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Report to the Ranking Minority Member, Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives

April 2006

NASA'S DEEP SPACE NETWORK

Current Management Structure Is Not Conducive to Effectively Matching Resources with Future Requirements

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Highlights

Highlights of GAO-06-445, a report to the Ranking Minority Member, Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives

April 2006

NASA'S DEEP SPACE NETWORK

Current Management Structure Is Not Conducive to Effectively Matching Resources with Future Requirements

Why GAO Did This Study

The President's Vision for Space Exploration calls for human and robotic missions to the Moon, Mars, and beyond. In response, over the next two decades, NASA may spend $100 billion on new technologies and facilities that will require reliable ground communications to achieve those missions. Presently, that communications capability is provided by NASA's Deep Space Network—a system of antennas located at three sites around the world. However, the Network faces challenges that may hinder its provision of current and future mission support.

This report discusses (1) the significant operational challenges faced by the Deep Space Network and (2) the extent to which NASA is integrating the Network into its future communications plans.

What GAO Recommends

GAO is making several recommendations to NASA that will assist the agency in better aligning resources for the Deep Space Network with overall agency requirements for future space exploration. NASA concurred with GAO's recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-06-445.

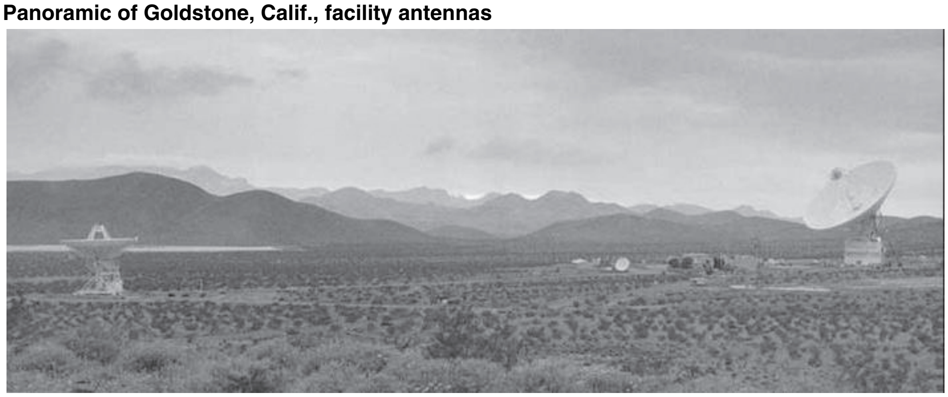
To view the full product, including the scope and methodology, click on the link above. For more information, contact Allen Li at (202) 512-4841 or lia@gao.gov.

What GAO Found

While NASA's Deep Space Network can meet most requirements of its current workload, it may not be able to meet near-term and future demand. The system—suffering from an aging, fragile infrastructure with some crucial components over 40 years old—has lost science data during routine operations and critical events. In addition, new customers find they must compete for this limited capacity, not just with each other, but also with legacy missions extended past their lifetimes, such as NASA's Voyager, that nonetheless return valuable science. Program officials doubt they can provide adequate coverage to an increasing set of new mission customers, especially if they increase dramatically under the President's Vision.

The Deep Space Network's future utility is also in question because NASA does not currently match funding for space communications capabilities with agency wide space communications requirements. While NASA created an agency level entity to review the technical requirements for integrating assets like the network into an agency wide space communications architecture for the future, that entity does not address program level requirements nor influence investment decisions. Control over such requirements and funding remains with the mission directorates and programs themselves. This disconnect allows programs to invest in capabilities that may undercut agency wide goals for space communications. After this review was initiated, NASA began to study how to better manage this gap between agency-level requirements and program-level funding, but no recommendations for action have yet been proposed.

Panoramic of Goldstone, Calif., facility antennas



Source: NASA.

Contents

Abbreviations

DSN	Deep Space Network
JPL	Jet Propulsion Laboratory
SCAWG	Space Communications Architecture Working Group
SCCIB	Space Communication Coordination and Integration Board
SMD	Science Mission Directorate
TOR	Terms of Reference

United States Government Accountability Office
Washington, DC 20548

April 27, 2006

The Honorable Mark Udall
Ranking Minority Member
Subcommittee on Space and Aeronautics, Committee on Science
House of Representatives

In January 2004, the President outlined a Vision for Space Exploration that calls for human and robotic missions to the Moon, Mars, and beyond. Over the next two decades, NASA plans to spend over $100 billion to develop a number of new capabilities, supporting technologies, and facilities that are critical to enabling these missions. These missions will have at least one thing in common: they will require a reliable network to handle all communication functions for both manned and unmanned spacecraft. Most of that functional capability for deep space communications currently resides in NASA's Deep Space Network (DSN).

