COST MANAGEMENT ISSUES IN NASA'S ACQUISITIONS AND PROGRAMS

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

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March 5, 2009

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COST MANAGEMENT ISSUES IN NASA'S ACQUISITIONS AND PROGRAMS

THURSDAY, MARCH 5, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON SPACE AND AERONAUTICS,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:00 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Gabrielle Giffords [Chairwoman of the Subcommittee] presiding.

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON SPACE & AERONAUTICS
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515

Hearing on

Cost Management Issues in NASA's Acquisitions and Programs

March 5, 2009
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

WITNESS LIST

Mr. Christopher Scolese
Acting Administrator
NASA

Ms. Cristina T. Chaplain
Director
Acquisition and Sourcing Management
Government Accountability Office

Mr. Gary P. Pulliam
Vice President
Civil and Commercial Operations
The Aerospace Corporation

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HEARING CHARTER

SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Cost Management Issues in NASA's Acquisitions and Programs

THURSDAY, MARCH 5, 2009
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

I. Purpose

The House Committee on Science and Technology's Subcommittee on Space and Aeronautics will convene a hearing to review the status of the National Aeronautics and Space Administration's (NASA) efforts to improve the cost management of its acquisitions and programs. The hearing will focus on (1) the results of the Government Accountability Office's (GAO) just-completed assessments of selected large-scale NASA projects and its designation of NASA acquisition management as a "high-risk" area, (2) the causes of cost growth and schedule delays in NASA acquisitions and (3) the Agency's progress in addressing them.

II. Witnesses

Christopher Scolese
Acting Administrator
National Aeronautics and Space Administration

Cristina T. Chaplain
Director
Acquisition and Sourcing Management
U.S. Government Accountability Office

Gary P. Pulliam
Vice President
Civil and Commercial Operations
The Aerospace Corporation

III. Overview

When programs cost more to build and take longer than planned, NASA is able to accomplish less with the resources it is allocated. Confronted with specific instances of cost growth and schedule delay, the Agency is forced to either seek additional funds or make difficult trade-offs among its portfolio of projects such as shortening missions or removing instruments. An important factor in mitigating cost growth and schedule delay is accurate information with which to make decisions and cost projections. For more than a decade, GAO has identified NASA's contract management as a high-risk area—in part because of NASA's inability to collect, maintain, and report the full cost of its programs and projects. GAO has said that in the absence of such information, NASA would be challenged to manage its programs and control program costs. GAO has also underlined the importance of sound cost management in other reports. For example, in reporting on NASA's initial efforts to implement President Bush's 2004 *Vision for Space Exploration,* GAO said that in the past, NASA has had difficulty meeting cost, schedule, and performance objectives for some of its projects because it failed to adequately define project requirements and quantify resources.

It is important to note that while essential to ensuring timely, effective and efficient acquisition of goods and services, integrating sound cost management in program management is not enough. For example, there must be transparency and clarity in the decision about whether design and development is appropriately performed internally or acquired from external sources. In addition, an emerging issue requiring NASA's focused attention is the impact of the growing number of bid protests lodged by vendors not selected in response to several of its procurements, such as those for new space suits (since resolved) and Commercial Resupply Services for

the International Space Station. Awaiting the outcome of such bid protests can have adverse impacts on the Agency's planned schedules and program budgets. Potential means of minimizing the impact of protests range from ensuring proposal evaluations are defensible to guarding against any appearances of conflict of interest in evaluation panelists and advisory review group members chosen. Finally, successful acquisition outcomes require a skilled and motivated acquisition work force. The NASA Project Management Study completed in 1981 concluded that

> *"Good people are the key to good project management. Sound project planning, management practices, and source evaluation approaches are all important. However, they cannot substitute for having high quality, and highly-motivated people responsible for project management; both inside and outside of government."*

As GAO has indicated, NASA's need to effectively manage its programs will gain even more importance as the Agency seeks to manage its wide-ranging portfolio in an increasingly constrained fiscal environment. While today's hearing will focus specifically on cost management, the Committee on Science and Technology will continue to monitor and review a range of issues that impact NASA's ability to acquire needed goods and services in a timely, cost effective and efficient manner.

IV. Potential Hearing Issues

The following are some of the potential issues that might be raised at the hearing:

- *What are the main causes of cost growth and schedule delays in NASA programs and projects? Is there a consensus on what causes cost growth and schedule delay? Are there any similarities with those experienced by the Department of Defense and other federal agencies in their acquisition of space systems?*
- *What has NASA done to mitigate cost growth and schedule delay? Can other federal agencies benefit from NASA's corrective actions?*
- In light of continued instances of cost growth and schedule delay in key programs such as Mars Science Lander and Glory, how effective have NASA latest efforts been?
- *What more needs to be done to mitigate cost growth and schedule delay in NASA programs?*
- *Why is NASA acquisition management still characterized by GAO as a high-risk area after 18 years?*
- *What has NASA done in response to GAO's characterization that NASA's acquisition management is a high-risk area?*
- *What must NASA do to warrant removal from GAO's high-risk list?*

V. Background

To effectively use public funds in carrying out its activities, the Federal Government is expected to employ sound management practices and processes, including the measurement of program performance. The Congress, Executive Branch officials, and the public want to know whether federal programs are achieving stated goals and what their costs are.

The Importance of Developing Reliable Cost Estimates

As stated in GAO's *"Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs"* [GAO–09–3SP], cost estimates are necessary for government programs for many reasons: supporting decisions about whether to fund one program over another, developing annual budget requests, and evaluating resource requirements at key decision points. Moreover, as stated in GAO's guide, having a realistic estimate of projected costs makes for effective resource allocation, and increases the probability of a program's success.

GAO's guide defines a cost estimate as the summation of individual cost elements, using established methods and valid data to estimate the future costs of a program, based on what is known today. The management of a cost estimate involves continually updating the estimate with actual data as they become available, revising the estimate to reflect program changes, and analyzing differences between estimated and actual costs.

The guide further states that the ability to generate reliable cost estimates is a critical function. Without this ability, agencies are at risk of experiencing cost overruns, missed deadlines, and performance shortfalls—all recurring problems that GAO's program assessments have revealed. Furthermore, cost increases often mean

that the government cannot fund as many activities as planned or deliver them when promised.

Cost Growth and Schedule Delays in NASA Programs

The need to mitigate cost growth and schedule delay in NASA programs is not a new concern. As early as 1981, it was identified by the NASA Project Management Study. In an article featured in NASA's *ASK* project management publication, Dr. C. Howard Robins, former Deputy Associate Administrator for Space, said that the study, colloquially referred to as the "Hearth Study," would *"come to be viewed within NASA as a landmark."* Both the House Committee on Science and Technology and House Committee on Appropriations requested the study due to congressional concerns about cost and schedule performance problems. The House Science and Technology Committee letter dated September 19, 1980 to NASA stated:

> *"A number of large projects, for example Galileo, LANDSAT–D, space telescope, and ISPM, are experiencing cost and schedule problems."*
>
> *"The Committee encourages NASA to take the necessary steps to minimize the cost and schedule impact of the problems associated with these ongoing programs. Further, the Committee has authorized new starts in the space and applications area and is anxious that sound project management principles be applied from the beginning of these new programs."*

The 1981 study was the first multi-project study of program/project management by NASA and also the first study of the topic by an agency-wide NASA team. Langley Research Center Director Donald P. Hearth led a team that studied thirteen robotic projects, including projects such as Viking and Voyager, undertaken over a twenty-two-year period.

The study found significant problems, including inadequate project definition and over-optimism during advocacy. Several recommendations were made, such as requiring a formal definition review prior to the NASA decision to include the project in its budget request. A more detailed list of conclusions and summary recommendations made in the Hearth Study are included in Appendix A. More importantly, the study said that its conclusions and recommendations should be viewed with the following comments in mind:

> *"During recent years, several projects have experienced major cost increases without apparent forewarning. This has damaged NASA's credibility and reputation for successful project management. Actions by NASA management are, therefore, necessary; particularly, in light of NASA's external environment and the pressures on government budgets.*
>
> *The Study Team verified, from its examination of a group of representative projects that the cost performance of a project is closely related to the application of sound project management principles and/or the use of available management tools. Therefore, the Study Team's Conclusions and Recommendations are not intended to suggest the superposition of either an additional hierarchy of management, or the addition of new management tools within the current NASA system. Rather they stress the need for continuing application of the basic principles of sound project management by NASA, refinement of existing management tools, and the continuing verification, by NASA's top management, that the principles are being followed and available tools are being used."*

In ensuing years, NASA cost growth and schedule issues were conducted in its robotic and human space flight mission areas, including the International Space Station. More recently, the issues of cost growth and schedule delays in NASA programs have been addressed in legislation and analyzed in studies by GAO, the National Research Council (NRC), and NASA itself.

NASA Authorization Act of 2005

Cost growth and schedule delay were addressed in the *NASA Authorization Act of 2005* (P.L. 109–155). Provisions were enacted to help NASA and Congress spot potential cost growth and schedule problems early in the development phase of a major program. Rather than discouraging risk taking, these provisions were intended to encourage NASA managers to identify risks as early as possible, when they are more readily managed and solutions are more easily implemented.

- Under the 2005 Act, a Baseline Report is required whenever a major program completes required reviews and is approved to proceed to implementation. NASA's policy defines a project life cycle in two phases—the formulation and implementation phases. During the formulation phase, projects develop and

define requirements and lead up to a preliminary design review. Projects also complete development of mission-critical or enabling technology with associated demonstrations. The implementation phase begins after project confirmation.

After completing the Baseline Report, the Act requires NASA to report periodically on a major program through an Annual Report, which is provided as part of the annual agency budget submittal to the Congress, until the program enters operation. The provision defines a major program as an activity with a life cycle cost estimate greater than $100 million. Having established the baseline, the 2005 legislation sets thresholds that, if exceeded, require agency action. Notification to Congress and an internal evaluation are required in the event that any major program exceeds its originally estimated development cost by more than 15 percent or exceeds its originally planned schedule by more than six months. The Act also requires Congress to evaluate whether to continue the major program in the event that it exceeds its originally estimated development cost by more than 30 percent or $1 billion.

- The *NASA Authorization Act of 2000* was amended to better reflect current mission cost categories by increasing the cost threshold that could trigger an independent cost analysis from $150,000,000 to $250,000,000 and by requiring the Administrator, rather than the chief financial officer, to conduct the independent cost analysis.

NASA Authorization Act of 2008

Concerns regarding the increasing number of Earth science missions that were exceeding the 15 percent threshold established in the *NASA Authorization Act of 2005* prompted a requirement in the *NASA Authorization Act of 2008* for an independent review of the situation. Specifically, the Act directs the NASA Administrator to arrange for an independent external assessment to identify the primary causes of cost growth in large, medium, and small space and Earth science spacecraft mission classes. The external assessment is to also identify recommendations and provide a report within 15 months of the enactment of the Act. The National Research Council has been tasked by NASA to perform this review.

In addition, the Glory program was reauthorized in the *NASA Authorization Act of 2008,* responding to the requirement in the 2005 *NASA Authorization Act* that Congress evaluate whether to continue a major program in the event that it exceeds its originally estimated development cost by more than 30 percent.

GAO Reports

GAO has issued a number of reports dealing with cost and schedule problems in NASA's programs and with NASA's acquisition process:

- In its report of May 2004 on what it described as NASA's lack of disciplined cost-estimating processes [GAO–04–642], GAO stated that the considerable flux it found in NASA's program cost estimates—both increases and decreases—was an indication that NASA lacked a clear understanding of how much its programs will cost and how long they will take to achieve their objectives. GAO found that the development cost estimates for more than half of the 27 programs it reviewed had increased, and that for some programs, this increase was significant—as much as 94 percent. GAO also reported that NASA's basic cost-estimating processes—an important tool for managing programs—lacked the discipline needed to ensure that program estimates were reasonable. GAO recommended that NASA take a number of actions to better ensure that the Agency's initiatives result in sound cost-estimating practices and are integrated into the project approval process. NASA concurred with GAO's recommendations.
- In March 2005, GAO reported [GAO–06–634] that the James Webb Space Telescope (JWST) program increased its life cycle cost estimate from $3.5 billion to $4.5 billion and extended its schedule by almost two years. More than a third of the cost increase was caused by requirement additions and other changes. An increase in the program's contingency funding ["reserves"] accounted for the remainder—about 12 percent—of the growth. About half of the cost growth was due to schedule slippage. A delay by the Administration in approving the use of a European Space Agency-supplied Ariane 5 launch vehicle resulted in a one-year delay; an additional 10-month slip was caused by NASA's budget profile limitations in fiscal years 2006 and 2007.

GAO reported that although the JWST program revised its acquisition strategy to conform to NASA's acquisition policies, the program still faced considerable challenges because it has not fully implemented a "knowledge-based" approach to its acquisition. For example, GAO noted that when program officials initiated work and before the JWST program revised its acquisition strategy, these officials had intended to have NASA commit to program start with immature technologies and without a preliminary design. Despite the program's change in acquisition strategy to address GAO's concerns, GAO concluded that the revised plan still might not permit the maturity of key technologies to be adequately tested prior to program start. Consequently, GAO recommended that the NASA Administrator direct the JWST program to (1) fully apply a knowledge-based acquisition approach to ensure that adequate knowledge is attained at key decision points and (2) continue to adhere to NASA acquisition policy and go forward only after demonstrating that it is meeting incremental knowledge markers and has sufficient funds to execute the program. NASA concurred with GAO's recommendations.

- Following a review requested by this Committee's then-Ranking Member, Rep. Bart Gordon, GAO reported in December 2005 [GAO–06–218] that while NASA's revised policy for developing flight systems and ground support projects incorporated some of the best practices used by successful developers, it lacked certain key criteria and major decision reviews that support a knowledge-based acquisition framework. For example, NASA's policy requires projects to conduct a major decision review before moving from formulation to implementation and that prior to moving from formulation to implementation, projects must validate requirements and develop realistic cost and schedule estimates. However, as GAO found, NASA's policies did not require projects to demonstrate technologies at high levels of maturity before program start. By not establishing a minimum threshold for technology maturity, GAO said that NASA increased the risk that design changes would be required later in development, when such changes are typically more costly to make. GAO made several recommendations to help ensure NASA uses a knowledge-based acquisition approach in making informed investment decisions. NASA concurred with GAO's recommendations.

  In releasing GAO's report, Rep. Gordon said:

  > *"As NASA embarks on an initiative to return American astronauts to the Moon—an endeavor estimated to cost more than $100 billion over the next 13 years—we need to have confidence that the Agency will be good stewards of taxpayer dollars." He added "In its report out today, the GAO offers some common sense recommendations aimed at reducing the chances that NASA's projects will suffer cost growth and schedule delays. I hope NASA will take the GAO's guidance seriously."*

- This week, GAO released its report [GAO–09–306] assessing the status of 18 large-scale projects at NASA. GAO's independent assessment was conducted in response to the explanatory statement of the House Committee on Appropriations accompanying the *Consolidated Appropriations Act of 2008;* the Committee on Science and Technology was a co-requester of the assessment. Ms. Cristina Chaplain, a witness at this hearing, directed GAO's work and will highlight the report's findings to the Subcommittee. GAO compared projects against best practice criteria for system development including attainment of knowledge on technologies and design. The office found that 10 out of 13 projects that had entered the implementation phase of the project life cycle experienced significant cost and/or schedule growth. For those projects, GAO found that development costs increased by an average of 13 percent from baseline cost estimates that were established just two or three years ago; average launch delay was 11 months.

