOD S&T community, acquisition programs involved in space, and DOD intelligence agencies.
- Ensure that the space S&T strategy fully reflects warfighter needs by establishing links between space S&T strategic planning and DOD's new JCIDS. In addition, establish links to architectural development processes to assure that S&T projects align with future technology requirements identified in space-related architectures.
- Continue to ensure that DOD has the right tools for measuring progress in achieving its goals for space by identifying metrics that could be used for assessing the value of S&T projects relative to strategic goals and knowledge being gained relative to goals.
- Develop plans for addressing barriers to achieving strategic goals for S&T, including deficiencies in RDT&E funding visibility, testing resources, and workforce. A first step would be to include skills critical to S&T in the workforce study identified in the Fiscal Year 2005 Defense Authorization Act Conference Report.

Agency Comments

In commenting on a draft of this report, DOD concurred with our recommendations and identified actions being taken to address them. (See app. V for DOD's comments.)

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

If you or your staff have any questions concerning this report, please contact me at (937) 258-7915. Key contributors to this report were Cristina Chaplain, Maricela Cherveny, Jean Harker, and Rich Horiuchi.



Michael Sullivan
Acting Director, Acquisition and Sourcing Management

Appendix I: Budget Activity Descriptions

Table 2: Description of Department of Defense's Budget Activities

Name	Budget activity	Description
Basic research	1	Basic research is systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. It includes all scientific study and experimentation directed towards increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. It is farsighted high-payoff research that provides the basis for technological progress.
Applied research	2	Applied research is systematic study to understand the means to meet a recognized and specific need. It is a systematic expansion and application of knowledge to develop useful materials, devices, and systems or methods. Applied research may translate promising basic research into solutions for broadly defined military needs, short of system development. Applied research precedes system-specific technology investigations or development.
Advanced technology development	3	Advanced technology development includes development of subsystems and components and efforts to integrate them into system prototypes for field experiments and/or tests in a simulated environment. The results of this type of effort are proof of technological feasibility and assessment of subsystem and component operability and producibility rather than the development of hardware for service use. Projects in this category have a direct relevance to identified military needs. Program elements in this category involve pre-acquisition efforts, such as system concept demonstration, joint and service-specific experiments, or technology demonstrations, and generally have technology readiness levels (TRLs) of 4, 5, or 6. Projects in this category do not necessarily lead to subsequent development or procurement phases, but should have the goal of moving out of space science and technology (S&T) and into the acquisition process within the future years defense program.
Advanced component development and prototypes	4	Advanced component development and prototypes consists of efforts necessary to evaluate integrated technologies or prototype systems in a high fidelity and realistic operating environment. These activities include system-specific efforts that help expedite technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives. Advanced component development and prototypes efforts are to occur before an acquisition program starts product development.
System development and demonstration	5	System development and demonstration consists of newly initiated acquisition programs and includes engineering and manufacturing development tasks aimed at meeting validated requirements prior to full-rate production. Characteristics of this activity involve mature system development, integration, and demonstration to support a production decision.

Name	Budget activity	Description
Research, development, test and evaluation (RDT&E) management support	6	RDT&E management support includes efforts to sustain and/or modernize the installations or operations required for general RDT&E. Such efforts may relate to test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the RDT&E program.
Operational system development	7	Operational system development includes development efforts to upgrade systems that have been fielded or have received approval for full-rate production and anticipate production funding in the current or subsequent fiscal year.

Source: DOD Financial Management Regulation (DOD 7000.14-R, Volume 2B, Chapter 5, June 2004).

Appendix II: Funding on Technology Development within Science and Technology and Acquisition Communities

Table 3: Funding by S&T Community

Dollars in millions

Title	BA	Category	Component	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Multi-Disciplinary Space Technology[a]	2	6.2	Air Force	$95.8	$101.4	$84.6	$81.1	$101.4	$123.2	$122.1
Space Technology 1[a]	2	6.2	Air Force	74.9	101.5	88.9	89.6	97.6	119.0	126.7
Advance Spacecraft Technology	3	6.3	Air Force	52.4	96.9	60.1	65.9	72.1	88.2	91.0
Maui Space Surveillance System	3	6.3	Air Force	47.1	51.6	6.3	6.3	6.4	6.5	6.6
Multi-Disciplinary Adv Dev Space Tech	3	6.3	Air Force	51.7	62.1	51.1	59.6	76.3	81.8	73.1
Command, Control, Communications	3	6.3	Army	8.7	11.3	10.0	14.4	14.9	11.2	6.5
Advance Aerospace Systems	3	6.3	DARPA	111.6	201.6	249.2	233.6	261.8	296.9	327.0
Integrated Broadcast System	3	6.3	Air Force	0.0	8.5	2.3	0.0	0.0	0.0	0.0
Total Space S&T funding				**$442.2**	**$634.9**	**$552.5**	**$550.5**	**$630.5**	**$726.8**	**$753.0**

Source: GAO analysis.