DSN was established in 1959 to support NASA's exploration of the solar system. According to agency officials, DSN is designed to communicate with spacecraft at distances greater than 1.2 million miles from Earth—the distance defined as deep space. It is currently the only system of its nature with the capability to serve vast numbers of deep space missions. Since its inception, the network has returned extensive science data and has proven to be a linchpin for successful space exploration missions. Its services are used by NASA, other domestic organizations, and foreign space agencies. However, over time, DSN officials have had to deal with maintaining an aged infrastructure and managing coverage time for an increasing mission set with limited capacity. In addition, although NASA has not made any definitive decisions in this regard, new deep space communications requirements are envisioned to support projected missions to the moon.

In maintaining a reliable deep space communication system for the near term, while also preparing for the future, NASA will need to effectively manage its communication needs and the allocation of resources to meet them. As recently as 2003, the National Research Council reported that DSN was suffering from insufficient communications capabilities and occasional failures. In light of these issues, you asked us to: (1) identify the challenges NASA's DSN program faces in meeting its current and planned space communications workload and (2) determine the extent NASA is integrating DSN into its space communications plans for the future.

To conduct our work, we reviewed documents and data related to the operations and capabilities of DSN as well as NASA-wide strategic planning documents about the Vision for Space Exploration. We interviewed program officials as well as contractor personnel about challenges they face in managing and operating DSN. Further, we collected and analyzed information related to space communications architecture management at NASA and held discussions with NASA space communications officials about future space communications architecture requirements, what assets the architecture will include, and how its development is being managed. We also held discussions with NASA's Space Communications Organization Study Group, which was established during the course of our review to develop options for how to manage space communications at NASA. We met with officials at NASA Headquarters and NASA's Jet Propulsion Laboratory (JPL), as well as ITT Industries contractors at their offices in Monrovia, Calif., and at the DSN facility in Goldstone, Calif. Complete details of our scope and methodology can be found in appendix I. We performed our review from May 2005 to April 2006 in accordance with generally accepted government auditing standards.

Results in Brief

NASA's Deep Space Network (DSN) is able to meet most of the requirements of its current workload, but serious questions exist as to whether it will be able to keep up with both near-term and future demands. In the near term, DSN faces a deteriorating infrastructure and a limited capacity to serve additional missions. System infrastructure, which has been marked by extensive deferred maintenance, is aging and is likely to become increasingly fragile and subject to breakdown at a time when demand is anticipated to increase. The potential exists for the loss of scientific data that would be difficult, if not impossible, to replace. In addition, new users will find that, aside from competing for network capacity with each other, they must also compete with legacy programs that have been extended far beyond their intended lifetimes, but still return science data and thus take up considerable network time. For example, the Voyager mission launched in 1977 still requires DSN support and is envisioned to rely on DSN for the foreseeable future. Capacity limits constrain the amount of science data that can be returned from deep space by new missions that are added to DSN's set of users.

DSN's future utility is also in question because NASA currently has no mechanism in place to match funding for space communications capabilities with agency-wide space communications requirements. The agency's Space Communication Coordination and Integration Board is responsible for reviewing the technical requirements of space communications programs to determine whether they fit into an agency wide architecture. However, according to agency officials, the Board is only advisory in nature and does not review all program requirements, such as infrastructure needs. As a result, such program requirements are often not raised at the agency level. Furthermore, funding for space communications capabilities is controlled by the individual communications programs and their associated mission directorates, who may not necessarily consider agency wide goals when making investments. This disconnect between establishment of requirements and control of resources creates the potential for programs to make investments in capabilities that may undercut agency wide goals for space communications. For example, agency officials noted both the Deep Space Network and the Ground Network programs recently were on a path to develop separate array technologies to support overlapping requirements for the same lunar missions. These efforts would have undercut the agency's goals of a seamless, integrated architecture for space communications and would have represented unnecessary duplication of effort and added costs. After our review was initiated, NASA created a task group to study how to better manage this gap between agency-level requirements and program-level funding, but it has not yet made any recommendations for action to address the situation.

We are making recommendations to NASA that the DSN program identify its current and future requirements in more comprehensive terms and how those requirements might be supported as well as items that NASA's task group on space communications should consider to better align program requirements with agency space communications goals. In written comments on a draft of this report, NASA concurred with our recommendations.