  As an illustration, the development cost of the Mars Science Laboratory (MSL) increased in the past year by over $200 million—more than a 26 percent increase and now stands at over $1.2 billion. GAO anticipates that the MSL's development cost will be even greater due to the launch being delayed from October 2009 to 2011, a 25-month delay. Initially scheduled for September 2009, the next window of opportunity for a Mars launch occurs in the October/November 2011 timeframe. NASA notified the Committee of that delay in December 2008, with the Agency stating that a 2009 launch would be too risky because of technical uncertainties. Regarding the challenges faced by MSL, GAO reported that the program relied on several heritage technologies that had to be re-designed, re-engineered, or replaced. For exam-

ple, the heat shield made of a light-weight material had flown on previous missions and was considered nearly ready. But a setback in testing forced NASA to select a new and less mature technology. Also, the initial decision to use dry lubricated lightweight titanium gears for rover actuators had to be revisited when NASA found, during fabrication, that the gears would not meet its durability needs. As a result, the project has had to revert to heavier stainless steel gears with a wet lubricant used by prior projects. To keep the lubricant from freezing in Martian temperatures, the project also had to add heaters. GAO said this increased the mass of the MSL's rover.

The underestimation of complexity resulting from the planned use of new or heritage technology is not unique to the MSL mission. GAO said that many of the projects reviewed indicated that they had experienced challenges in developing new technologies or retrofitting older technologies as well as in managing their contractors. From a general standpoint, NASA projects faced difficulty understanding the risks and challenges they were up against when they started their efforts. Challenges GAO identified included technology maturity, design stability, complexity of heritage technology, contractor performance, and performance by a development partner such as an international space agency. GAO did not make recommendations in this report as it acknowledged that NASA was undertaking an array of initiatives aimed at improving program management, cost estimating, and contractor oversight. However, GAO said that NASA would benefit from a more disciplined approach to its acquisitions and called for continued attention to NASA's efforts to enable the Agency to maximize the effectiveness of its acquisition investments.

NRC's Review of NASA's Beyond Einstein Program

NRC released a report in September 2007 entitled *"NASA's Beyond Einstein Program: An Architecture for Implementation."* Prompted by Congress and the Office of Science and Technology Policy, NASA and the Department of Energy asked the committee to assess the five proposed mission concepts for achieving the goals of the Beyond Einstein space-based physics research initiative, and recommend one for first development and launch.

As part of its charge, the committee was tasked with determining the realism of preliminary technology and management plans, and cost estimates of the candidate Beyond Einstein mission set. Five mission areas—Joint Dark Energy Mission, Black Hole Finder Probe, Inflation Probe, and Einstein Great Observatories—comprised 11 mission candidates. Criteria used by the committee included plans for the maturing of critical mission technology, technical performance margins, schedule margins, risk-mitigation plans, and the proposal's estimated costs versus independent probable cost estimates prepared by the committee.

The committee worked with an experienced outside contractor to develop independent cost estimates and a probable cost range for each candidate mission. The probable cost ranges were also compared with those of previous missions of similar scope and complexity. In all cases, the committee found higher costs and longer schedules than those estimated by the mission teams. The committee observed that this is typical of the differences between the estimates developed by mission teams and by independent cost estimators at this early stage of a program. Given the long history of missions comparable to the Beyond Einstein mission candidates, the committee said that it believed that the most realistic cost range for each of these missions is significantly more than the current estimates provided by the research teams.

In discussing its assessment of mission readiness, the committee stressed the importance of technology readiness as a key consideration in the decision to proceed to mission development. The committee said that ideally, mission development should not commence until all new technologies necessary for mission success have reached a certain level of technology readiness. Experience has shown, the committee added, *"that NASA and other missions pay the price when a mission enters development prematurely."*

NASA Self-Examinations

NASA research on incidents of cost and schedule growth and their causes is conducted by a number of organizations and individuals. Typically, according to NASA, this research is intended to assist the organization in evaluating performance trends; evaluate the effectiveness of their own organizational processes, tools and methods; and develop proposals for changes to their organization, processes, methods, and tools. NASA's Office of Program Analysis and Evaluation (PA&E) performs

studies on an on-going basis and the topic of cost growth is frequently discussed at NASA Project Management Workshops and Cost Community Events such as a Cost Symposium. Because there is no clearinghouse for all cost estimating research being undertaken within NASA, the full extent of the Agency's research in cost growth and schedule delay cannot be fully characterized. Nonetheless, the following four examples are illustrative of self examinations the Agency has undertaken in recent years.

- In February 2004, NASA completed an analysis comparing initial and final budget estimates of development costs for 45 recent projects and computed percent budget growth as a surrogate for cost growth. The analysis found that an average cost growth of 36 percent and a median growth of 26 percent; 35 of 45 projects exceeded the initial budget estimate. The relative change from the total of the 45 initial budgets to the total of the 45 final budgets indicated a total growth of 28 percent. In comparing historical budget growth trends in the Department of Defense (DOD) and NASA as well as describing the cost-estimating process changes made by DOD, NASA analysts suggested that NASA cost-estimating processes were in need of reform. But the analysts also listed a number of changes already in progress that would have beneficial impact, such as the then near-release of an update of NPR 7120.5 codifying the requirement for an Independent Program Assessment Office project review prior to the two key project milestones and requirements for a Cost Analysis Requirements Description (CARD) and a full continuum of sound cost- and program management practices; updating of NASA's Cost Estimating Handbook; and development of training tools for program managers. But the analysts also indicated that still needed was a method for capturing project cost, technical, and schedule data recorded in a standardized format and collected at a reasonable frequency.

- At a NASA Cost Symposium in July 2007, analysts from the Aerospace Corporation and NASA conducted a presentation entitled *"Using Historical NASA Cost and Schedule Growth to set Future Program and Project Reserve Guidelines."* Analysts discussed their investigation of the cost and schedule growth history for 40 science missions—the "mission set." By looking at historical schedule and cost growth, analysts sought to determine whether the past could be used to establish guidelines for the levels of reserves needed for future missions.

  Reserves are unallocated funds that are provided to counter risks to costs and schedule that are unanticipated; they reduce the probability that actual costs will overrun estimates. In essence, they act as contingency funds to address circumstances or outcomes that were not conceived of by an observer at a given point in time—what is commonly known in project planning as "*unknown* unknowns." In contrast, "known unknowns" refers to circumstances or outcomes that are known to be possible, but for which it is unknown whether or not those outcomes or circumstances will be realized.

  Examination of the historical data set by the analysts from Aerospace and the Science Mission Directorate (SMD) showed that the majority of projects had experienced cost and schedule growth and that this cost and schedule growth was substantial. The average cost and schedule growth for the mission set was 27 percent and 22 percent, respectively. Analysts said the data highlighted that the primary internal reason for cost and schedule growth was instrument development issues, and the fundamental external reason for the growth was launch vehicle delay.

  Analysis of project reserves was challenging to the analysts. This is because reserve levels are not explicitly identified in NASA budget documents. Using NASA backup budget documents and other sources, analysts were able to identify reserve values for eighteen of the forty missions were obtained. The cost reserve levels held by each mission varied from 10 to 30 percent while the average reserve was on the order of 18 percent. Additionally, although specific schedule reserve could not be identified from the budget, a general industry rule of thumb that was prevalent when these missions were developed was that a mission should carry one-month of schedule reserve for each year of development. This equates to an 8.3 percent schedule reserve for the project.

  Suggestions provided by analysts from Aerospace and SMD included doing the following:

- Requiring better technical and programmatic definitions at the beginning of a project
- Independently assessing design and cost/schedule assumptions
- Performing earlier instrument development to reduce risk
- Holding instrument CDR prior to spacecraft and mission PDR
- Considering increased cost and schedule reserves for projects, some to be held outside the project.

"Best Practices" for the control of cost and schedule in a project were also identified, including:

- Proper mission scoping
- Robust initial cost and schedule estimate
- Monthly estimates to complete
- Importance of managing to schedule
- Effective Use of Earned Value Management (EVM). Both the IMAGE and Stardust missions used EVM. EVM is a technique that compares the value of work accomplished during a given period with the work scheduled for that period. By using the value of completed work as a basis for estimating cost and time needed to complete the program, earned value can alert program managers to potential problems early in the program. As was stated for the IMAGE mission: *"The Earned Value system worked well as an early indicator of cost problems ahead."*

Analysts also stated that the real problem is that there is no incentive for any project manager to underrun cost estimates. They said that in today's culture, an underrun is considered evidence that the project manager did not do enough testing or analysis or should have added another instrument or made the resolution better. A secondary problem identified by the analysts was that project managers do not have the authority to control costs, such as not being able to remove excess personnel without Center Director approval. Until more control is given to the project manager and incentives are put into place to return funding, analysts concluded that cost growth will still occur.

- In March 2008, NASA's SMD, assisted by the Science Applications International Corporation (SAIC) presented a summary overview entitled *"SMD Cost/Schedule Performance Study"* before the NASA Advisory Council's Planetary Science Subcommittee. The objective of the study was to evaluate the cost/schedule performance record of selected SMD flight projects to determine key drivers of cost/schedule performance, and implementation approaches that enhance performance of SMD missions. Project Managers and other key staff members were interviewed to collect narrative descriptions to compare with and explain the detailed historical data. Among its findings, the study showed that:
  - Cost history data for 21 of the 24 projects studied indicated cost growth. Total cost growth from the start of the design phase to Estimate-to-Complete (ETC) at Launch for all projects studied represented a combined impact of $2.0 billion to SMD's mission portfolio.
  - Schedule history data indicated schedule slips for 19 of the 24 projects studied. The delays ranged from five to 42 months.
  - Interview comments by eight projects cited early planning deficiencies as a significant source of development problems (underestimates, inexperience, inadequate early technology investment, and/or design heritage that was not realized).
  - The four projects that reported using EVM as a management tool showed lower average growth in development costs compared to projects that did not use EVM.

Regarding the key drivers that affected cost/schedule performance for SMD projects, internal factors identified were over-optimism early in the project's formulation phase, as instrument development complexity. Launch service issues and unstable or inadequate initial funding profiles were cited as the most common external factors affecting cost and schedule. Among the study's recommendations to mitigate cost growth and schedule slips was one that SMD require more rigor in the process used to generate early cost and schedule estimates and establish a minimum set of requirements for a credible

basis of estimate for mission concept costing. It was also recommended that projects be encouraged to include more conservatism in base estimates early in the process and be required to carefully evaluate all key project assumptions including design heritage credits.

- At a presentation before the Goddard Space Flight Center Symposium in June 2008, a member of the Aerospace Corporation discussed perspectives on mission cost and schedule performance trends, building on his team's review of 40 NASA robotic science missions. The team's findings included the following:
  - While estimates become more accurate as a project matures, the greatest growth manifests itself late in the project during integration and test.
  - Data highlighted that the primary reason for cost and schedule growth is internal project technical and development issues often associated with instruments.
  - Initial project estimates may be unreliable due to design and technology immaturity and inherent optimism.
  - Better technical and programmatic appraisal early in the life cycle is needed along with independent assessment of design and programmatic assumptions.

  In addition, the team analyzed the relationship between cost, schedule and complexity. A complexity index was established for the projects reviewed based on performance, mass, power and technology choices. The team plotted missions' cost versus complexity index and found a near linear rising "band" where successful missions cluster. On the other hand, those missions failed that were below that clustered range. This led the team to characterize this area as the "no-fly zone."

GAO's Characterization of NASA Acquisition Management as High-Risk

Since 1990, GAO has periodically reported on government operations that it identifies as "high-risk." This effort has brought focus to problems impeding effective government and costing the government billions of dollars each year. GAO's high-risk status reports are provided at the start of each new Congress. Historically, high-risk areas have been so designated because of traditional vulnerabilities related to their greater susceptibility to fraud, waste, abuse, and mismanagement. As GAO's high-risk program has evolved, it has increasingly used the high-risk designation to draw attention to areas associated with broad-based transformations needed to achieve greater economy, efficiency, effectiveness, accountability, and sustainability of selected key government programs and operations. In 1990, GAO designated NASA's contract management as high-risk in view of persistent cost growth and schedule slippage in the majority of its major projects. Since that time, GAO's high-risk work has focused on identifying a number of causal factors, including antiquated financial management systems, poor cost estimating, and undefinitized contracts.

In the January 2009 update of its high-risk list [GAO–09–271], GAO reported that since the 2007 high-risk update, NASA had taken significant steps to improve its acquisition management with the implementation of new policies and procedures and the development of a corrective action plan to address weaknesses in areas identified as high-risk by GAO. For example, NASA revised its acquisition and engineering polices to incorporate elements of a knowledge-based approach that should allow the Agency to make informed decisions. According to GAO, NASA is also instituting a new approach whereby senior leadership is reviewing acquisition strategies earlier in the process and developed broad procurement tenets to guide the Agency's procurement practices. Among procurement policy reforms, GAO noted that an earned value management procurement policy has been established and a requirement that all award fee contracts undergo a cost-benefit analysis has been codified to improve the likelihood that NASA is using its resources most effectively. GAO noted NASA's broad plan for reducing acquisition risk and observed that successful implementation of both the plan and revised policies should stem cost growth and schedule slippage.

However, GAO said that because cost growth and schedule delays persist, this area—now titled "acquisition management" because of the scope of issues that need to be resolved—remains high-risk. GAO added that to maximize NASA's investment dollars, implementation needs to be complemented by vigorous executive leadership to foster the expansion of a business-oriented culture and a sustained commitment to identify and take action on projects that are not achieving cost, schedule or per-

formance goals upon which they were based when they were initiated. Ms. Cristina Chaplain, who directed GAO's effort looking at NASA, is a witness at today's hearing and will highlight her team's findings.

Similarities Between NASA and DOD in Their Acquisition of Space Systems

GAO has reported that the costs for DOD space acquisitions over the past several decades have consistently been underestimated—sometimes by billions of dollars. For example, Space Based Infrared System High program costs were originally estimated at $4 billion, but the program is now estimated to cost over $10 billion. Estimated costs for the National Polar-orbiting Operational Satellite System program—conducted jointly by DOD, the National Oceanic and Atmospheric Administration and NASA—have grown from almost $6 billion at program start to over $11 billion.

GAO found in November 2006 [GAO–07–96] that, for the most part, cost growth in DOD space acquisitions has been caused by the tendency to start programs before knowing whether requirements can be achieved within available resources—largely because of pressures to secure funding. GAO reported that unrealistic program office cost estimates exacerbated space acquisition problems and that with budgets originally set at unrealistic amounts, DOD has had to resort to continually shifting funds to and from programs, and such shifts have had costly, reverberating effects.

GAO's analyses of six ongoing space programs shows some parallels with challenges faced by NASA. GAO found that original cost estimates were particularly unrealistic regarding the potential for savings from increased contractor program management responsibilities, the constancy and availability of the industrial base, savings that could be accrued from heritage systems, the amount of weight growth that would occur during a program, the availability of mature technology, the stability of funding, the stability of requirements, and the achievability of planned schedules. Ms. Cristina Chaplain, who directed GAO's effort looking at DOD's space acquisitions, is a witness at today's hearing and will highlight her team's findings. In addition, Mr. Gary P. Pulliam, from the Aerospace Corporation, has been asked to comment on whether there are any similarities in cost growth and schedule delays experienced by NASA and the Department of Defense/other federal agencies in their acquisition of space systems, and whether there are any "lessons learned" that would be applicable to these organizations.