Note: The above R&D categories include (6.2) Exploratory Development and (6.3) Advanced Development. R&D category (6.1) Basic Research is not included because these efforts are general in nature and not specific to space.

[a]Funding going toward a variety of projects and sources.

Table 4: Advanced Component Development and Prototypes Funding for Space Acquisition Programs

Title	BA	Category	Component	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Army Missile Defense Systems Integration	4	6.3	Army	$57.0	$35.5	$4.9	$8.3	$11.9	$11.7	$15.8
Navstar Global Positioning System III	4	6.3	Air Force	46.6	0.0	40.6	180.0	291.0	779.5	794.0
Advanced Extremely High Frequency satellite system	4	6.3	Air Force	802.7	802.3	612.1	410.0	316.8	189.5	131.1
Polar Milsatcom	4	6.3	Air Force	22.4	5.5	1.0	0.0	0.0	0.0	0.0
National Polar-Orbiting Operational Environmental Satellite System	4	6.3	Air Force	232.1	264.7	0.0	0.0	0.0	0.0	0.0

Title	BA	Category	Component	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Space Control Technology	4	6.3	Air Force	12.8	14.6	15.1	14.1	23.0	30.5	40.3
International Space Cooperative R&D	4	6.3	Air Force	.6	.5	.6	.6	.6	.6	.6
Transformational Satcom	4	6.3	Air Force	111.5	335.4	774.8	1,192.4	1,346.7	1,830.1	1,038.6
Integrated Broadcast System	4	6.3	Air Force	38.4	16.2	23.9	20.2	20.8	21.3	21.6
Wideband Gapfiller System	4	6.3	Air Force	13.8	36.3	73.5	16.0	9.3	5.7	6.4
Scamp Block II	4	6.3	Army	14.1	27.7	10.2	92.5	0.0	0.0	0.0
Air Force/Nat Prog Coop	4	6.3	Air Force	2.3	0.0	0.0	0.0	0.0	0.0	0.0
Space-Based Radar	4	6.3	Air Force	45.4	172.6	327.7	466.2	502.7	1177.7	1550.0
Total Space 6.3 funding in BA4				**1,399.7**	**1,711.3**	**1,884.4**	**2,400.3**	**2,522.8**	**4,046.6**	**3,598.4**

Source: GAO analysis.

Note: The above R&D category is Advanced Development (6.3).

Appendix III: Technology Readiness Levels and Their Definitions

Technology readiness level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle, or space.
8. Actual system completed and "flight qualified" through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system "flight proven" through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

Source: GAO analysis based on NASA and DOD guidance.

Appendix IV: Organizations That Participated in Developing the Space Science and Technology Strategy

Air Force Research Laboratory

Air Force Space Command

Assistant Secretary of the Air Force for Acquisition

Assistant Secretary of the Army for Acquisition, Logistics and Technology

Central Intelligence Agency

Community Management Staff

Defense Advanced Research Projects Agency

Defense Research and Engineering

Deputy Under Secretary of Defense for Science and Technology

Missile Defense Agency

National Aeronautics and Space Administration

National Geospatial-Intelligence Agency

National Reconnaissance Office

National Security Agency

National Security Space Office

Naval Operations Staff

Naval Research Laboratory

Office of Naval Research

Space and Missile Defense Command

Space and Missile Systems Center

Space and Naval Warfare Systems Command

U.S. Marine Corps

U.S. Strategic Command

Appendix V: Comments from the Department of Defense

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
3030 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3030

JAN 21 2005

Mr. Michael Sullivan
Director, Acquisition and Sourcing Management
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO 05-155, "TECHNOLOGY DEVELOPMENT: New DOD Space Science and Technology Strategy Provides Basis for Optimizing Investments, But Future Versions Need to Be More Robust," dated December 16, 2004 (GAO Code 120384).

The draft report recommends that the Secretary of Defense direct the Under Secretary of Defense (Acquisition, Technology and Logistics) to direct the Director, Defense Research and Engineering to work with the Executive Agent for Space to make improvements to space S&T strategic planning. Four specific recommendations were made. The Department concurs with the recommendations and provides comments on these recommendations in the enclosure.