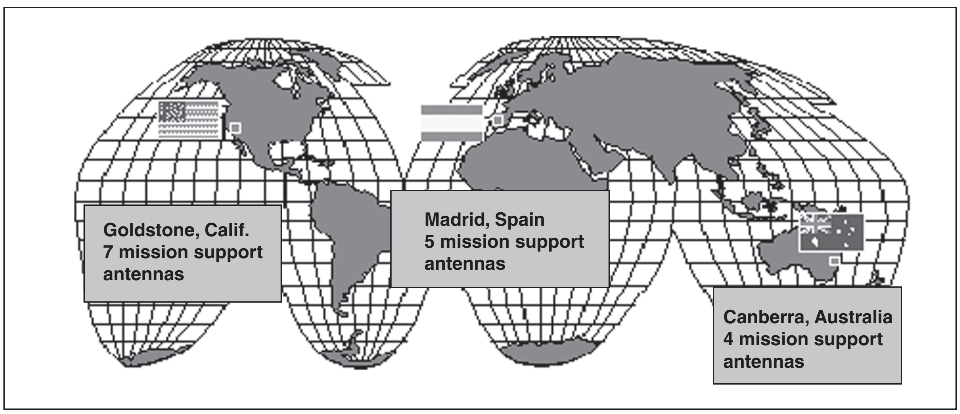
Background

NASA established DSN over 40 years ago with the intention of coordinating all deep space communications through a single ground system to improve efficiency and minimize duplication. Today, DSN consists of communications antennas at three major sites around the world—Goldstone, Calif.; Madrid, Spain; and Canberra, Australia.[1] These

[1]The relationships between the United States and Spain and Australia are outlined in international agreements. According to DSN officials, in exchange for use of land by NASA's assets in these foreign countries, the Spanish and Australian space agencies have full access to all deep space science collected by NASA spacecraft.

sites are specifically positioned to offer complete coverage to deep space mission craft regardless of their positions around the Earth. DSN officials informed us that while contractor personnel operate all three sites, NASA owns the physical assets and is responsible for funding all operations at the sites. Each site has a 70-meter antenna, which can provide communications with the most distant spacecraft, and several smaller antennas that can facilitate communications with closer spacecraft or can be arrayed to communicate with more distant missions. NASA's Jet Propulsion Laboratory is responsible for management of DSN and also serves as the distribution point for data collected from deep space.

Figure 1: Location of Primary Deep Space Network Communications Sites



Source: NASA.

DSN supports an average of 35 to 40 deep space missions each year. According to program officials, as a mission is being developed, a representative from the DSN program works with the mission team to establish the amount of coverage the mission will need from DSN assets during its lifetime. This coverage includes the amount of time per day for routine communications and also critical coverage of major mission events. In most cases, missions must negotiate with the DSN program because they desire more coverage than DSN can provide. Once the amount of coverage time is established and major mission events are scheduled, DSN commits to that coverage in a Service Agreement with the mission. Within the agreement, DSN commits to providing coverage for 95 percent of the time agreed to with its mission customers, while the remaining 5 percent allows for unexpected disruptions during that coverage. This 95 percent commitment almost guarantees that all critical mission events will be covered without disruption. Once this is put into place, missions are generally free to trade time amongst themselves if priorities change or a particular mission gets kicked off the network due to an unexpected anomaly in the system. The missions that DSN supports are not charged for their usage of the system, unless they require a unique technology that DSN must add to its system in order to provide coverage. This is a relatively rare phenomenon, however. DSN is primarily funded through its managing entity, the Science Mission Directorate, and receives resources consistent with its performance the previous year and its previous year's budget.

DSN works in conjunction with NASA's other space communications assets to provide coverage to missions at all distances from the Earth. The Ground Network provides communications capabilities to spacecraft in low-Earth orbit. Additionally, the Space Network, including the Tracking and Data Relay Satellite System, is an Earth-based satellite relay system that also facilitates missions in low-Earth orbit. In order for a spacecraft to receive support from all of these communications assets, NASA must ensure they are coordinated and can provide the capabilities for which they are intended.

Throughout its history, NASA has had different management structures trying to achieve this coordination. According to NASA officials, from the Apollo missions in the 1960s through 1995, space communications was managed through an agency wide communications entity with budgetary authority to provide appropriate investments in system capabilities. In 1995, this management and budget authority was devolved to a central contract managed out of the Johnson Space Center in an effort to cut costs and streamline maintenance to the assets. The savings from this realignment were never realized for the agency and the communications assets were severely underfunded as a result of how they were managed under this arrangement. Subsequently, management and budget authority for these assets were brought back to NASA headquarters in 2001 and aligned with the mission directorate responsible for the customers each asset served. NASA then created the Space Communication Coordination and Integration Board to oversee the technical integration of these assets into a seamless space communications architecture. This is how space communications assets, including the DSN program, are managed currently at NASA.

The NASA Authorization Act of 2005 contains a requirement that the NASA Administrator submit a plan for updating NASA's space communications architecture for low-Earth orbital operations and deep space exploration so that it is capable of meeting NASA's needs over the next 20 years.[2] This plan is due to be submitted to the House Committee on Science and the Senate Committee on Commerce, Science and Transportation no later than February 17, 2007. In addition, the Conference Report accompanying the Science, State, Justice, Commerce and Related Agencies Appropriations Law, 2006[3] requires that NASA include a 10-year funding profile for DSN in its fiscal year 2007 budget request.[4]

DSN Challenges Could Hamper Its Ability to Meet Future Mission Requirements

DSN is currently able to meet most requirements of its existing workload. However, according to program officials, DSN's current operational ability is no predictor of future success, and they have significant concerns about the ability of the system to continue to meet customer requirements into the future. These concerns are based on the system's aging infrastructure and projected additional workload on top of servicing existing missions.