Latest Actions by NASA to Address Cost Growth and Schedule Delay in Its Programs

In addition to agreeing to the recommendations made by GAO, NASA has implemented corrective actions on its own to address the issue of cost and schedule performance. For example, it has:

- Issued the 2008 NASA Cost Estimating Handbook (CEH), a reorganized and updated version of the 2004 handbook. According to NASA, the handbook provides useful information on cost estimating for the entire NASA Cost Estimating Community. It is meant to be both informative for the new cost estimator and a good reference document for the experienced cost estimator. Explanatory material accompanying the handbook indicates that based on the extensive feedback from the NASA Cost Estimating Community, the 2008 edition of the handbook has been streamlined to make references easy to find, simplified to make new initiatives easy to understand, and clarified to communicate key policy messages efficiently. The material also says that the handbook's information provides NASA-relevant perspectives and NASA-centric data useful in the NASA environment and facilitates the development of reliable, comprehensive, defensible, and well documented cost estimates.
- Instituted a policy of budgeting to the 70 percent confidence level. The policy, which is applicable to space flight and information technology programs and projects, is institutionalized in a new NASA Policy Directive (NPD 1000.5), effective January 15, 2009. Programs are to be budgeted at a confidence level of 70 percent or the level approved by an authority of the Agency-level management council. As an example, a 70 percent confidence level is the point on the joint cost and schedule probability distribution where there is a 70 percent probability that the project will be completed at, or lower than, the estimated cost and at or before the projected completion date. In the case of the Constellation program, the confidence level was set at 65 percent by then-Administrator Michael Griffin due to programmatic conclusions regarding the amount of technology heritage that would inform the Constellation designs.
- Emphasized educating NASA staff on the need for probabilistic cost and schedule estimating, how to do it, and providing enabling tools.

- Implemented independent assessments of projects through Standing Review Boards.
- Conducted in depth interviews with past NASA Program Managers to better understand root causes of cost growth and schedule delay. In particular, NASA recognized the need to fully understand which factors contributed the most.
- Collected ideas to improve cost and schedule estimates, such as spending more on R&D to mature technology readiness levels, developing instruments first, demanding better data to support claims at decision gates, and keeping requirements stable.
- Established, under the Office of the Chief Engineer, the Academy of Program/Project & Engineering Leadership (APPEL) which provides leadership, advice, direction, and support for the development and education of the NASA program/project management and engineering community. Among its numerous functions, the Academy facilitates the dissemination of "lessons learned" and "best practices" through knowledge sharing activities, including conferences, forums, publications, case studies, and communities of practice.

Risk Management and the Challenge of Containing Project Costs

Meeting technical and safety goals while also meeting programmatic constraints related to cost and schedule is a tremendous challenge. To that end, identifying and managing risks can be of significant help, as they are closely related to cost management efforts—initially in the planning of the project when costs are estimated and later during development when cost fluctuations invariably occur. Since mission success is the primary goal of any NASA activity, the Agency has recognized that effective risk management is critical to achieving that mission success. The implementation of a thorough, disciplined risk management approach is now required of all NASA programs and projects.

Because of the pressure to contain costs, difficult decisions often need to be made when unplanned increases occur. To manage cost increases, particularly when increased funding is not provided, NASA projects have in the past altered (1) the scope of the project, including the elimination of scientific instruments, (2) management oversight by reducing the number of personnel assigned to that function, and (3) the testing sequence or reduced the testing requirements.

When performed without sufficient recognition of risks, making such alterations can lead to catastrophic results as was demonstrated by the "lessons learned" activity following the failure of the Mars Climate Orbiter probe. That spacecraft, developed under the Faster, Better, Cheaper (FBC) mantra advanced by NASA in the 1990s, was lost as it was landing on Mars in September 1999. In its report on Project Management in NASA dated March 13, 2000, the Mars Climate Orbiter Mishap Investigation Board stated that:

> *"Greater attention needs to be paid to risk identification and management. Risk management should be employed throughout the life cycle of the project, much the way cost, schedule and content are managed. Risk, therefore, becomes the "fourth dimension" of project management—treated equally as important as cost and schedule."*

The Board also said that it saw strong evidence that the systems engineering team and the systems processes were inadequate on the project, adding that:

> *"Inadequate independent verification and validation of Mars Climate Orbiter ground software (end-to-end testing to validate the small forces ground software performance and its applicability to the software interface specification did not appear to be accomplished)."*

With regards to reduced oversight, the Board noted:

> *"To exacerbate this situation, the mission was understaffed, with virtually no Jet Propulsion Laboratory oversight of Lockheed Martin Astronautics' subsystem developments. Thus, as the mission workforce was reduced and focus shifted from spacecraft development to operations, several mission critical functions—such as navigation and software validation—received insufficient management oversight."*

The lesson learned, the Board said was that:

> *"In the era of "Faster, Better, Cheaper," projects and line organizations need to be extremely vigilant to ensure that a* **Mission Success First** *attitude propagates through all levels of the organization. A proper balance of contractor and*

project oversight by technical divisions at NASA field centers is required to ensure mission success and to develop a sense of ownership of the project by the institution."

Appendix A

NASA PROJECT MANAGEMENT STUDY
(January 1981)
(Known as the "Hearth Study")

OBJECTIVES

- To assess project management in NASA
- To identify generic reasons which aggravate cost and schedule growth
- To recommend appropriate actions by NASA

SUMMARY CONCLUSIONS

- Significant contributors to cost growth of several NASA projects
  - Technical complexity of projects
  - Inadequate definition prior to commitment
  - Effect of low contractor bids
  - Poor tracking of contractor accomplishments
- Significant contributors to good cost performance of several NASA projects
  - The function of the NASA project manager
  - Adequate definition prior to commitment
  - Proper planning and management of reserves
  - Early understanding between NASA and implementing contractor
  - Good implementation by NASA and contractor(s)
- Not significant factors in cost growth of several NASA projects
  - Inability to make cost estimates when project well defined
  - Non-utilization of classified technologies
  - Excessive influence of "users"
- Difficulty to quantify effect of high inflation has contributed to cost growth in recent years
- Use and definition of reserves not consistent within NASA
- Ground segments have experienced cost growth and are not well defined prior to implementation
- Management of some projects assigned to multiple NASA Centers without timely interface definition
- Concurrent developments increase risk substantially
- Other concerns
  - Industry's workload, interest in NASA work, etc.
  - Composition of NASA workforce.

SUMMARY OF RECOMMENDATIONS

- Continue to pursue technically-advanced projects. Expect cost growth in some future projects.
- Require pre-project analysis and definition phases. Sufficient definition funding in NASA budget. Formal definition reviews. Require approved project initiation agreement and project plan.
- Select contractors primarily on technical considerations, management plans, past performance, etc.
- Issue NASA Policy to have adequate visibility of contractor activity. Center Directors responsible for policy implementation. Requires strong NASA in-house capability and adequate center resources.
- Fund implementing contractor at low level to develop thorough understanding. NASA project manager reconfirms or changes initial commitment.
- Provide completion costs of major projects in terms of budget-years dollars.

- Issue NASA Policy to have adequate reserves in all major projects. Based on definition maturity, risk, technical complexity, and concurrent developments. Managed by Headquarters program manager and project manager.
- General practice, minimize NASA management interfaces. When teaming of NASA Centers is appropriate, define interfaces prior to project implementation.
- Revise and re-issue NASA management Instructions defining project management policies.

Chairwoman GIFFORDS. Good morning, everyone. I am very pleased to welcome all of you to the first hearing on the Subcommittee for Space and Aeronautics of the 111th Congress. I am very much looking forward to working with the Ranking Member Pete Olson, who represents a district that has JSC in it and my colleagues on both sides of the aisle, I am very pleased that we have Members that make up many of the NASA facilities and a real passion on this committee or this subcommittee for space and aeronautics.

We have a lot to do this year, but I am confident that we will have a productive and a cordial year ahead of us. I think that all Members of the Subcommittee would agree that NASA is one of America's greatest achievements, and as we look forward to the next two years on the Subcommittee, Congress and the American people will be looking to NASA to help solve some of our greatest challenges: development of Orion, the next exploration vehicle, as the Shuttle is scheduled to retire in 2010; the ability to forecast and understand changes in climate as our planet continues to warm; other countries competing in space exploration for both military, also technological and scientific purposes; and the continuing decline that we have in numbers of STEM field graduates. The United States is not graduating enough students inspired to pursue career areas in these important areas of science, technology, engineering, and mathematics.

What I like about this committee, well, I guess there is a lot I like about this committee, but one is this quote that stands above us. "Where there is no vision the people will perish." So I think about NASA, and I want the American people to know as we continue to look for all of you that vision, that you have inspired us, that you have captured our imaginations, and you have transformed our nation.

Our jobs as Members of Congress is to give you the tools and the resources you need to do your jobs, but we also have to be responsible as good stewards of the American taxpayers for the dollars that are allocated to your agency. And this is a responsibility that the Subcommittee Members take very seriously.

With that the legislative session, the hearing today is going to be on cost management issues in NASA's acquisition and programs. I want everyone to know that this subcommittee hearing, just like all the Committee hearings, will be cast on the web, but I believe this is a good start for us, because it is appropriate for us to take some time to look at our oversight activities. It is clear that good cost and schedule management will be critical to the success of NASA's planned robotic and human space flight activities. It is good common sense given that NASA will always be working with a constrained budget and competing priorities.

As has been summarized in numerous reports and studies, NASA has suffered cost growth and schedule delays of a number of projects and programs in recent years. The stated causes of the cost growth and delays have varied, and the prescriptions to fix the problems offered by individuals inside and outside the Agency are also varied, and indeed, sometimes have been in conflict.

I want to use this hearing to start to sort out the facts and to explore what can and should be done to reduce the instances of cost

and scheduled growth that we see at NASA. As was noted in the charter for today's hearing, cost and scheduled growth has been a concern at NASA since the early 1980s, if not earlier. Moreover, from my vantage point on the House Armed Services Committee it is clear that our military space programs suffer from similar problems.

However, it is also clear that NASA, DOD, and the other agencies of the Federal Government involved in space activities have many dedicated and competent scientists and engineers working long hours to try to deliver complex and successful projects. That tells me that dealing with these costs and schedule issues is hard, and that there is no simple fix or situation. If that was the case, certainly we would have resolved this a long time ago.

So we need to figure out why preventing cost and schedule growth in our space project is so hard, but more importantly what we can do about it to be on a better path for the future. I suspect that getting on that better path will involve the need for improved practices within NASA in the Agency's oversight of its contractors and in its collaborations with our international partners, as well as better efforts by us, those of us in Congress, and the White House to reduce the vagaries of the budgeting process that introduce additional instability in NASA programming planning.

It may not be possible to achieve perfection, but we certainly need to do our best to ensure that NASA is making the best use of its funds it has been given. We owe that to the American taxpayers as well as to those who are working so hard to advance this nation's agenda in space and aeronautics research.

Today's hearing should be viewed as simply a first step in this subcommittee's oversight of NASA's acquisition and program management. I am very pleased that we have an incredibly knowledgeable panel of witnesses here before us today. I want to welcome each of you, and I look forward to hearing your testimony.

With that I now yield to Mr. Olson for any opening statement that he would care to make.

[The prepared statement of Chairwoman Giffords follows:]

PREPARED STATEMENT OF CHAIRWOMAN GABRIELLE GIFFORDS

Good morning. I'm pleased to welcome everyone to this the first hearing of the Subcommittee on Space and Aeronautics in the 111th Congress.

I'm very much looking forward to working with Ranking Member Olson and my colleagues on both sides of the aisle this year to tackle the important space and aeronautics issues facing the Nation.

We have a lot to do, but I am confident that we will have a productive—and collegial—year ahead of us.

I think all Members of the Subcommittee will agree with me that NASA is one of America's greatest achievements.

As we look to the next two years, Congress and the American people will be looking to NASA to help solve some of our greatest challenges: the development of our next exploration vehicle as the Shuttle is scheduled to retire in 2010; the ability to forecast and understand changes in climate as our planet continues to warm; other countries competing in space exploration for both military, technological and scientific purposes; the continuing decline in numbers of STEM field graduates as are not graduating enough students inspired to pursue a career in these important areas.

This quote that appears above us —**where there is no vision the people perish.**

So as we look to the next two years, I want the American people to continue to look to NASA for that vision, and our job as Members of Congress is to ensure that

NASA has the resources and tools you need to carry out the vision including the many tasks that we have given you.

With that, however, goes the responsibility of ensuring that NASA is being a good steward of the resources provided to you by our constituents.

I take that responsibility seriously, as I know my colleagues do, and that is why we are kicking off this legislative session with today's hearing—a hearing that is also being webcast, as are all of the Science and Technology Committee hearings.

The topic of today's hearing—*Cost Management Issues in NASA's Acquisitions and Programs*—is an appropriate one with which to begin the Subcommittee's oversight activities.

It is clear that good cost and schedule management will be critical to the success of NASA's planned robotic and human space flight activities.

That is only good common sense, given that NASA will always be working with constrained budgets and competing priorities.

As has been summarized in numerous reports and studies, NASA has suffered cost growth and schedule delays in a number of projects and programs in recent years.

The stated causes of the cost growth and delays have varied, and the prescriptions to fix the problems offered by individuals inside and outside of the Agency have also varied—and indeed sometimes have been in conflict.

I want to use this hearing to start to sort out the facts and to explore what can and should be done to reduce the instances of cost and schedule growth that we see at NASA.

As was noted in the charter for today's hearing, cost and schedule growth has been a concern at NASA since the early 1980s, if not earlier.

Moreover, from my vantage point on the House Armed Services Committee, it is clear that our military space programs suffer from similar problems.

However, it is also clear that NASA, DOD, and the other agencies of the Federal Government involved in space activities have many dedicated and competent scientists and engineers working long hours to try to deliver successful projects.

That tells me that dealing with these cost and schedule issues is hard, and that there's no simple fix or the situation would have been resolved long ago.

We need to find out why preventing cost and schedule growth in our space projects is so hard, and more importantly, what we can do to put us on a better path for the future.

I suspect that getting on that better path will involve the need for improved practices within NASA, in the Agency's oversight of its contractors, and in its collaborations with its international partners—as well as better efforts by Congress and the White House to reduce the vagaries of the budgeting process that introduce additional instability in NASA's program planning.

It may not be possible to achieve perfection, but we certainly need to do our best to ensure that NASA is making the best use of the funds that it is given.

We owe that to the American taxpayers, as well as to those who are working so hard to advance the Nation's agenda in space and aeronautics research.

Today's hearing should be viewed as simply a first step in this subcommittee's oversight of NASA's acquisition and program management.

I am very pleased that we have a very knowledgeable panel of witnesses here today to help us in that work.

I want to welcome each of you, and I look forward to your testimony.

With that, I will now yield to Mr. Olson for any opening statement that he would care to make.

Mr. OLSON. Madam Chairwoman, thank you for convening this hearing today. The subject matter we are going to discuss is always of great concern but particularly now in the current budget environment. I, too, want to welcome and thank our witnesses for taking the time to brief us on the GAO report, assessments of selected large-scale projects at NASA.

Since this is our first Subcommittee hearing of the 111th Congress, I would like to offer my gratitude to Chair Gordon and Ranking Member Hall for this opportunity to serve. I would especially like to say that I am extremely pleased to be working with our Chairwoman Gabrielle Giffords. In every conversation we have had she has been more than gracious in the welcoming of my thoughts and perspectives. I want to thank you for that. And as further en-

couragement it turns out our thoughts and our perspectives are often the same. Our goals are similar, and our respect for the men and women of our nation's space and aeronautics agencies and industries are beyond measure.