Sincerely,

Ronald M. Sega

Enclosure:
As stated

GAO DRAFT REPORT DATED DECEMBER 16, 2004
GAO-05-155 (GAO CODE 120384)

"TECHNOLOGY DEVELOPMENT: New DOD Space Science and Technology Strategy Provides Basis for Optimizing Investments, But Future Versions Need to Be More Robust"

DEPARTMENT OF DEFENSE COMMENTS
TO THE DRAFT GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommended that the Secretary of Defense direct the Under Secretary of Defense (Acquisition, Technology and Logistics) to direct the DDR&E to work with the Executive Agent for Space to establish protocols and mechanisms for enhancing coordination and knowledge sharing between DOD S&T community and organizations not explicitly included in the strategy-that is, acquisition programs involved in space as well as DOD intelligence agencies. (p. 16/GAO Draft Report)

DOD RESPONSE: CONCUR. DDR&E and the DoD Executive Agent for Space recognize the need for, and benefit from, continually enhancing coordination and knowledge sharing between the DoD Space S&T community and the larger National Security Space enterprise. DDR&E and the Executive Agent for Space have formally agreed, and documented in the Space S&T Strategy, to jointly hold semi-annual Summit reviews of Space S&T investments. Acquisition organizations, DoD, and Intelligence Community organizations are represented in these forums. This effort will continue to enhance the coordination of Space S&T development among the National Security Space community. To date, two Summits have been convened with the next planned for March 2005. In addition, the DDR&E and Executive Agent for Space have embarked on a detailed Independent Research and Development (IRAD) review of the Space related industry efforts.

RECOMMENDATION 2: The GAO recommended that the Secretary of Defense direct the Under Secretary of Defense (Acquisition, Technology and Logistics) to direct the DDR&E to work with the Executive Agent for Space to ensure that the space S&T strategy fully reflects war fighter needs by establishing links between S&T strategic planning and DOD's new Joint Capabilities Integration and Development System. In addition, establish links to architectures being developed by the National Security Space Office to assure that S&T project align with future technology requirements identified in the architectures. (p.16/GAO Draft Report)

DOD RESPONSE: CONCUR. Activities are underway to ensure Space S&T investments, guided by strategic operational vectors, are synchronized with needs identified by both the Warfighter and Intelligence Community, and by the respective acquisition organizations. During formulation of the Space S&T Strategy, the Department specifically included Flag-level representatives from the Joint Staff, U.S. Strategic Command, and U.S. Air Force Space Command. These representatives provided warfighter perspective. DDR&E agrees the Joint Capabilities and Development System (JCIDS) is the appropriate mechanism to ensure space capability investments reflect warfighting needs. DDR&E has habitual relationships with the Joint Capability Working Groups which feed the JCIDS process, and will leverage these linkages to inject warfighter requirements through the appropriate Joint Capability Board (JCB). Applying the linkages from this recommendation with Recommendation One, above, will allow the National Security Space Office (NSSO) to align future technology requirements identified in the architectures.

RECOMMENDATION 3: The GAO recommended that the Secretary of Defense direct the Under Secretary of Defense (Acquisition, Technology and Logistics) to direct the DDR&E to work with the Executive Agent for Space to ensure that DOD has the right tools for measuring progress in achieving its goals for space by identifying metrics that could be used for assessing the value of S&T projects relative to strategic goals and knowledge gained relative to goals. (p.16/GAO Draft Report)

DOD RESPONSE: CONCUR. Metrics will be established and used to monitor level of effort, progress, and Technology Readiness Level (TRL).

RECOMMENDATION 4: The GAO recommended that the Secretary of Defense direct the Under Secretary of Defense (Acquisition, Technology and Logistics) to direct the DDR&E to work with the Executive Agent for Space to develop plans for addressing barriers to achieving strategic goals for S&T, including deficiencies in RDT&E funding visibility, testing resources, and workforce. (p. 16/GAO Draft Report)

DOD RESPONSE: CONCUR. Implementation of the Space S&T Strategy and recent internal initiatives address the identified barriers (funding visibility, testing resources, and workforce). The virtual Major Force Program (vMFP) program element assignment process, one method already in place, will provide improved funding visibility as the vMFP moves to a 'steady state.' The Executive Agent for Space is also working with the S&T community on two initiatives (DT&E Facilities Database and S&T Space Flight Opportunities Survey) to help address the need for improved testing resources. Finally, the state of the Space S&T workforce is a top priority for both DDR&E and the Executive Agent for Space and, as such, is being worked in concert with larger DoD manpower efforts.

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