Sustainability of DSN's Infrastructure Is Unknown

DSN suffers from an aged, fragile infrastructure. Significant parts of that infrastructure—including many antennas—were first built in the 1950s and 1960s and are showing their age. DSN program officials stated that the Goldstone complex is down, on average, 16 hours per week for maintenance and repairs due to problems associated with its age. While Goldstone contains some of the oldest equipment in the system and the poor condition of much of its equipment characterizes the underlying fragility of the network, operational disruptions occur across the entire network. For instance, the 70-meter dishes are widely regarded by program officials and mission customers as increasingly fragile, which calls into question expectation of their continued reliability. In fact, mission customers shared similar concerns that DSN's infrastructure is not in the appropriate condition that it should be to support their missions. With increasing use of these assets, they fear service will only deteriorate and more disruptions will occur during service to their missions. Program officials and mission customers provided some examples, as follows, of

[2] See sec. 102(c)(1), Public Law 109-155.

[3] See H.R. Conference Report 109-272 accompanying Public Law 109-108.

[4] This profile was not included in NASA's fiscal year 2007 budget request.

disruptions that have occurred during service as a result of infrastructure deterioration:

- During a critical event for the Deep Impact Mission on July 4, 2005, corrosion of the sub reflector on the 70-meter dish at DSN's Madrid site caused an unexpected disruption in service. In response, program managers had to shift coverage to alternative antennas. While they were able to provide adequate coverage of the event for the Deep Impact Mission, the shift to back-up antennas forced other users off at that time, which meant they lost coverage.

- In October 2005, a significant power disruption caused by corrosion to a major power line resulted in multiple antennas at the Goldstone complex going offline, resulting in several hours of downtime and a subsequent loss of scientific data.[5]

- In November 2005, failure of a prime network server resulted in several hours of unexpected downtime, which in turn caused considerable loss of data to four research projects. During this anomaly, the Stardust, Mars Reconnaissance Orbiter, Mars Odyssey and Mars Global Surveyor missions lost a total of 241 minutes of coverage to their missions.

Program officials also expressed concern about the possibility of massive antenna failure due to metal fatigue. Ultimately, such a failure would result from a partial or total collapse of an antenna structure. Although no DSN antenna has yet collapsed from fatigue, an antenna in West Virginia similar in design and age to those already used by the DSN program collapsed unexpectedly in 1988. DSN program managers are in the process of finding an engineering firm to conduct a survey of the program's antenna assets to assess their structural reliability. Beyond that action, program officials rely mostly on their experience and visual observations to assess the condition of these assets.

[5]Although we requested the amount of science data lost due to this disruption, the program could not provide it.

Figure 2: External corrosion on 70-meter antenna

Source: GAO observation at NASA Goldstone facility.

Deferred maintenance also poses a significant challenge to the sustainability of DSN assets. Since 2002, the program has consistently deferred approximately $30 million in maintenance projects each year. These projects are commonly associated with infrastructure that is not directly related to system performance and have been given lower priority when more pressing needs limit the system's ability to provide coverage for its customers. For example, several roadway, water and electrical projects at the Goldstone facility have consistently been deferred due to the need to address system maintenance needs considered to have become more pressing. Although the program does seek to prioritize its most pressing projects and direct resources to them once its budget is allotted, operating aging facilities and systems inevitably results in the need for new repairs rising unexpectedly, which forces program managers to constantly have to juggle priorities to address them.

Figure 3: Road Damage to Asphalt Roadway at Goldstone Facility

Source: NASA.

Figure 4: Water Intrusion to Internal Antenna Structure at Goldstone Facility

Source: NASA.

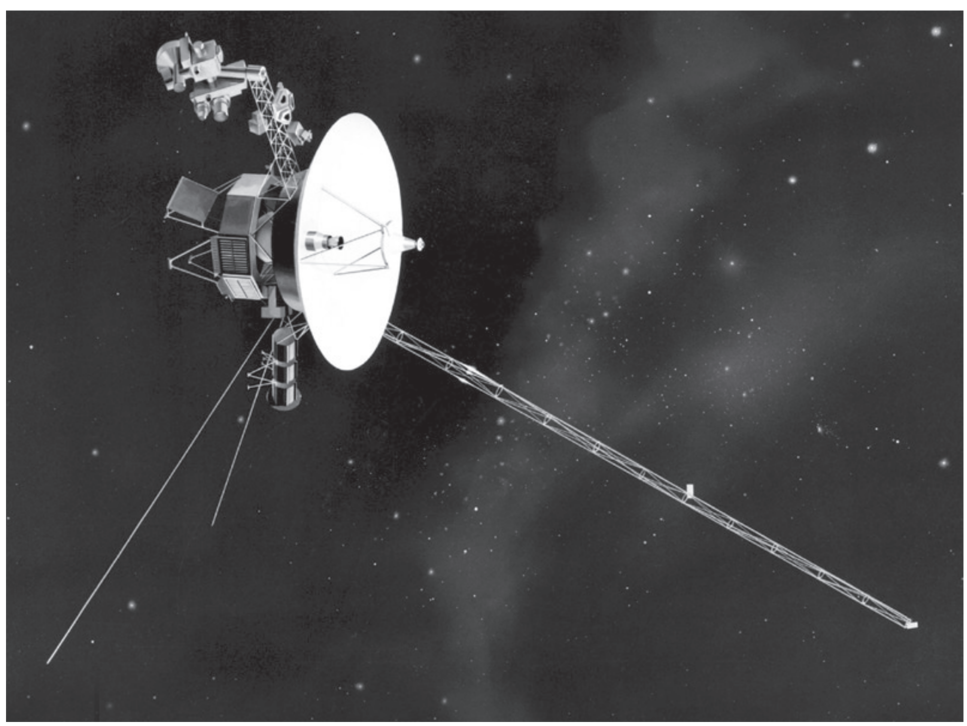
Limited Capacity to Provide Coverage Is Exacerbated By An Increasing Mission Set