Our nation faces enormous challenges. In their own way the sectors we will be dealing with can help by offering ways to meet those challenges, whether by creating jobs, performing cutting-edge scientific research, or serving as the inspiration to a new generation of explorers. We must work to serve—our work must serve as a means to help those who are doing the work to fulfill their missions in the most effective way possible.

And along those lines today's hearing on cost effectiveness in particular is a very critical one. Right now NASA has as much room for error in their budgeting as they do for one of their manned space missions. That much. The Agency needs to have a well-balanced, well-managed, and cost-efficient system of budgeting and scheduling for their future missions.

I am glad to read that NASA, according to the GAO, has "developed a comprehensive plan to address systematic acquisition management weaknesses." I look forward to learning how this was done, what challenges remain, and how this will apply to future missions. But the GAO also writes that NASA "would benefit from a more-disciplined approach to its acquisitions."

There are many Members of this—in this Congress, myself and the Chairwoman chief among them, who stand ready and willing to stand up for increased NASA funding. To be effective in doing so we need to be able to show our colleagues and most importantly the American people that their tax dollars are being invested wisely.

Thank you again for being here, and I look forward to hearing your statements into our discussion. Thank you.

[The prepared statement of Mr. Olson follows:]

PREPARED STATEMENT OF REPRESENTATIVE PETE OLSON

Madame Chairwoman, thank you for convening this hearing today. The subject matter we are going to discuss is always of great concern, but particularly now in this current budget environment. I too want to welcome and thank our witnesses for taking the time to brief us on the GAO report assessing selected large-scale projects at NASA.

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ward to learning how this was done, what challenges remain, and how this will apply to future missions. But GAO also writes that NASA "would benefit from a more disciplined approach to its acquisitions."

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Thank you again for being here and I look forward to hearing your statements and to our discussion.

Chairwoman GIFFORDS. Thank you, Mr. Olson. If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I would like to introduce our witnesses. First up we have Mr. Christopher Scolese, who is currently the Acting Administrator at NASA. I would note that we will be having hearings on NASA's fiscal year 2010, budget request in the near future, and Members will have plenty of opportunities to ask questions of the Agency on the budget request at those hearings. So I would like to ask Members to confine their questions to Acting Administrator Scolese today to the topic of this hearing.

We also have with us Ms. Cristina Chaplain, who is the Director of Acquisition and Sourcing Management at the Government Accountability Office, and we have Mr. Gary Pulliam, who is Vice President for Civil and Commercial Operations at the Aerospace Corporation. Welcome.

As our witnesses should know, you will each have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When you have all completed your spoken testimony, we will begin with questions. Each Member, myself included, will have five questions for the panelists, and I would like to start with Mr. Scolese.

STATEMENT OF MR. CHRISTOPHER SCOLESE, ACTING ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Mr. SCOLESE. Thank you, Ms. Chairwoman, and Members of the Subcommittee. Thank you for the opportunity to appear today to discuss NASA's efforts to improve the cost and schedule of the Agency's projects.

NASA missions have allowed us to rove the surface of Mars, other planets, to send people to live and work in space, to improve our understanding of the universe, and to better understand our Earth. So we recognize the importance of delivering missions on cost and on schedule and developing clear and stable baselines for planning.

We continually strive to improve our tools so that we can develop better estimates and implement corrective actions, and we are pleased that the Government Accountability Office recognizes these efforts. Today I will outline the progress NASA has made to date.

NASA is fortunate to be entrusted with conducting revolutionary missions in Earth and space science, aeronautics, and human space flight. These missions are often one of a kind and require new capabilities and new technologies to meet mission goals. These new developments, while exciting and offering benefits to society, seldom have clear analogs to past missions, thus presenting chal-

lenges for the development of cost and schedule estimates. As a result, there is no perfect formula for estimating cost, so we must rely on a combination of experience, cost models based on past missions, and actual costs when available.

We recognize two types of growth to understand our projects. First is internal growth, resulting from actions by the project. Examples are optimism in estimates of cost, optimisms in estimates of schedule or technology readiness, under-estimation of mission complexity, or the over-estimation of the utility of heritage components, components that have flown before. Growth may also be caused by poor management. We don't see this very often, but we do see it.

The other type of growth result from external factors that are beyond the control of the project, and I mean, the project. Sometimes they are beyond the control of NASA, sometimes they are beyond the control of the government, but strictly speaking we are talking about the project. These include partner performance, industrial base issues, launch manifest issues, or changes in planned budget or budget profile.

However, not all external factors affecting a project are due to poor performance. A project can be impacted by the success of other missions, missions that last well beyond expectation in terms of discovery and lifetime.

We are planning to conduct further study to improve our understanding of these factors and to allow us to better estimate project life cycle costs. The existing analysis indicates that early in the project development estimates can be driven by the optimism I mentioned earlier. Typically, NASA uses these early estimates for planning purposes to identify the rough cost and schedule range for the proposed mission. It is important to note that we do not consider these early estimates as cost commitments.

As a project advances, we develop a better understanding of the challenges, risks, technologies, and therefore, costs and schedule. We believe that we have the best estimate at a time when decisive action can still be taken at the completion of a properly-funded preliminary design. Thus, it is at this point that NASA makes our cost and schedule commitment for the project to the Congress.

I am pleased to say that we have put improvements in place in our processes and tools to improve our cost and schedule performance. This was recognized by the GAO in the high-risk series. Improvements include standardization of project life cycle milestones and reports to ensure that all projects are measured consistently and are reporting to our stakeholders is likewise more consistent.

Use of historical cost analysis, where possible, to identify areas that need to be addressed with corrective actions. Implementation of joint cost and schedule probabilistic estimation tools to better provide estimates for both early phase planning and later to support our commitment when we make it.

Implementation of a rigorous monthly review process to provide ongoing senior management review of program project and institutional performance so we can correct problems before they become serious. Use of independent review boards to evaluate project performance at key decision points. Formal commitment of cost and

schedule following the preliminary design review, and better use of tools such as earned value management.

Also, annual assessments of proposed new missions versus the approved activities that are already in place to determine industrial base, partner, and NASA ability to accomplish those objectives.

We recognize that cost and schedule estimation of a one-of-a-kind mission is difficult. Therefore, multiple techniques are required to improve estimates and performance. Let me assure you and the American public that we are committed to this improvement and to working with the GAO and Congress to provide consistent metrics on our performance. There are many improvements already in place. Others are underway. From these we have developed and will continue to develop improved NASA processes yielding results now and in the years to come.

Thank you for the time to speak today, and I am ready for questions.

[The prepared statement of Mr. Scolese follows:]

PREPARED STATEMENT OF CHRISTOPHER J. SCOLESE

Ms. Chairwoman and Members of the Subcommittee, thank you for the opportunity to appear today to discuss NASA's progress in managing the cost and schedule of the Agency's projects. NASA missions have allowed us to rove the surface of other planets, to send people to live and work in space, to improve our understanding of the Universe, and to better understand our Earth. NASA recognizes the importance of delivering missions on cost and on schedule, and developing clear and stable baselines for planning. We strive to continually improve our tools to identify issues so we can implement corrective action. Today, my testimony will outline NASA's progress to date and the actions the Agency is taking to continue to improve its performance. We are pleased that the Government Accountability Office (GAO) recognizes our efforts to mitigate acquisition management risk and lay a foundation to improve project cost and schedule performance.

Federal Research and Development Environment

As one of the Federal Government's research and development (R&D) organizations, NASA functions in an environment where we must accept and manage considerable risk and uncertainty. NASA develops scientific instruments, spacecraft, and new launch systems that redefine state-of-the-art. The Agency strives to standardize and reuse systems and capabilities where feasible. However, where we endeavor to achieve the next goal, develop the next technology, and make the next discovery, we venture beyond the realm of past experience and into an environment of uncertainty and higher risk. This is just one of the facts of life in an aggressive and exciting R&D environment.

Let me take a moment to share some examples with you, partially because they are illuminating, and partially because they show why people really love working at NASA.

The International Space Station (ISS), permanently crewed since November 2000, is being built by over a dozen nations. The ISS already has the American *Destiny* and European *Columbus* science laboratories on board and, with the flight of STS–127 later this year, the Japanese *Kibo* laboratory will be complete. Upon its completion next year, the ISS will have a mass of over 900,000 pounds and be a world-class research center for conducting experiments in life and materials sciences; it will also serve as a training ground for long-duration human space missions. The ISS has repeatedly demonstrated the ability of nations to work together on complex projects: with Station components being designed and built in different countries, many were actually assembled for the first time in orbit. Now, international crews are operating, repairing, and utilizing the ISS for the benefit of the world. This kind of cooperation is essential if we are to continue to expand our reach beyond our planet. Research results have already improved medical science here on Earth: as you probably know, experiments conducted aboard the Space Shuttle and the ISS have been useful in demonstrating techniques for the development of salmonella

vaccines. The ISS Program represents unprecedented international cooperation on a peacetime task of immense technical complexity.

In the past five years, NASA has landed three vehicles on the surface of Mars—each without human intervention. The planning and on-board capabilities to avoid obstacles make these landings some of the most difficult accomplishments imaginable. Think of shooting a basketball from Washington, DC, and making a perfect shot through a basketball hoop located at in Los Angeles without hitting the rim, while the rim is moving. The discoveries made by these rovers and their companion orbiters have changed our view of Mars. We now know that, at one time, Mars was indeed a wet planet, and our vehicles have found ice on its surface. More mysteries remain to be unlocked. The Mars Science Laboratory (MSL) is the next in the series of missions to Mars. MSL is significantly more complex than its predecessors, as it builds upon the lessons and discoveries they made to address the next level of scientific questions. As a result, the MSL vehicle is much larger—about the size of a Mini-Cooper—than the Mars Rovers *Spirit* and *Opportunity*—roughly the size of a coffee table—so it requires a new type of landing system.

The Nation and the world benefit from NASA's breakthrough research in Earth science and technology on a daily basis. This legacy began in April 1960 when NASA launched the world's first environmental satellite. The focus then was to improve weather forecasts. Our focus now is much more challenging. NASA conducts a comprehensive research program to advance fundamental knowledge on the most important scientific questions on the global and regional integrated Earth system. NASA presently operates 15 on-orbit Earth science missions, making measurements ranging from precision sea level through atmospheric chemistry and composition, and winds through ocean color and land vegetation, as well as ice cover and surface temperature. NASA's robust research and analysis develops outstanding scientific advances that improve climate projections and provide societal applications. NASA has six missions in formulation and development, and is pleased to have a first-ever National Research Council Decadal Survey for Earth science and applications that establishes NASA's priorities for satellite missions to study changes in the Earth's climate and environment. Achieving simultaneity of NASA's outstanding measurements is a major challenge for progress in understanding the changing climate, its interaction with life, and how human activities affect the environment.

As you can imagine, the NASA and Earth science communities are saddened at the loss of a key Earth science asset when the NASA Orbiting Carbon Observatory satellite failed to reach orbit last week following launch. NASA immediately convened a Mishap Investigation Board to determine the cause of the launch failure. In addition, we are assessing options for its replacement. Although rare, these kinds of events demonstrate the need for flexibility in NASA's ongoing portfolio.

The scientific and technical results across NASA's portfolio are substantial, and often extraordinary. However, as we push the performance envelope on several fronts, NASA's specific cost and schedule performance has, indeed, been less than desired in the past. It is NASA's responsibility to maximize the value of the American taxpayer's dollars. We already have some tools in place, but we also have plans to incorporate additional tools and make better use of existing tools and processes to improve our delivery of missions on cost and on schedule.

Potential Causes of Cost Growth and Schedule Delay

NASA puts great effort into managing the environment of uncertainty that naturally surrounds a project. Some uncertainties are within the realm of the project's control. Proposers can be overly optimistic in their efforts to provide the most attractive package in a competition. The cost savings assumed based on the use of "heritage technology" for spacecraft or instruments can be over estimated. New technology development can ultimately be much more challenging than anticipated. Sometimes inadequate time is planned for early engineering efforts and refinement of requirements. These are all areas within project accountability and the majority of this statement outlines the steps NASA has taken to address these issues.

I would like to digress for a moment to add a bit of "ground truth" on cost or schedule variances. NASA focuses a great deal of effort on measuring variations from plans and responding to trend patterns reported in monthly Baseline Performance Reviews, and in program and project reviews. NASA's renewed emphasis on the use of various tools such as Earned Value Management also help provide indications of problems early enough to take corrective action.

Reports of apparent cost growth can be misleading. If one measures project cost or schedule from the very earliest conceptual phase, as compared to measuring cost after the preliminary design is complete, the project typically appears to have incurred significant growth. NASA commits to project cost and schedule estimates at the completion of the preliminary design phase when technology readiness is better

understood, preliminary designs are complete, and partner arrangements and industrial base considerations are better understood. This information provides a much better basis for estimating cost and schedule. While useful and necessary for the initial planning phase of a mission, early estimates are, at best, educated guesses made with preliminary conceptual information. As an example, although there remains plenty of room for improvement in the case of MSL, one of these early conceptual estimates quoted in the press for MSL was not even an estimate produced by NASA.

Other events can occur that are not within the control of the project, but are typically under the control, and within the accountability, of the overall program or the Agency. Owing to other stresses in the host program, funding flexibility to address problems may be inadequate, there may be inadequate validation of cost and schedule assumptions, or performance on one project may negatively affect others. This last point needs clarification. Not all projects that adversely impact other projects are poor performers. Sometimes they are stellar performers. For example, because on-orbit lifetime of a mission is difficult to predict from afar, projects already in operation that extend well beyond the original planned operational life may require more funding, resulting in the need to obtain resources from other sources, often projects in development. As an example, the Spirit and Opportunity Rovers on Mars were planned for approximately three months of operation, but are now past five years of operations and are still returning valuable data. NASA also tries to estimate these costs and control impacts by having a group of independent experts periodically review these extraordinary missions to assess their value and the likelihood that they will operate until the end of the projected budget horizon. However, who could have guessed that the Terra Earth Science mission—approaching its 10th anniversary—would operate over twice its design life, or that the Voyagers—at over 30 years in space—would still be operational outside of our solar system?

Of course, some events occur that are not under the control of the project or the Agency, although we take measures to mitigate the attendant risk. In the case of the Solar Dynamics Observatory, national launch manifest priorities—not project performance—resulted in delays of about a year, with the attendant cost growth. In the case of the Glory project—a first-of-a-kind Earth science mission—the mission experienced unexpected problems due to a loss of contractor expertise, which is illustrative of challenges in the aerospace industrial base. Simply put, the number of capable suppliers has substantially contracted and the demand is such that the skills of the remaining suppliers are difficult to maintain. Contributions from our international partners can be late. Launch vehicle delays or price increases have also had significant impacts. External changes in budget profiles, including the unavoidable impacts of Continuing Resolutions, can also occur. Out of the ten NASA projects in the GAO QuickLook Report that exceeded the Congressionally-mandated cost and schedule thresholds, approximately half did so as a result of external factors; some with limited solution options open to NASA.

In an effort to better understand the extent to which our performance has been impacted by events that are beyond the control of the project and program, we have initiated a study of NASA and Department of Defense projects with the objective of being able to quantitatively separate internal and external growth. This will enable the Agency to better compare the results of a project's detailed cost estimate with the results of analytical cost estimates based upon historical performance. NASA currently anticipates completing this study by the end of calendar year 2009. We will keep the Congress informed of our progress in evaluating these factors.

Historical Cost and Schedule Studies

Over time, various NASA organizations have studied cost and schedule growth after the fact. Most of the studies were focused on a specific question, or measured cost or schedule from different points in a project's life cycle. Additionally, the individual research tasks utilized different data, methods, and approaches, and thus are not directly comparable.