DSN also faces increasing competition between new and old users for coverage time on the system. There is a growing demand for a level of service that DSN is not likely to be able to provide to its customers. DSN promises 95 percent availability to its mission customers for routine mission coverage. According to program officials, the remaining 5 percent is reserved for unexpected failures and downtimes during mission coverage. They said DSN can maintain its 95 percent commitment to its mission customers within its current mission set. However, as that mission set increases, officials become less confident in their ability to continue to achieve that level of service.

New missions are continuing to increase as they have in the past—by some 350 percent over the last 20 years. By the year 2020, DSN is projected to be required to support twice the number of missions it does currently. DSN officials thus find themselves faced with the need to balance this new demand with an equally compelling demand from existing “legacy” missions that have remained operational beyond their original lifetimes but are still returning science data and need to be maintained. Such legacy missions include the following:

- The Voyager missions—two similar spacecraft launched in 1977 to conduct close-up studies of Jupiter and Saturn, Saturn’s rings, and the larger moons of the two planets—are still supported by DSN today even though their primary missions were completed in 1989. Each mission receives approximately 12 hours of coverage each day using one of the network’s 70-meter dishes.

Figure 5: Voyager I Mission Spacecraft



Source: www.nasa.gov.

- The Mars Rover missions, although scheduled to end their prime missions in mid-2004, have gone well beyond their forecasted lifetimes. Program officials pointed out that even though they did not have a role in the decision to extend the missions, the program continues to allocate funds to support their operations through present day.

Figure 6: Mars Exploration Rover

Source: www.nasa.gov.

It is up to the DSN program to determine how best to provide service to its many mission customers, but this task is becoming increasingly complex. The effort to balance conflicting program priorities is a continuing struggle for DSN program managers. So far, DSN has been able to avoid stressing the capacity of the system because a select number of missions it was scheduled to support were either canceled or failed before requiring significant support. However, according to program officials, if the number of missions the system is scheduled to support begins to increase, the amount of service the system can provide will be limited. Further, officials expect that any commitments to provide support for manned missions under the coming Vision for Space Exploration, in addition to what it currently must support, will prevent them from being able to provide necessary coverage to new mission customers or maintain the service guarantee of 95 percent availability to any customer.

In addition, the DSN program is planning to begin decommissioning its 26 meter antennas in 2006 due to costs of maintenance associated with their age. Officials told us that they believe the program's remaining 34- and 70-meter antennas will be unable to sustain the anticipated workload in the very near future, and one projection is that the system will reach capacity in 2013. If this occurs, the opportunity to continue adding new mission customers will be limited and the potential for lost deep space science is significant.

Existing Management Structure Does Not Allow NASA to Match Space Communications Resources With Requirements

DSN's future utility is also in question because NASA currently does not have a mechanism in place to match funding for space communications assets with program requirements, such as infrastructure and technology development needs, from an agency wide perspective. At the end of 2003, NASA created the Space Communication Coordination and Integration Board with the intent of reviewing requirements for integration of space communications assets into a seamless architecture, but according to agency officials, the Board does not review individual program requirements or have any authority over the allocation of resources to the space communications programs. Instead, funding for space communications capabilities is controlled by the individual communications programs and their associated mission directorates, who may not consider agency wide goals when making investments. This disconnect between requirements and resources has caused program level requirements to be given low priority by the agency, which in turn has forced programs to make tradeoffs to maintain functionality and has offered the potential for programs to make investments that may undercut agency wide goals for space communications. In light of this problem, NASA has recently established a task group to identify ways to better address how to match agency requirements with program resources.