To provide a proactive means to control costs, NASA has implemented monthly reviews—using common data set requirements and consistent data and analyses that are centrally coordinated—to produce results that are comparable from project to project and from year to year. It is this data that is now reported both internally to NASA and to the Administration and externally to the Congress. The January 2009 update to the GAO High-Risk Series notes a number of these changes that have improved NASA's standard reporting.

Additionally, NASA is using the research on historical cost and schedule performance to identify areas that need to be addressed with corrections to tools or processes. A number of changes have been initiated that address common issues such as optimism in cost estimates and schedules, inadequate identification of risks, and

unrealistic assumptions on technology maturity, along with external issues such as instability in funding, launch vehicle issues, and the performance of partners.

Steps Already Taken

The Agency has undertaken a number of actions to address cost and schedule growth through modifications to NASA's project lifecycle. These actions are also noted in the NASA High-Risk Corrective Action Plan, which the Agency developed in recognition of the complexity and cross-functional nature of the issues identified in the GAO High-Risk Series. While NASA continues to address the issues outlined in the GAO High-Risk series, we were pleased that the January 2009 update to the series highlighted the efforts we have made to improve NASA acquisition management.

Some actions that NASA has taken relate to the definition of a project life cycle that is now used by all space flight projects. Examples include:

- The project life cycle has six phases that each space flight project now must address. This is a change from the past, where different types of projects followed different paths, so that comparisons were more difficult to make, and most importantly, progress across NASA was difficult to assess.
- To ensure that we have an unbiased assessment of project performance and plans, NASA has implemented the use of Standing Review Boards to evaluate the project at each key decision point in the project's life cycle. The Standing Review Boards are composed of discipline experts who are independent of the project being reviewed. The Boards provide the Agency with independent advice on project design implementation, manufacturing plans, cost and schedule planning, risks, and margins. This change helps address past performance issues related to optimism, inadequate evaluation of technology maturity, heritage assumptions, etc.
- NASA commits to the project content, cost, and schedule baseline only after successful completion of the Key Decision Point C (KDP–C). At that point in the life cycle, following the completion of the Preliminary Design Review, project management has a more thorough understanding of the technological maturity, complexity, and risk associated with the project. As a number of risks have been retired by that point, and the implications of the project requirements are better understood, the baseline established at KDP–C provides a more meaningful basis for measuring cost and schedule performance. Several NASA research efforts confirm that the Agency's cost and schedule performance is better when measured from the KDP–C gate than when measured from the earlier milestones.

Recent Actions

In January 2009, NASA adopted a new acquisition strategy policy, which improves its ability to manage performance risk (including the adoption of probabilistic cost and schedule estimating methods). Among its features, the new policy requires space flight and information technology projects and programs to develop joint cost and schedule probabilistic estimates. Probabilistic estimating provides NASA with an approach that fully integrates technical, cost, and schedule plans and risks to develop both an understanding of the sensitivity of parameters to each other and the most likely estimate. Using this approach allows NASA to understand and document how the mitigation of technical risks would enable an increase in the project confidence level. Conversely, the introduction of a budget reduction would have the effect of increasing technical and schedule risks and thus lower the confidence level for the project. The use of probabilistic estimates also generates baseline values that include funding to address impacts associated with contingencies and uncertainties, such as industrial base, partner performance and technology optimism.

The introduction of probabilistic joint cost and schedule estimating puts NASA on the leading edge of applying these techniques in both the federal and space sectors. Because this estimating approach requires the employment of new tools and techniques, full implementation will take some time to deploy; we are currently estimating at least two years to develop the tools, training, and understanding across the Agency. Given the deployment and the typical project development cycle of three to five years, it is unlikely that NASA will be able to evaluate the impact of these changes for a few more years. The recent GAO QuickLook Report underlines the fact that it takes time to realize the results from policy and process changes. Further, as we implement this joint confidence level policy, we are looking back at existing projects in development to ascertain risks and make adjustments where prudent to improve our cost and schedule posture.

As noted earlier in this testimony, there have been issues with the consistency of historical data used for various cost research studies. In another recent action, NASA has taken steps to improve and bring consistency to the cost and schedule data collection that is now included in the Cost Analysis Data Requirement documents. This effort is also part of the NASA High Risk Corrective Action Plan. These documents serve to collect data in a standard format to allow us to assess performance on current projects and to provide a reference for future activities. At this time, NASA has completed detailed documentation on 38 historical projects and has captured data from 90 KDPs on current projects.

NASA is committed to using our tools and processes to identify issues and take corrective actions to address those issues. The steps that we have taken to standardize our project life cycle, to utilize Standing Review Boards to provide focused assessments at Key Decision Points, the renewed emphasis on tools such as Earned Value Management, the institution of strengthened acquisition planning and monthly reviews, and the use of joint cost and schedule confidence levels in our decision-making, have all moved NASA along a path towards improving our delivery of projects on time and within budget.

Conclusion

In closing, cost and schedule estimation and performance are extremely important, and the Agency has taken a number of steps in recent years that have been acknowledged in the January 2009 update to the GAO High-Risk Series. We understand and support transparency and accountability in NASA project cost and schedule assessment.

NASA is dedicated to the continuous improvement of its acquisition management processes and performance. There are many improvement efforts already in place, and others are underway. From these, we have developed—and will continue to develop—significantly improved NASA processes yielding results now and in the years to come.

I would be happy to respond to any questions you or the other Members of the Subcommittee may have.

BIOGRAPHY FOR CHRISTOPHER J. SCOLESE

Since January 20, 2009, Mr. Christopher J. Scolese has been serving as the Acting Administrator of the National Aeronautics and Space Administration (NASA). As the Acting Administrator, Mr. Scolese is responsible for leading the development, design, and implementation of the Nation's civil space program. As such, Mr. Scolese provides overall leadership for NASA's multiple field installations, works closely with the Executive and Legislative branches to ensure that NASA is supporting appropriate national policy, and leads an international collaboration in carrying out high-profile space missions including the Space Shuttle, the International Space Station, the Hubble Space Telescope, and a multitude of other scientific and technological efforts.

In addition, Mr. Scolese is still serving in the position of Associate Administrator, NASA's highest-ranking civil servant. As Associate Administrator, Mr. Scolese is responsible for the oversight and integration of NASA's programmatic and technical efforts to ensure the successful accomplishment of the Agency's overall mission.

Previously, Mr. Scolese served as NASA's Chief Engineer. As Chief Engineer, Mr. Scolese was responsible for ensuring that development efforts and mission operations within the Agency were planned and conducted on a sound engineering basis, as well as for the long-term health of the NASA engineering workforce.

Formerly, Mr. Scolese was the Deputy Director of the Goddard Space Flight Center where he assisted the Director in overseeing all activities. He also served as the Deputy Associate Administrator in the Office of Space Science at NASA Headquarters. In this position, he was responsible for the management, direction and oversight of NASA's Space Science Flight Program, mission studies, technology development and overall contract management of the Jet Propulsion Laboratory.

Mr. Scolese also served as the Earth Orbiting Satellite (EOS) Program Manager and the Deputy Director of Flight Programs and Projects for Earth Science at Goddard. In these positions, he was responsible for the operation and development of all Earth Science missions assigned to Goddard. While there, he also served as the EOS Terra Project Manager. In addition, Mr. Scolese was the EOS Systems Manager responsible for the EOS system architecture and the integration of all facets of the project. During his tenure at Goddard, he chaired the EOS Blue Team that re-scoped the EOS Program; he supported the EOS investigators in the development of the EOS payloads in the restructured EOS; and he has been responsible for the

adoption of common data system architecture on EOS and some other Earth orbiting spacecraft.

Prior to his 1987 appointment at Goddard, Mr. Scolese's experience included work in industry and government. While a senior analyst at the General Research Corporation of McLean, Va., he participated in several SDIO programs. He was selected by Admiral Hyman Rickover to serve at Naval Reactors where he was associated with the development of instrumentation, instrument systems and multi-processor systems for the U.S. Navy and the DOE while working for NAVSEA.

Mr. Scolese is the recipient of several honors including the Presidential Rank Award of Meritorious Executive, Goddard Outstanding Leadership, two NASA Outstanding Leadership Medals and the American Institute of Aeronautics and Astronautics (AIAA) National Capital Section Young Engineer/Scientist of the Year award. He was recognized as one of the outstanding young men in America in 1986, was a member of college honor societies including *Eta Kappa Nu* and *Tau Beta Pi,* and was recipient of the 1973 Calspan Aeronautics award. He is a Fellow of the AIAA and a member of the Institute of Electrical and Electronics Engineers. He also served as a member of the AIAA Astrodynamics Technical Committee and chaired the National Capitol Section Guidance Navigation and Control Technical Committee.

Chairwoman GIFFORDS. Thank you, Mr. Scolese.

Ms. Chaplain, please.

STATEMENT OF MS. CRISTINA T. CHAPLAIN, DIRECTOR, ACQUISITION AND SOURCING MANAGEMENT, GOVERNMENT ACCOUNTABILITY OFFICE (GAO)

Ms. CHAPLAIN. Madam Chairwoman and Members of the Subcommittee, thank you for inviting me to discuss our work on NASA's major acquisitions. In addition to my formal written statement, I would like to point out that GAO has just issued its first annual comprehensive assessment of major NASA programs, which is available on the GAO.gov website.

To put this work into context I would like to start with our designation of NASA's contract management as a high-risk area in 1990. We put NASA on GAO's high-risk list because our work was continually finding there was little emphasis on end results, performance, and cost control. At the time NASA found itself procuring expensive hardware that did not always work properly.

Numerous reviews following that report identified some more issues. Fourteen years later in a review of NASA's cost estimating practices, we concluded that acquisition problems still existed and found significant cost growth across a portfolio of 27 programs. In that review we found NASA lacked basic cost-estimating processes needed to establish priorities, quantify risks, and make informed investment decisions.

We also found that programs were being moved forward into the development phases without a clear understanding of whether their requirements could be achieved within available funding, technologies, expertise, and other resources.

Five years later in this most recent review we are finding that improvements have been made, but problems still exist. To NASA's credit much has been done to address the causal factors identified in our previous work, particularly in the areas of cost estimating, cost reporting, program management, and oversight.

In addition, Congress has also done its part by instilling requirements that make cost growth more transparent and limit the circumstances in which programs can be re-baselined and by asking

GAO to conduct an independent, annual assessment of major projects, many of which do not receive much external oversight.

Because baselines were set just two or three years ago, the true magnitude of cost growth in the programs in our assessment is understated. Nevertheless, it is clear that programs still anticipate growth and cost and schedule. In just two or three years 10 of 13 projects we assessed in implementation experienced an average of 13 percent cost growth, and they had an average launch delay of 11 months.

Many of the projects we reviewed indicated they have experienced challenges in developing new technologies or retrofitting older technologies, as well as in managing their contractors and more generally understanding the risks and challenges they were up against when they set their baselines.

In conducting this work, we assessed the level of knowledge programs have about technologies, design, and their contractors at certain points in the development process, while at the same time tracking other causal factors that we have identified in previous reviews such as funding instability, requirements growth, program and contract management weaknesses.

This methodology is designed to provide more insight into why programs encounter problems, as well as what actions are needed to address problems. While it is beneficial to have a wealth of policies and procedures aimed at ensuring successful execution, it is still necessary for us and the Congress to see what is happening on the ground and what types of unknowns exist in programs despite what policies encourage.

This assessment is not meant to create a debate over the uniqueness of NASA's projects or what specific criteria should be applied to assess what types of unknowns and problems exist in programs and implementation, but rather to serve as a useful oversight and management tool. We remain open to working with NASA to determine the best way forward for measurement. Though the criteria we have used has been time-tested, it is based on sound program management practices, and it has been well-received in communities involving all types of complex and technical development efforts, including the defense space community.

In conclusion, what is fundamentally important today is that NASA is being asked to undertake new missions in space science and aeronautics. As such, it is vital that NASA and Congress clearly understand the costs and uncertainties of programs proposed for authorization and during their execution. It is equally important that problems be transparent, well understood, and tracked. We believe our report sets the course for doing so.

Thank you, and I am happy to answer any questions.

[The prepared statement of Ms. Chaplain follows:]

PREPARED STATEMENT OF CRISTINA T. CHAPLAIN

Madam Chairwoman and Members of the Subcommittee:

Thank you for inviting me to discuss the National Aeronautics and Space Administration's (NASA) oversight and management of its major projects. As you know, in 1990, GAO designated NASA's contract management as high-risk in view of persistent cost growth and schedule slippage in the majority of its major projects. Since that time, GAO's high-risk work has focused on identifying a number of causal factors, including antiquated financial management systems, poor cost estimating, and

undefinitized contracts. Because cost growth and schedule delays persist, this area—now titled acquisition management because of the scope of issues that need to be resolved—remains high-risk.

To its credit, NASA has recently made a concerted effort to improve its acquisition management. In 2007, NASA developed a comprehensive plan to address systemic weaknesses related to how it manages its acquisitions. The plan specifically seeks to strengthen program/project management, increase accuracy in cost estimating, facilitate monitoring of contractor cost performance, improve agency-wide business processes, and improve financial management.

While we applaud these efforts our recent work has shown that NASA needs to pay more attention to effective project management. It needs to adopt best practices are adopted that focus on closing gaps in knowledge about requirements, technologies, funding, time and other resources before it makes commitments to large-scale programs. For instance, the Mars Science Laboratory, which was already over budget, recently announced a two-year launch delay. Current estimates suggest that the price of this delay may be $400 million—which drives the current project life cycle cost estimate to $2.3 billion; up from its initial confirmation estimate of $1.6 billion. Also, in just one year, the development costs of NASA's Glory mission increased by 54 percent, or almost $100 million, because of problems NASA's contractor is having developing a key sensor. Total project costs for another project, Kepler, have increased almost another $100 million within two fiscal years because of similar issues. Taken together, these and other unanticipated cost increases hamper NASA's ability to fund new projects, continue existing ones, and pave the way to a post-Shuttle space exploration environment.

Given the constrained fiscal environment and pressure on discretionary spending it is critical that NASA get the most out of its investment dollars for its space systems. The Agency is increasingly being asked to expand its portfolio to support important scientific missions including the study of climate change. Therefore, it is exceedingly important that these resources be managed as effectively and efficiently as possible for success. The recent launch failure of the Orbiting Carbon Observatory is an all-too-grim reminder of how much time, hard work, and resources can be for naught when a space project cannot execute its mission.

In response to congressional direction, we have prepared a comprehensive report on the management and oversight of NASA's major projects. It contains summaries of 18 projects with a combined life cycle cost exceeding $50 billion. It also contains an assessment of issues affecting projects across-the-board. A copy of this report is now available on GAO's website (*www.gao.gov*).[1] In conducting this work, we compared projects against best practice criteria for system development including attainment of knowledge on technologies and design, as well as various aspects of program management. We expect to continue this assessment on an annual basis and to continually refine our examination so that our work can inform your oversight and NASA's own efforts to improve in the high-risk area of acquisition management.

In responding to our report, NASA asserted that the unique nature of its work and external factors beyond its control make it difficult to apply the same criteria that we apply to other major government acquisitions, particularly those with large production runs. We disagree. The criteria we used to assess NASA's projects represent commonly accepted, fundamental tenets of disciplined project management, regardless of complexity or quantity. In fact, the concept of the knowledge-based approach we use has been adopted in NASA's own acquisition policy. Key criteria that we use have been developed by NASA and/or incorporated into its engineering policy. Moreover, facing long-standing cost and schedule growth and performance shortfalls, the Department of Defense (DOD) acknowledges the need for a knowledge based approach in the Air Force's "back to basics" policy for space systems. Lastly, we remain open to discussions with NASA as to whether additional criteria can and should be applied to its systems to ensure that decisions to move forward in development are well-informed and ultimately, that taxpayer dollars are well spent.

Today I will be highlighting the results of this work, the actions NASA is taking to address the concerns raised in our high-risk report and better position its projects to meet their goals, and what we believe is necessary to make these actions successful. Because we also have responsibility for examining military space systems, we will also highlight common challenges with space acquisitions within NASA and the Department of Defense (DOD). This testimony is based on previously issued GAO work, which was conducted in accordance with generally accepted government auditing standards.

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[1] GAO, *NASA: Assessments of Selected Large-Scale Projects.* GAO–09–306SP (Washington, D.C.: Mar. 2, 2009).

Acquisition Management Problems Persist

We assessed 18 projects in NASA's current portfolio. Four were in the "formulation" phase, a time when system concepts and technologies are still being explored, and 14 were in the "implementation" phase,[2] where system design is completed, scientific instruments are integrated, and a spacecraft is fabricated. When implementation begins, it is expected that project officials know enough about a project's requirements and what resources are necessary to meet those requirements that they can reliably predict the cost and schedule necessary to achieve its goals. Reaching this point requires investment. In some cases, projects that we reviewed spent two to five years and up to $100 million or more before being able to formally set cost and schedule estimates.

Ten of the projects in our assessment for which we received data and that had entered the implementation phase experienced significant cost and/or schedule growth from their project baselines.[3] Based on our analysis, development costs for projects in our review increased by an average of almost 13 percent from their baseline cost estimates—all in just two or three years—including one that went up more than 50 percent. It should be noted that a number of these projects had experienced considerably more cost growth before a baseline was established in response to statutory reporting requirement. Our analysis also shows that projects in our review had an average delay of 11 months to their launch dates.

We found challenges in five areas that occurred throughout the various projects we reviewed that can contribute to project cost and schedule growth. These are not necessarily unique to NASA projects and many have been identified in many other weapon and space systems that we have reviewed and have been prevalent in the Agency for decades.

- *Technology maturity.* Four of the 13 projects in our assessment for which we received data and that had entered the implementation phase did so without first maturing all critical technologies, that is they did not know that technologies central to the project's success could work as intended before beginning the process of fabricating the spacecraft. This means that knowledge needed to make these technologies work remained unknown well into development. Consequences accrue to projects that are still working to mature technologies well into system development, when they should be focusing on maturing system design and preparing for production. Simply put, projects that start with mature technologies experience less cost growth than those that start with immature technologies.
- *Design stability.* The majority of the projects in our assessment that held a critical design review did so without first achieving a stable design. If design stability is not achieved, but a product development continues, costly re-designs to address changes to project requirements and unforeseen challenges can occur. All of the projects in our assessment that had reached their critical design review and that provided data on engineering drawings experienced some growth in the total number of design drawings after their critical design review. Growth ranged from eight percent to, in the case of two projects, well over 100 percent. Some of this increase can be attributed to change in system design after critical design review.
- *Complexity of heritage technology.* More than half the projects in the implementation phase—eight of them—encountered challenges in integrating or modifying heritage technologies. Additionally, two projects in formulation—Ares I and Orion—also encountered this problem. We found that the projects that relied on heritage technologies underestimated the effort required to modify them to the necessary form, fit, or function.
- *Contractor performance.* Six of the seven projects that cited contractor performance as a challenge also experienced significant cost and/or schedule growth. Through our discussions with the project offices, we were informed that contractors encountered technical and design problems with hardware that disrupted development progress.
- *Development partner performance.* Five of the thirteen projects we reviewed encountered challenges with a development partner. In these cases, the devel-

[2] We only received data for 13 of the 14 projects in implementation. NASA did not provide cost or schedule data for the James Webb Space Telescope, which is in implementation.

[3] For purposes of our analysis, significant cost and schedule growth occurs when a project's cost and/or its schedule growth exceeds the thresholds established for Congressional reporting per the *National Aeronautics and Space Administration Authorization Act of 2005,* Pub. L. No. 109–161, § 103; 42 U.S.C. § 16613 (b), (f) (4).

opment partner could not meet its commitments to the project within planned timeframes. This may have been a result of problems within the specific development partner organization or as a result of problems faced by a contractor to that development partner.

Common Acquisition Management Challenges Persist between NASA and DOD

The challenges we identified in the NASA assessment are similar to ones we have identified in other weapon systems, including Defense space systems. For example, we testified last year that DOD space system cost growth was attributable to programs starting before they have assurance that capabilities being pursued can be achieved within available resources and time constraints. For example, DOD's National Polar Orbiting Environmental Satellite System (NPOESS) has doubled in cost from $6 billion to $12 billion due to challenges with maturing key technologies. We have also tied acquisition problems in space systems to inadequate contracting strategies and contract and program management weaknesses. Further, we issued a report in 2006 that found DOD space system cost estimates were consistently optimistic. For example, DOD's Space-Based Infrared High System was originally expected to cost about $4 billion and is now expected to cost nearly $12 billion.

We have found these problems are largely rooted in the failure to match the customer's needs with the developer's resources—technical knowledge, timing, and funding—when starting product development. In other words, commitments were made to achieving certain capabilities without knowing whether technologies and/or designs being pursued could really work as intended. Time and costs were consistently underestimated. As we have discussed in previous work on space systems at both DOD and NASA, a knowledge-based approach to acquisitions, regardless of the uniqueness or complexity of the system is beneficial because it allows program managers the opportunity to gain enough knowledge to identify potential challenges earlier in development and make more realistic assumptions about what they can achieve.

NASA Is Making a Concerted Effort to Reduce High Risk in Acquisition Management But More Needs to Be Done

NASA has also taken significant steps to improve in the high-risk area of acquisition management. For example, NASA revised its acquisition and engineering polices to incorporate elements of a knowledge-based approach that should allow the Agency to make informed decisions. The Agency is also instituting a new approach whereby senior leadership is reviewing acquisition strategies earlier in the process and has developed broad procurement tenets to guide the Agency's procurement practices. Further, NASA is working to improve management oversight of project cost, schedule, and technical performance with the establishment of a baseline performance review with senior management. In order to improve it's contracting and procurement process, NASA has instituted an agency wide standard contract-writing application intended to ensure all contracts include the most up-to-date NASA contract clauses and to improve the efficiency of the contracting process. NASA is also requiring project managers to quantify the program risks they identify and collect more consistent data on project cost and technologies. It is taking other actions to enhance cost estimating methodologies and to ensure that independent estimates are used.

These changes brought the policy more in line with best practices for product development. However, the Agency still lacks defined requirements across centers and mission directorates for consistent metrics that demonstrate knowledge attainment through the development cycle. In order for a disciplined approach to take hold, we would expect project officials across the Agency to be held accountable for following the same required policies.

More steps also need to be taken to manage risk factors that NASA believes are outside of its control. NASA asserts that contractor deficiencies, launch manifest issues, partner performance, and funding instability are to blame for the significant cost and schedule growth on many of its projects that we reviewed. Such unforeseen events, however, should be addressed in project-level, budgeting and resource planning through the development of adequate levels of contingency funds. NASA cannot be expected to predict unforeseen challenges, but being disciplined while managing resources, conducting active oversight of contractors, and working closely with partners can put projects in a better position to mitigate these risks should they occur. Realistically planning for and retiring technical or engineering risks early in product development allows the project to target reserves to issues NASA believes are outside of its control.

In conclusion, managing resources effectively and efficiently as possible is important more than ever for NASA. The Agency is undertaking a new multi-billion dollar program to develop the next generation of spacecraft for human space flight and at a time when it is faced with increasing demands to support important scientific missions, including the study of climate change, and to increase aeronautics research and development. By allowing major investment commitments to continue to be made with unknowns about technology and design readiness, contractor capabilities, requirements, and/or funding, NASA will merely be exacerbating the inherent risks it already faces in developing and delivering new space systems. Programs will likely continue to experience problems that require more time and money to address than anticipated. Over the long run, the extra investment required to address these problems may well prevent NASA from pursuing more critical science and space exploration missions. By contrast, by continuing to implement its acquisition management reforms and ensuring programs do not move forward with such unknowns, NASA can better align customer expectations with resources, minimize problems that could hurt programs, and maximize it ability to meet increased demands.

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

BIOGRAPHY FOR CRISTINA T. CHAPLAIN

Ms. Chaplain currently serves as a Director, Acquisition and Sourcing Management, at the U.S. Government Accountability Office. She has responsibility for GAO assessments of military and civilian space acquisitions. Ms. Chaplain has also led a variety of DOD-wide contracting-related and best practice evaluations for the GAO. Before her current position, Ms. Chaplain worked with GAO's financial management and information technology teams. Ms. Chaplain has been with GAO for 18 years. She received a Bachelor's degree, *magna cum laude,* in International Relations from Boston University and a Master's Degree in Journalism from Columbia University.

Chairwoman GIFFORDS. Thank you, Ms. Chaplain.

Mr. Pulliam.

STATEMENT OF MR. GARY P. PULLIAM, VICE PRESIDENT, CIVIL AND COMMERCIAL OPERATIONS, THE AEROSPACE CORPORATION

Mr. PULLIAM. Good morning. Madam Chairwoman and Members of the Subcommittee, I am pleased to represent the Aerospace Corporation and to appear before you today as you deliberate cost management issues in NASA's acquisitions and programs.

As a private, non-profit corporation, the Aerospace Corporation has provided engineering and scientific services to government space organizations for almost 50 years. As its primary activity Aerospace operates a federally-funded research and development center, but we also undertake projects for NASA and other civil agencies.

The Subcommittee asked us to focus on the main causes of cost and schedule delays at NASA, how effective NASA has been at mitigating these problems, and similarities we see in other agencies. While there are many factors affecting cost and schedule growth, I will briefly discuss four main causes as we see them.

First, sometimes NASA is too optimistic in its initial designs. This is understandable because NASA's job is to push science to new frontiers, yet there is palpable pressure for mission execution at the lowest-possible cost. The net result can be a less-than-complete appreciation for the complexity of the technical baseline. This can lead to artificially-low initial cost estimates and optimistic schedules. The cost-estimating process itself can introduce optimism depending on what data and what missions are included. These factors taken together can increase the likelihood that the

initial cost estimate will not be an accurate indicator of the final program cost.

Second, there can be scope changes as the design evolves. Designs and technologies mature as projects proceed through development. This, too, is understandable and perhaps even desirable from a science perspective. The project manager wants to deliver maximum value to his customer.

However, the effects are clear. An instrument that is more complex than originally thought will likely require more mass or more power. We should not be surprised that these changes from the original design produce changes in cost and schedules as well.

Third, the inherent difficulty of developing world-class technologies contributes to cost and schedule growth. Technology immaturity is most often apparent in the advancement of science through new instrument development. Delays in instrument development can lead to schedule delays for the entire project. NASA is working toward reducing risks associated with immature technologies but has reduced technology development in some other areas.

Fourth, we must acknowledge that external influences can have a major effect on cost and schedule performance. From the program or project manager's perspective whether that change comes from the Congress or from inside NASA the effects are the same. Project changes can set off chain reactions all across an agency. Cost growths in one program may result in reducing funding from other programs that were performing well, making them less executable. Missions can be delayed or canceled because existing programs are consuming available budget. Each of these actions has a negative impact on established costs and schedule.

In looking at the effectiveness NASA has in mitigating cost and schedule growth we believe NASA deserves some credit for their efforts. In the past few years NASA has initiated several measures specifically designed to solve this problem. Some are strategic such as budgeting at a higher confidence level, and some are tactical, such as collecting the necessary data for sound cost estimating. NASA should be commending, commended for investing in new and innovative technologies and techniques.

One example is schedule estimating, which is a relatively new capability in our industry. Another is affordability analysis, which allows examination of the portfolio interactions, long-range planning, and evaluation of costs, risks, and program reserves. These are ground-breaking efforts, and they will produce positive results.

Even with these management actions, however, there is still uncertainty in the cost management process. NASA is attempting to manage this uncertainty through establishing cost estimates at a higher level of confidence than in previous years. While commendable, this higher level of confidence is valid only if the baseline remains stable, if technology maturation is controlled, and if external influences are understood and managed. Effective cost and schedule management requires a project manager to accept, be accountable for, and execute to a valid baseline. NASA is studying how to reconcile project estimates with independent estimates. Greater transparency into both processes and reconciliation of these basis of estimate will yield positive results.

Our overall assessment of NASA's mitigation efforts is that the Agency is implementing many measures which should provide increased capability for cost and schedule management, and as a result better cost and schedule performance.

And finally, the Committee asked us to look at similarities between NASA and other federal agencies. We found far more similarities than differences. As outlined above, optimism, baseline growth, technology changes, and external influences are not unique to NASA. Dozens of commissions and panels have studied cost and schedule for decades, and the themes are generally consistent. While each federal agency can point to their unique problems and circumstances, the fundamental challenges of good cost and schedule estimating and performance are remarkably similar across federal agencies.

Madam Chairwoman, I am pleased to present our findings and assessments to the Subcommittee, and I look forward to your questions.

[The prepared statement of Mr. Pulliam follows:]

PREPARED STATEMENT OF GARY P. PULLIAM

Madam Chairwoman and Members of the Subcommittee:

I am pleased to present The Aerospace Corporation's findings, assessments, and recommendations on cost and schedule management issues in NASA's programs.

The Aerospace Corporation

The Aerospace Corporation is a private, nonprofit corporation, headquartered in El Segundo, California. Aerospace was created in 1960 at the recommendation of Congress and the Secretary of the Air Force to provide research, development, and advisory services to the United States government in the planning and acquisition of space, launch, and ground systems and their related technologies. We provide a stable, objective, expert source of engineering analysis and advice to the government, free from organizational conflict of interest. We are focused on the government's best interests, with no profit motive or predilection for any particular design or technical solution.

Aerospace does not compete with industry for government contracts, and we do not manufacture products. The government relies on Aerospace for objective development of pre-competitive system specifications and impartial evaluation of competing concepts and engineering hardware developments to ensure that government procurements can meet the user's needs in a cost-and-performance-effective manner.

Aerospace employs about 4,000 people of whom 2,700 are scientists and engineers with expertise in all aspects of space systems engineering and technology. As its primary activity, Aerospace operates a Federally Funded Research and Development Center sponsored by the Under Secretary of the Air Force, and managed by the Space and Missile Systems Center in El Segundo, California. Our principal tasks are systems planning, systems engineering, integration, flight readiness verification, operations support, and anomaly resolution for National Security Space (NSS) systems. Through our comprehensive knowledge of space systems and our sponsor's needs, our breadth of staff expertise, and our long-term, stable relationship with the government, we are able to integrate technical lessons learned across all NSS space programs and develop system-of-systems architectures that integrate the functions of many separate space and ground systems.

The Aerospace Corporation also undertakes projects for civil agencies, including the National Aeronautics and Space Administration (NASA). Such projects contribute to the common good of the Nation while broadening the knowledge base of the corporation. Aerospace's support to NASA includes work on solutions to the foam and ice debris damage that resulted in the loss of the Space Shuttle *Columbia,* analysis of alternatives to robotically servicing the Hubble Space Telescope, and contributions to the Mars Exploration Rovers program. Our support to NASA includes its headquarters and virtually all directorates as well as almost every NASA Center. NASA and the NSS clients emphasize different areas when they task Aerospace. NASA requests far less support but proportionately more programmatic and budg-

eting support while the NSS clients place primary emphasis on technical support. While Aerospace certainly does not have full and complete insight into all NASA programs and projects, nor do we support all NASA programs, we have a unique relationship with NASA and have unique insights which we are privileged to share with the Committee.