Agency Space Communications Oversight Board Establishes Limited Requirements

At the end of 2003, NASA created the Space Communication Coordination and Integration Board to establish technical requirements for the integration of NASA's space communications assets into a seamless communications architecture for the future. According to NASA officials, the Board is technical in nature and not intended to manage space communications, but rather focus on integrating the architecture. Further, officials said that no other agency-level entity reviews requirements for individual communications programs or establishes broader mission requirements for space communications. As a result, they informed us that program requirements, such as infrastructure and technology development needs, have consistently been given low priority by the agency. They said that the DSN program is forced to make tradeoffs to maintain functionality, but it is not able to fully address its requirements and has concerns about its ability to continue supporting the operations for which it is entrusted.

Currently, identification of appropriate investment resources (in line with decisions made about the architecture) is performed by the mission directorate with responsibility over the program and the program's customers. There is no overarching entity for space communications management at NASA to consider the specific investment needs of the programs and direct funding accordingly. And while all programs are supposed to consider the broader needs of the agency and other programs in their investment decisions, officials informed us that there is no formal oversight mechanism to ensure that investment decisions made at the program level are in line with those broader requirements.

As a result of this mismatch between agency level requirements and investment decisions for the programs that support those requirements, NASA has limited ability to prevent competing programs from making investments that, while supporting individual program requirements, undercut broader agency goals. For example, several agency officials noted both the Deep Space Network and the Ground Network programs recently were on a path to develop separate array technologies to support overlapping requirements for the same lunar missions, which would have undercut agency efforts to create a seamless, integrated architecture for space communications and would have represented unnecessary duplication of effort and added costs. But officials said these pilot efforts were terminated after much of the planning for them had taken place. However, the termination was a result of budget constraints and lack of clearly defined requirements, as opposed to a decision by an authority with an agency wide investment perspective. In addition, another potential DSN customer—the Solar Dynamic Observatory—recognized that DSN could not provide it with the service it needed, so it invested in its own communications antennas to provide the coverage it needed. Such duplication undermines the original intent of DSN to be an efficient, single network for NASA's deep space communications on Earth.

NASA Efforts Address Mis-Match Between Requirements, Resources

During the course of our review, NASA established a task group to address how best to manage the agency's space communications programs so program resources are invested in a way that supports agency wide goals. The task group has yet to make any recommendations to address these issues.

Currently, the task group must consider two primary competing viewpoints within the agency. One viewpoint holds that the current structure of space communications, in which mission directorates and programs control resources, is ideal because it allows communications support to be controlled by the same entity that establishes and funds the programs that use the system. For example, DSN is funded by the Science Mission Directorate, which also supports the vast majority of missions that the DSN serves. Some agency officials believe that this approach provides better customer service, since resource trade-offs can be made by those closest to both the customers and the service provider. However, under this current structure, maintenance requirements for DSN have consistently been deemed a low priority.

Alternatively, others in the agency point to the success of a more centralized space communications structure, as was in place before 1995. Under this structure, resource decisions can be made in light of an overall agency perspective on which communications program can best fulfill agency wide communications goals. However, one official suggested that under this structure, maintenance requirements for DSN could become an even lower priority as the requirements of other programs are considered. In the former case, a program like DSN must compete for funding against individual missions. In the latter case, a program like DSN will compete for funding against other space communications assets.

Conclusion

By establishing DSN as the primary communications system for supporting deep space missions, NASA will be reliant on the system for mission successes—both now and in the distant future. By virtue of this reliance, NASA has a responsibility to ensure that the system is operationally sound and meets user needs. The system faces challenges that call into question how well it will continue to be able to adequately support deep space missions. The potential for more significant system failure and major disruption to the deep space exploration program, both manned and unmanned, looms large if nothing is done to address the condition of DSN. As NASA continues to depend on the program for meeting its deep space communications requirements, the program and the agency will have to determine what those requirements are and how they can best meet those requirements with a viable system for the future. Establishing these requirements in terms more comprehensive than just being able to provide coverage for 95 percent of committed time will provide for a better understanding of what is needed by the program. Furthermore, quantification and characterization of such requirements in more comprehensive terms will be critical to the development of a plan as required under the 2005 NASA Authorization Act.

As NASA prepares to take on extensive exploration initiatives under the President's Vision for Space Exploration, the agency needs to position itself to make investment decisions from an agency-wide perspective. Currently, because NASA does not consider program level requirements when planning agency wide commitments for space communications, many of these program requirements, such as infrastructure needs, are not being addressed, which means they will worsen and inhibit the agency's ability to support future space exploration initiatives. Also, since space communications programs have the ability to direct resources to investments, investments made may not support agency wide requirements conducive to a broader and possibly more efficient space communications capability for the agency. As NASA begins to commit more resources to deep space exploration in the future, the agency must ensure that it properly addresses the communications needs of all of its missions and makes investments from that viewpoint. NASA has the opportunity to address this issue through a newly created task group charged with analyzing how this can best be achieved.