The Subcommittee asked us to focus our testimony on: 1) Identifying the main causes of cost growth and schedule delays in NASA programs and projects found during the course of The Aerospace Corporation's body of work at NASA; 2) Assessing the effectiveness of NASA's efforts in mitigating them; and 3) Identifying, in the context of The Aerospace Corporation's work at other federal agencies, any similarities in cost growth and schedule delays experienced at NASA.

Identifying the main causes of cost growth and schedule delays in NASA programs and projects found during the course of The Aerospace Corporation's body of work at NASA

Aerospace has enjoyed a relationship with NASA for many years. We have studied NASA project cost and schedule for the Administrator, Associate Administrator, the Office of Program Analysis and Evaluation, Headquarters Mission Directorates, and many NASA Centers. Our work with NASA reveals that cost growth and schedule delays result from a variety of complex reasons.

In recent years, NASA has commissioned several studies to determine the primary contributing factors to cost and schedule growth. These studies, as well as others in the field, identified several common themes: significant optimism in initial designs, changes in scope associated with the evolution of the design over time, the inherent technical difficulty of developing world class technologies, and the effect of external influences on the project such as funding instability. Although the conclusions stated above are primarily drawn from the analysis of a subset of NASA's science missions, we believe that the observations are applicable to a broader array of NASA projects.

Optimism in Initial Design

NASA, as part of its charter, conducts unprecedented exploration and science. These missions continually push the envelope of the capabilities required by its human space flight and scientific instruments and spacecraft. The novelty and value of these science instruments are indisputable, as evidenced by the recent discovery by the Fermi Gamma Ray Space Telescope of the highest-energy gamma-ray burst ever recorded. At the same time, there is significant competitive pressure, both within NASA and among its contractors, to initiate a mission at the lowest possible cost. As noted by former NASA Administrator James Webb, it is not unusual for teams to "put their best foot forward" when proposing a new mission. In a recent study of the cost and schedule growth of 40 NASA science missions, only five of the 40 missions investigated resulted in no cost and schedule growth while over a quarter experienced cost growth greater than 40 percent above and beyond the project's internal cost reserves. In some cases, the content or complexity of the technical baseline is under-appreciated. In other cases, the initial estimate of technical resources such as mass or power is inadequate or reliance on heritage systems is overstated. The initial inadequate technical baseline and/or poorly defined requirements lead to an artificially low initial cost estimate resulting in significant cost growth beyond the project's internal cost reserves. Furthermore, optimism may be introduced into the cost estimating process from empirical cost models that do not incorporate canceled missions, missions currently in development that are experiencing difficulties, or missions whose actual costs have been omitted or modified based on "unusual" circumstances. Another key driver of a project's final cost is schedule risk, which is often not adequately captured, making the initial schedule incompatible with the budget, resulting in an overall plan that is not executable. In summary, the optimism in the initial design starts the cycle, which is exacerbated by limitations in the cost estimating process.

Scope Changes as the Design Evolves

The natural progression of a mission from its early conceptual design through its detailed design and implementation typically requires that resources (weight, power, performance, etc.) be added to meet stressing requirements. This growth in required spacecraft resources results in an associated cost growth. The understatement of the required resources is built into how the cost of the initial technical baseline is estimated. For example, while a recent historical study of robotic science missions observed that mass grew over 40 percent on average from initial design inception to flight design, large mass growth factors are typically not applied in determining a

cost estimate. Often, the complexity of the development effort, underestimated at the outset, is more fully understood as the development progresses. While the accuracy of project estimates improves over time, cost growth, over and above reserves, still occurs deep into the project life cycle. In short, the concept that is proposed is often not what is built. The initial cost estimate is likewise not representative of the final, as-built configuration due to required changes as the understanding of the design evolves. In essence, cost estimators are trying to estimate a moving target as projects progress toward their final design form.

Inherent Difficulty of Developing World Class Technologies

NASA is continually pushing the technological envelope to reach its science objectives. The difficulty of landing a piece of hardware the size of a small car on the surface of another planet is only one example of the challenges that NASA faces on a regular basis. Each NASA development is unique, technically challenging and inherently difficult. To confront these challenges, technology is essential. The lack of mature critical technologies at project start contributes to the cost and schedule growth. A generally accepted risk avoidance practice is to fund focused technology development prior to system development. NASA, however, has reduced technology development funding in many areas due to budget constraints. Technology immaturity in science missions is often most apparent in instrument development, as opposed to spacecraft. Instrument development difficulties often lead to schedule delays in which a "marching army" cost is incurred awaiting instrument delivery. Additional investment to mature instruments, prior to the start of full project development, could potentially lead to reduced cost and schedule growth for science missions.

External Influences

External influences can have a major effect on cost and schedule performance. From the program or project manager's perspective, whether change comes from Congress or from inside NASA, the effects are the same. Examples of external influences outside a project's control include budget modifications, funding instability, changes in requirements or priorities, and launch vehicle delays. The project manager depends on access to unallocated budget, or reserves, to address problems. When Headquarters or Congress reassigns budget or change priorities, it is often at the cost of increased execution risks that fall outside of a given project's ability to accommodate within reserves. Within a portfolio, cost growth in one project may result in reducing funding to other projects making them all less executable. The resulting domino effect impacts all missions that follow as missions that have not started are postponed or missions early in their development are stretched to fit annual budget constraints.

Assessing the effectiveness of NASA's efforts in mitigating them (cost and schedule delays)

NASA initiated several measures to mitigate cost and schedule growth since the middle of this decade. Some of these measures are strategic in nature, such as budgeting at the 70 percent confidence level, and some are more tactical, such as the collection of historical data to provide a sound basis for new cost and schedule methodology development. Schedule estimation, which is a relatively new capability within the industry, is an area in which NASA is investing to improve the state of the practice commensurate with the more mature cost analysis methodologies. Affordability analysis, which allows examination of portfolio interactions, longer-range planning/analysis, and evaluation of cost risk and reserve policies, is another capability in which NASA has invested. Several introspective studies were commissioned to more fully understand the reasons for cost and schedule growth and provide recommendations on how to limit growth. The majority of these studies received peer review and have been published in the public domain. The progress in each of these areas is commendable.

The collection of cost, schedule, and technical data is vital to developing representative cost and schedule models that are based in historical fact. NASA has embarked on an initiative to collect data, the Cost Analysis Data Requirement (CADRe) initiative. Aerospace is a contributor to this effort. Prior to the CADRe initiative, NASA's historical cost and schedule data collection from the early 1990s had been scarce and was based primarily upon the ability of individual organizations or programs to gather their own cost data. The CADRe initiative has institutionalized collection of data at specific milestones for a large set of missions across a large number of organizations. This data is invaluable in understanding and analyzing

the cost and schedule growth of NASA projects and identifying contributing factors and causal relationships.

In spite of these efforts, significant uncertainty remains in the cost estimating process. To offset this uncertainty, NASA has moved to estimating cost in a probabilistic fashion where a range of cost is estimated with associated confidence levels. NASA has also instituted a new requirement for budgeting projects at a higher level of confidence than previously experienced with a goal of giving projects a 70 percent chance of successfully meeting their budget. The validity of this approach, however, depends on the stability and soundness of the baseline. Every project has a budget estimate set by many inputs. Significant changes in these underlying assumptions and technical baseline will reduce the program's budget confidence. Furthermore, substantial differences of opinion remain within the cost-estimating community on how to develop and interpret probabilistic estimates.

For effective NASA cost and schedule performance execution, the project must manage to a valid baseline estimate. One area of concern for the NASA project managers is the relevance and utility of independent cost estimates they do not own. Different methodologies are used by the project and independent estimate such that there is not a common understanding of the basis of estimate for each. Projects typically use bottoms up estimates that do not necessarily incorporate all of the risks. The disconnect between independent cost estimates and project estimates is exacerbated by the fact that unanticipated risks often manifest themselves late in development cycle during integration and test, when it is often too late to make adjustments. Greater transparency into the basis of estimate for each approach is important and needs to be communicated in ways that both the cost estimating community and project managers understand and recognize. One effort underway to strengthen the connection between an independent cost estimate and the project estimate is to include the effects of risk and risk mitigation to promote the project's ownership of the estimate. Incorporating the project's assessment of risks into the cost estimating process earlier and more often can put greater validity into the project's baseline cost estimate and provide a more robust reserve posture and promote the project's ownership of the estimate. NASA is using aspects of this philosophy on some of its projects. Continued expansion of its use should reduce unexpected cost and schedule growth in the future.

The results of these measures have not yet had time to reach fruition as missions developed under the new initiatives have not yet been fully deployed. New methodologies such as schedule analysis tools and strategic mission portfolio models take time to influence project and program design in order to develop more robust project and program plans. Although it is too early to make an assessment, the studies that NASA has conducted and the initiatives that NASA has begun should move the Agency toward a more positive outcome and improve the ability to predict and control cost and schedule in its future.

Identifying, in the context of The Aerospace Corporation's work at other federal agencies, any similarities in cost growth and schedule delays experienced by NASA

NASA is not alone in facing challenges in cost and schedule growth. The causes outlined above including optimism, growth, technology, and external influences, are not unique to NASA. The military procurement system has been analyzed for decades. Dozens of major commissions, panels, and academic studies have echoed these same issues, and we generally concur with the findings. The Aerospace Corporation's current and previous Presidents supported the May 2003 Defense Science Board/Air Force Scientific Advisory Board Joint Task Force on Acquisition of National Security Space Programs. That group reported:

> *The space acquisition system is strongly biased to produce unrealistically low cost estimates throughout the acquisition process. These estimates lead to unrealistic budgets and unexecutable programs.*

The Task Force went on to note the need for new technology and the impact of technology risk on cost and schedule risk.

In its most recent critique of defense acquisition, the Government Accountability Office noted:

> *Invariably, the Department of Defense and the Congress end up continually shifting funds to and from programs—undermining well-performing programs to pay for poorly performing ones. At the program level, weapon system programs are initiated without sufficient knowledge about requirements, technology, and design maturity. Instead, managers rely on assumptions that are consistently too optimistic, exposing programs to significant and unnecessary risks and ulti-*

mately cost growth and schedule delays." (Defense Management: Actions Needed to Overcome Long-standing Challenges with Weapon Systems Acquisition and Service Contract Management. GAO–09–362T, February 11, 2009)

While each federal agency can point to unique problems and circumstances which impact project development, the fundamental challenges of good cost and schedule estimating and performance are remarkably similar across federal agencies.

Conclusion

NASA's challenging mission includes a varied portfolio and substantial technological challenges. Many factors contribute to cost and schedule growth, but optimism in initial designs, changes in scope over time, the inherent technical difficulty of maturing technologies, and external influences are common themes we found. Many of these conditions and constraints exist for other federal agencies. NASA has initiated several measures to mitigate cost and schedule growth and these efforts should provide positive results over the next few years.

The Aerospace Corporation is pleased that the Subcommittee requested we offer our views and stand ready for your questions.

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BIOGRAPHY FOR GARY P. PULLIAM

Gary P. Pulliam is Vice President of Civil and Commercial Operations. He was appointed to this position in December 2004. Pulliam directs all civil and commercial business at Aerospace and is responsible for contracts valued at $90 million annually. Key customers include the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and a wide number of other civil and commercial organizations in the United States and overseas.

In addition to his responsibilities in Civil and Commercial Operations, Pulliam is Corporate Director of Government Relations.

Pulliam joined The Aerospace Corporation in 1994 as Director of Government Operations after serving for five years as Chief of Staff for U.S. Representative Earl Hutto of Florida's first congressional district. He concurrently was a professional staff member for the House Armed Services Committee, supporting Chairman Hutto, and was the Congressman's campaign manager.

Pulliam was appointed General Manager in charge of non-Defense Department business at Aerospace in 1997. He has continued to handle government relations responsibilities while managing increasingly important civil and commercial programs.

During a 20-year career in the Air Force, Pulliam served as a pilot and instructor and held assignments at the Aeronautical Systems Center in Dayton, Ohio. He also held several positions at the Pentagon, including an assignment as legislative liaison in the Office of the Secretary of the Air Force.

He holds a Bachelor's degree in English from Clemson University and earned a Master's in operations management at the University of Arkansas. He also is a graduate of Harvard University's Kennedy School of Senior Managers in Government Program.

The Aerospace Corporation, based in El Segundo, California, is an independent, nonprofit company that provides objective technical analyses and assessments for national security space programs and selected civil and commercial space programs in the national interest.

DISCUSSION

IMPEDIMENTS TO PERFORMANCE IN NASA PROJECTS

Chairwoman GIFFORDS. Thank you, Mr. Pulliam. At this point we are going to begin our first round of questions. The Chair recognizes herself for five minutes.

Beginning with Mr. Scolese, we have heard testimony from Ms. Chaplain and Mr. Pulliam about the factors that have historically led to cost scheduled growth. They have also been able to identify some of the standard approaches that should be considered in attempting to mitigate such growth. But none of these approaches or none of these factors are certainly new, dating back to 1981, to the Hearth Report, certainly earlier than that there have been similar causes and mitigation strategies for cost and schedule growth in NASA and certainly for projects.

Yet we are sitting here today because these projects continue to persist. I see from your biography that you have been on the front lines of the battle to control costs as a NASA Project and Program Manager in a variety of important positions. So in addition to knowing theoretically what should be done, you have actually experienced first-hand the real life challenges of attempting to manage cost and schedule.

What from your perspective specifically are the most important real world impediments to consistently achieving on-budget, on-schedule performance in NASA's projects and programs? And following that are we just going to have to accept some level of cost growth if we want to conduct space research and exploration? I realize that this is very challenging what we are asking you to do,

but—or is it possible that measures that you and the other witnesses have outlined can make a significant difference?

Mr. SCOLESE. Well, to answer the question first, you are correct. Many of these techniques have been talked about in the past, and Gary and Cristina discussed techniques that we are using. One of the things we are doing different today is we are using all of them in a consistent framework, so that we are not just doing cost estimation, we are not just improving our models, we are not just using EVM. We are taking all of those tools, and we are using all of them.

In addition, we are having other people look at it, people that are independent of the performing organization, whether it is a project or a program or a center to go off and look at it because when you are sitting there, and you are looking at it, and you are doing it day to day, you think you can solve the problem. Otherwise you probably wouldn't be in the job. But somebody else looking at it is going to be a little bit more skeptical and look at what you are doing a little bit more clearly and bring that back for others to go off and evaluate and see if we can't make adjustments to help do it, to help correct problems, whether they are due to the project or they are outside of the project's control. That can be done if we know what they are early enough.

You also asked, having lived in the trenches, what are the things that are most important to a project in order to be successful. Probably the most important thing is stability. One of the things that is extremely difficult in the project environment is uncertainty in your budget or uncertainty in requirements that you don't control. Once they are stable and they usually become stable later in the program development, things go fairly well. I mean, there can be surprises. There is no doubt about it. We are doing things that oftentimes haven't been done before, so we do get surprised. But stability was one of the things that we really looked for, and we really looked for, and we really felt that we needed in order to be successful.