Recommendations for Executive Action

To better position the Deep Space Network to meet existing workload challenges and prepare the network for future deep space communications responsibilities, we recommend that the NASA Administrator direct DSN to (1) identify total program requirements for deep space communications capabilities for the near and long term, in terms better defined than the single coverage commitment of 95 percent, (2) determine the extent to which the program's current capabilities can support those identified requirements and (3) develop a plan to address any gap between those capabilities and requirements and identify the estimated costs of any enhancements needed.

As NASA's task group on space communications considers how program requirements can be better integrated into overall agency goals for space communications capabilities, we recommend that the NASA Administrator direct the group to consider the following in carrying out its task: (1) identify what priority program-level requirements have in agency-level decisions affecting space communications, (2) determine how program-level requirements for space communications programs can be identified and communicated to agency-level decision makers, and (3) establish how the agency can identify program-level investments needed to address program requirements that support agency wide goals for space communications and how to coordinate those investments to avoid duplication and additional costs. While considering these recommendations and the task at hand, the group should also consider the importance of having shared knowledge and communication about these issues openly with all entities involved.

Agency Comments and Our Evaluation

NASA concurred with our recommendations. In commenting on the draft of our report, NASA pointed out that it already had a plan in place that addresses our first set of recommendations, namely the need for the agency to identify all DSN requirements for the near and long-term, how it will meet those requirements, and identify costs associated with meeting those requirements. While we recognize that NASA has a DSN Roadmap, the agency still lacks a detailed strategy for addressing DSN needs for the future that includes all program requirements, i.e. deferred maintenance, in addition to the already projected mission needs. Furthermore, the DSN Roadmap does not include estimation of costs and does not address the impact of unmet needs on its ability to meet mission requirements.

NASA also commented that the DSN has not been responsible for the loss of missions. Our report does not state that missions were lost because of the DSN. However, NASA officials provided GAO evidence that mission science had been lost as a result of disruptions in the operation of DSN, and that point is characterized in the report.

As agreed with your offices, unless you announce its contents earlier, we will not distribute this report further until 30 days from its date. At that time, we will send copies to the NASA Administrator and interested congressional committees. We will make copies available to others upon request. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841 or lia@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are acknowledged in appendix III.

Allen Li, Director
Acquisition and Sourcing Management

Appendix I: Objectives, Scope, and Methodology

To identify the challenges facing NASA's Deep Space Network program in meeting its current and planned space communications workload, we performed the following:

- We obtained and analyzed NASA documents and briefing slides related to the operation and capabilities of the Deep Space Network, including budget submissions and funding breakouts, workforce projections, missions lists, fiscal year 2004 and fiscal year 2005 Program Operating Plans, the DSN Strategic Roadmap, mission agreements, the memorandums of agreement with the host countries of the foreign DSN sites, a 2004 NASA-wide facilities condition assessment, deferred maintenance information and work breakdown system data, risk assessments for various aspects of the network, return on investment analyses for various technology upgrades and system performance and reliability data, including records of downtimes.

- We reviewed the NASA Vision for Exploration roadmaps and the National Research Council reports on those roadmaps, the Vision for Exploration Architecture report, and NASA Strategic Plan for 2005 and Beyond for information about the role of DSN in the Vision. We also reviewed previous GAO reports on infrastructure investment, technology development and deferred maintenance.

- We interviewed NASA mission officials to receive their feedback on the performance of DSN, including performance shortfalls, in meeting their needs and collected information related to those specific missions. We also discussed the nature of challenges experienced by the program through interviews with NASA and Jet Propulsion Laboratory officials and DSN contractor personnel and received written and oral responses from all.

To determine the extent NASA is integrating DSN into its space communications plans for the future, we performed the following:

- We collected and analyzed information related to space communications architecture management at NASA, including the NASA 4.0 Communication and Navigation Capability Roadmap, space communication architecture plans, descriptions of the various space communications assets intended to play a role in the future architecture, Memorandum of Agreement for the Management of NASA's Space Communications Networks, and a description of the history of space communications management at NASA.

- We held discussions with NASA space communications officials about future space communications architecture requirements, what assets the architecture will include, and how its development is being managed by the Space Communication Coordination and Integration Board (SCCIB) and Space Communications Architecture Working Group (SCAWG). We reviewed the charter of the SCAWG. We also discussed the budget development and execution process for DSN at the Science Mission Directorate (SMD) level, and how that impacts integration of the DSN into the overall agency space communications architecture.

- We met with NASA's Space Communications Organization Study Group, which was established during the course of our review, to discuss its task of identifying options for the management of space communications for the future of NASA space exploration. We also reviewed the Terms of Reference (TOR) for this group to better understand its goals and time frames.

To accomplish our work, we visited and interviewed officials responsible for DSN operations at NASA Headquarters, Washington, D.C.; the Jet Propulsion Laboratory in Pasadena, Calif.; and ITT Industries contractor officials at their offices in Monrovia, Calif., and at the DSN site complex in Goldstone, Calif. At NASA Headquarters, we met with officials from the Science Mission Directorate, including lead representatives from the Deep Space Network program, the Exploration Missions Directorate and the Space Operations Mission Directorate, including the Space Communications Architecture Working Group. We also met with DSN mission officials from the Mars Rovers, Deep Impact, Cassini-Huygens, and Stardust programs.

We conducted our review from May 2005 to April 2006 in accordance with generally accepted government auditing standards.

Appendix II: Agency Comments from the National Aeronautics and Space Administration

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

April 10, 2006

Mr. Allen Li
Director, Acquisition and Sourcing Management
United States Government Accountability Office
Washington, DC 20548

Dear Mr. Li:

Thank you for the opportunity to review and comment on the draft report entitled "NASA's Deep Space Network: Current Management Structure is Not Conducive to Effectively Matching Resources with Future Requirements (GAO-06-445)." In general, it identifies many of the issues and tradeoffs NASA faces daily in managing the Deep Space Network. Clearly, it is a challenge to balance the need to make the program responsive to specific users with the need to manage DSN as an Agency-wide asset. We appreciate GAO's acknowledgment of that balancing act. In the same vein, we agree with many of GAO's recommendations regarding the importance of conducting long-term planning for the future of the Deep Space Network, in particular the need to identify long-term requirements, assess current and projected capabilities against those requirements, and develop mechanisms for bridging any gaps. Those recommendations and our responses are discussed in greater detail below.

The GAO recommended "…that the NASA Administrator direct DSN to (1) identify total program requirements for deep space communication capabilities for the near and long term, in terms better defined than the single coverage commitment of 95 percent, (2) determine the extent to which the program's current capabilities can support those identified requirements, and (3) develop a plan to address any gap between those capabilities and requirements and identify the estimated costs of any enhancements needed."

NASA concurs with the recommendations and is, in many ways, already implementing them. As NASA moves forward with the program, the Agency developed a "Roadmap" to help guide the future of the Deep Space Network. The Roadmap proceeded in stages that mirror GAO's recommendations. First, it proposed a series of upgrades based on projected mission demands through 2030. Second, NASA circulated that upgrade plan within the user community and reviewed their input in order to ensure that the proposed upgrades aligned with future user needs. During the process, NASA also sought to identify and resolve likely gaps between future demands and future capabilities. Finally, the Roadmap was presented to the Agency-wide Space Communications Architecture Working Group (SCAWG), which in turn developed a

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future architecture. NASA is currently in the process of refining that architecture and estimating the costs of implementing it. We believe that GAO's recommendations on positioning the DSN to prepare for future communications responsibilities are very helpful and that the refined architecture and cost estimates will consider those recommendations.

The GAO raises important points about the difficulty of making tradeoffs between missions and the relative age of the Deep Space Network infrastructure. It notes instances in which these tradeoffs resulted in less-than-ideal outcomes. While we may take issue with some of the specific anecdotes GAO identified, the overall report will be helpful in educating the American people about the challenges of exploring space. NASA strives for the ideal outcome for all parties concerned, but the fact is that DSN does not have infinite capability, and it will be impossible to meet all of the potential demands of all of the potential users all of the time. With that in mind, I am concerned that the GAO report may create the wrong impression: that the DSN network as a whole is not currently meeting mission demands. In fact, NASA has never lost a mission due to issues associated with the DSN network. More importantly, no mission has been unable to meet its mission requirements due to a lack of capability in the DSN.

Nevertheless, NASA shares GAO's concerns about the future capacity and capabilities of the system. As I mentioned earlier, the road-mapping exercise that NASA initiated before GAO began its study will help us plan the system's long-term evolution. As GAO noted, however, not all of the issues associated with the DSN revolve around resources, capabilities, and requirements. So, NASA initiated a study to review the management structure for all NASA space communications. As noted in the GAO report, DSN has not always been managed under its current structure. An alternative may, in fact, be preferable given the evolution of the Agency. Our ongoing study, being conducted by the Office of Program Analysis and Evaluation (PA&E), will help answer that question in the broader context of the Agency's plan for space exploration. The PA&E study will take into account GAO's recommendations to: (1) identify program level requirements and their priority in Agency-level decision-making, (2) determine how program level requirements can be identified and communicated to Agency-level decision-makers, and (3) establish a process by which the Agency can identify the program-level investments needed to address program-level requirements that serve Agency-wide goals for space communications while avoiding duplication and excess cost. We will certainly keep your GAO team informed as to the result of our ongoing study.

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Thank you again for the opportunity to comment on the GAO report. I hope you will keep my comments, and those of NASA personnel, in mind as you complete and publish the study.

Cordially,

Shana Dale
Deputy Administrator

Appendix III: GAO Contact and Staff Acknowledgements

GAO Contact

Allen Li (202) 512-4841

Staff Acknowledgements

In addition to the individual named above, Brendan Culley, James Morrison, Sylvia Schatz, Robert Swierczek, Trevor Thomson, Hai Tran and Thomas Twambly made key contributions to this report.

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