And last you asked do we have to live with consistent cost overruns. I think the answer is no, and I think you have heard from the three of us that we can do better. If implement these tools, we can better predict what our costs will be. Will they be totally gone? No. I don't think so, because what we do is very different. We have high-risks, and therefore, there is probability of failure and there is probability of cost growth. But overall we can do better, and I think when we put all these tools together you will see our performance improve.

NASA IMPLEMENTS INCENTIVE AND PUNITIVE MEASURES TO INCREASE ACCOUNTABILITY

Chairwoman GIFFORDS. Mr. Scolese, when instances of cost growth arise, many in the public want to know who exactly is accountable. It seems that assigning accountability can be difficult when there are a number of contributing factors that have led to the cost growth, but the desire for accountability at heart is based on the belief that it can contribute to preventing future cost and schedule growth at the Agency.

As you know, in trying to deal with such growth and if some have called for punitive measures and some have called for providing incentives for good performance, what mechanisms does NASA currently have for penalizing poor cost and schedule performance, and conversely, what kinds of incentives does NASA provide for good performance?

Mr. SCOLESE. Well, first and most important is, as you said, we need to understand what caused the growth. If it was something that was clearly caused by the project, the performance of the project, then, indeed, we do take actions, and over the last several years, over the life cycle of projects coming to completion now, we have replaced probably about 10 percent of our project managers. So there is strong accountability there for performance, if it is due to the project.

Oftentimes it is not due to the project. It is due to that lack of stability, it is due to unforeseen technical problems. It is due to taking over a project that was originally in trouble. So first we look at what the causes are and then we take the appropriate actions as needed.

In addition, we clearly hold accountable all of the people that are in the project. If a contractor is not performing, we have award fee scores. How much additional fee or how much fee we provide to them for their performance. Theoretically, if they were perfect, they would get 100 percent, and if they were terrible, they would get zero percent. So we evaluate based on that.

I do want to say, though, that when we do that, we recognize that many of the people, most of the people that are performing on these projects are very good people. They have distinguished themselves in other fields, in other areas within NASA. So while they may not be successful here, we rely on our people to do our missions. Without them we can't do them. We rely on our contractor personnel and our partner personnel to do our missions.

So when we do have to take action, we recognize these people have distinguished themselves somewhere else, and we move them onto other activities. So there is no public, you know, discussion of this. They move onto other things where they were at one time very good.

But overall I think we have the tools to reward people for doing good performance. We have the tools to penalize people and organizations for doing bad performance.

Chairwoman GIFFORDS. Thank you, Mr. Scolese.

The Chair will now recognize Mr. Olson for five minutes.

Mr. OLSON. And thank you, Madam Chairwoman. With your permission I would like to extend my time to the Ranking Member of the Full Committee and a fellow Texan, Mr. Hall.

Mr. HALL. Thank you. I am not sure I thank you, but I didn't get to hear all of the—but, you know, we have a problem. We have a new Administrator coming aboard, and I don't think there is any secrets that Chair Gordon and I joined as Ranking Member requested the President to maintain Mike Griffin, and I know everything he did was not perfect, but he was always upright with us and made projections that we doubted but understood. And we are here with a four-year gap in there that concerns everybody, and we

don't want to depend on nations that we don't really trust, but we are under some type of contract with them now.

NASA'S PROBLEMS COULD BE FIXED WITH A SMALL FRACTION OF STIMULUS

I understand the acting Administrator can tell us about that, but I guess what I am trying to say is that, "be not the first by whom the new is tried nor yet the last to lay the old aside." I don't know about the lone experience of schedule and cost growth and very complex robotic missions, and I think maybe we ought to just impose higher costs and schedules there in the projects' outset at the very beginning rather than trying to squeeze in too small reserves when the project encounters difficulties.

But no matter what, where we are now and we need to somehow squeeze together those four years between the time that we can quit using Discovery and Endeavor and Atlantis, and get the project Constellation underway. Somehow—and with the minute budget compared to the overall budget that we extract for this project, it just seems to make sense to me, and with the offsets of—and the $850 billion expenditure and throwaway that the former President launched and the stimulus program of $700 or $800 billion. It makes our project look like a very small cost and easy to add to.

So I hope that we can all get together and push and carry out the program that had been set forward. The—and the hopes are—and it makes our expenditures look minute compared to the give-aways and the waste-aways and the throw-aways that they are, because I believe Jay Leno was right when he said that he thought the automobile-makers ought to keep on making automobiles and those guys on Wall Street ought to start making license tags.

But we have such a small comparative budget and request for such an important program project. I just hope we will be more realistic in our approaches. And I didn't get to hear all the testimony, but that is the only thing I can offer.

I yield back and thank you, Madam Chair.

Chairwoman GIFFORDS. Thank you, Mr. Hall. I think everyone on this committee agrees that we always look forward to your comments and you're an incredible asset to this subcommittee.

The Chair will now recognize Ms. Fudge, who has Glenn in her district. Ms. Fudge, please.

COST MANAGEMENT OF HUMAN FLIGHT MISSIONS COMPARED TO ROBOTIC MISSIONS

Ms. FUDGE. Thank you, Madam Chair.

My first question is for Mr. Scolese. Are—do you believe that human space flight projects are likely to encounter cost and schedule growth? Are they more likely than if you use robotic science projects?

Mr. SCOLESE. I don't think they are inherently different in terms of their purpose, but the difference is with human space flight programs we tend to do developments on such long time scales that they are separated by such a large amount of time. We started designing the Shuttle in the 1970s and began flying it in the 1980s.

We did the Station in the 1990s, and we are doing Constellation now in the 2000s. And that presents some challenges because with robotic missions we tend to do several per year. With our aeronautics activities we tend to do several per year.

So we don't have as strong a historical database to allow us to make the predictions that we can do with the robotic missions. So from that standpoint I think we have greater uncertainties in our initial estimates for the human missions than we do for the robotic missions, but that is because we haven't done so many of them. You can basically count on one hand all the human missions or the human space flight activities that we have done in the four decades, five decades that the space program has been around.

So that presents a challenge for us. But to say that they are inherently different or that one can do different things than the other, that is certainly true, but that doesn't add to it. It is the fact that we don't do as many human missions as we do robotic missions.

Ms. FUDGE. Thank you. Mr. Pulliam——

Mr. PULLIAM. Yes, ma'am.

SHOULD NASA FREEZE COST ESTIMATE DESIGN?

Ms. FUDGE.—you stated in your testimony that the initial cost estimate is not representative of the final as built configuration due to required changes. Should NASA either freeze requirements early on or not proceed to implementation until it establishes greater knowledge of requirements and the resources needed?

Mr. PULLIAM. Thank you. It is among the most difficult problems to try to solve at NASA or other agencies spending taxpayer dollars. As we noted, when you start a program, you don't know everything that you need to know to execute that program. Sometimes the technologies just are in development, and that goes the way it goes.

There is this optimism at the beginning. That is in part fostered by an increasingly competitive environment for NASA programs, so contractors and bidders are likely to bid more and more against the mission that is available. That contributes to optimism.

So while one could just freeze design and say we are not going to allow any of this, our view is you would wind up not being able to accomplish the mission that is so important to NASA, and that is to put the world's best technology up for the benefit of mankind.

So it is a difficult dilemma, that the answer in our view is somewhere along the way. You have to manage this technology maturity in a planned organizational way, understand the path that technology maturity is on, and understand the changes that accompany that to both your cost and your schedule. And then as NASA has stated, confirm that baseline at some point, at which time you have an executable program.

So we wouldn't suggest that technology just continues to roam indefinitely, nor would we suggest locking it down so early solely for the benefit of cost and schedule because you would lose out on what you are trying to accomplish to some extent.

LONG-DURATION HUMAN SPACE FLIGHT AND ITS EFFECT ON COST

Ms. FUDGE. Thank you. And this is for any member of the panel. Certainly assuring the health and safety of our crews is critical to the success of NASA's exploration mission, and I guess because of NASA Glenn, we have had some discussions about the lack of timely demonstrations of hardware and techniques to mitigate the adverse effects of long duration space flights.

Does that cost become one of the costs that you can't contain, or is that one of the issues that arises that creates some growth in the cost?

Mr. SCOLESE. It certainly could, and that is one of the things that, of course, we have to address if we are going to do long-duration space flight. The Space Station is the tool to help us do that, and the better we can utilize it, the better we can retire those risks and develop better cost estimations, schedule estimates, and better estimates overall about when we can start sending people on those long-duration missions beyond low Earth orbit.

So, yes, it does add an uncertainty to what we are doing. We are looking at that for the, you know, utilization of the Space Station. I am certain some of the efforts that Glenn is pursuing in those areas would be included in that.

Ms. FUDGE. Thank you, Madam Chair. I yield back.

Chairwoman GIFFORDS. Great. Thank you, Ms. Fudge.

Mr. Olson, please.

SHRINKING INDUSTRIAL BASE ADDS TO COST

Mr. OLSON. Thank you, Madam Chairwoman. And, Mr. Scolese, I have a question for you. In your opening statement you mentioned the issues with the American industrial base, and I was just wondering if you could elaborate on the impact that a dwindling industrial base has on NASA and its maintaining a cost-effective schedule.

Mr. SCOLESE. Yes, sir. As the industrial base has collapsed, of course, one of the initial or I shouldn't say collapsed. That is too strong of a word. As the industrial base has shrunk and consolidated that provides us less opportunity for competition. So oftentimes we have to go with the supplier that exists, and we don't have a choice.

The bigger problem probably is the loss of expertise that was mentioned earlier in the opening statements. We don't have as many scientists and engineers and technicians to go off and build our instruments, build our spacecraft, build the components that go into those instruments or spacecraft, and that has created some degree of a problem for us.

In addition, it has some unintended consequences because we have to go overseas for many of our components, and that, of course, hurts American industry.

A third factor that plays into this is with lack of some parts we have had a rise in the number of counterfeit parts, things that we can't deal with. This is a worldwide problem. It is not a U.S. problem. This is a worldwide problem, and in dealing with that you find out late typically when you get counterfeit parts. We do inspec-

tions, we do all the things that you are supposed to do. That adds cost clearly, but when you find out about them, if you don't find out about them at receipt, you find out about it when you are in test or you find out about it when you are sitting on top of the rocket or worse, you find out about it when you are in space. And all of those have cost implications.

One of the things that could help that, of course, is having, you know, more missions that are available along the lines of what we are talking about here. If we can reduce our costs, improve our cost estimations, we can provide, you know, opportunities to do that. But I think what I said pretty much summarizes the concerns that we see with the consolidation of the industrial base.

GROWING AMERICAN INDUSTRIAL BASE MEANS CHANGES TO ITAR

Mr. OLSON. Thank you very much. In addition to having more missions, any suggestions what we can do as a nation to help grow the American industrial base to ensure we are competitive and we have the capacity here in America to perform the missions that NASA performs?

Mr. SCOLESE. Yes, sir. One area clearly is, I believe there was a hearing last week about the ITAR activities, and we are all very concerned about our national defense and recognize what ITAR's purpose is. But its implementation has been, has had an effect, a negative effect on our ability of our industry to compete overseas.

It has also made it very difficult for us as the Nation's Space Program to also work with our partners overseas because we can't necessarily share information with them in ways that are as effective as they could be. It has also delayed our ability to make agreements, which has caused cost growth that we have talked about.

When it takes a year or two to come to an agreement about a mission that you have agreed to do, you have clearly built risk into it as you can't talk to the international organizations that are providing resources. But for our industry they lack the ability to go off and compete because a contract on a communications satellite usually has about what, 30 days or 60 days, to put in a bid. It takes that long to get through the process.

So reducing some of those requirements or streamlining the process, and there is other people that know more about it than I do, could certainly help our industrial base be able to compete on the open market.

EXTERNAL FACTORS IN NASA'S COST GROWTH

Mr. OLSON. Thank you for that question. That is a nice segue to my final question here, but in your testimony you indicated that ten of the projects that—of the ten projects that exceeded the costs five of those were due to external factors out of NASA's control. The ITAR thing is probably a great example.

What are these external factors? Could you elaborate, and what can we do to help mitigate?

Mr. SCOLESE. Well, not all can be mitigated easily. Three of them, I think four of them, in fact, were due to issues with either the launch manifest or with partner performance, and we have a

backed up launch manifest right now. Two of the missions were delivered on time and unfortunately, the launch manifest is backed up to the point where one, the solar dynamics observatory will be delayed almost a year. That is something that we couldn't foresee. We are, of course, working with our colleagues in the Defense Department and the commercial industry to try and improve the launch manifest to improve our launch posture, but that is one area where we could, you know, clearly see some help.

The other missions were affected by partner performance, international or U.S. partner performance, where they ran into difficulties that were unforeseen to us, and I am not sure there is much more that could be done that we haven't talked about. They have the same issues as was mentioned earlier that we do in terms of optimism and over-estimation, as well as stability of their funding requirements.

And in at least one case it was due to, you know, industrial concerns, where, you know, if you went to a government lab or you went to a university or you went to industry, you might have had the same problems because of the lack of expertise. But that was an issue that we experienced.

So it was those three things; the launch manifest, which is something we can do by, you know, encouraging a robust launch capability in this country, by partner issues, which were for a variety of different reasons that could have been unforeseen.

Mr. OLSON. Thank you very much, and I yield my time.

Chairwoman GIFFORDS. Great. Thank you, Mr. Olson.

And just for the record, I think it is important to note that Mr. Olson and all of these Members down on this side either represent a NASA center or are adjacent to a NASA center and have NASA employees in it.

And with that, Mr. Griffith, who represents Marshall.

NASA SUCCESS HAS LED TO HEIGHTENED PUBLIC EXPECTATIONS

Mr. GRIFFITH. Thank you, Madam Chair, and thank you, panel, for being here, and I would like to make a comment. Many of the questions that I had have been asked.

One of the frustrations that I think that we are hearing is that cost overruns are inherent in any scientific endeavor. They are not budgeted, cannot be budgeted. Burn rates for discovering the unknown are going to be there. We understand that. I think it is unfortunate in a way that NASA has been so successful, has held themselves to such a standard of excellence that the general public expects that NASA is like starting their car in the morning. And that is really not that much science to it anymore, and there is not that much danger anymore, and there is not that much that really goes into it. We are just building rockets and exploding them into space.

Nothing could be further from the truth. We are still on the frontier. China walked in space two months ago. Japan is on the way up, India is on the way up, Russia, of course, has been up. For the last 50 years NASA has established excellence in the pursuit of science and now you are going to become part of the high ground and the national defense. I expect there to be cost overruns, not

only for safety issues but because we are going to be pushing the envelope because we will remain number one in space.

So I think my question to you would be can we do a better job letting the public know what a huge scientific endeavor this is and how much we really don't know when we send humans into space? And can we maybe reeducate the public that we are on the great frontier again, trying to achieve the high ground, competing not only with Russia now but China, India, Japan, and certainly others?

So I appreciate our attention to the detail of costs, but when we were discovering the vaccine for polio, we did not ask that question. We needed Dr. Salk and Dr. Sabin to get that polio vaccine. I think we are going to have the same attitude towards NASA. We want you to do what you need to do, and we want to help you do that, so my question is can we educate the public so they are not frustrated about the scientific method? And the other thing, what can we do to help you?

And thank you very much, and I will yield my time.

Mr. SCOLESE. Well, thank you for that. I think if we could copy that speech we would go a long way towards addressing that question, and you bring up, you know—actually I only want to correct one thing that you said. We don't like to explode our things into space.

But you bring up, you know, a very important point. We can't lose sight of the need for mission success or safety. We have to balance the success of the mission, the risk of the mission with the cost and the schedule. We can't focus on any one of those three or four items in order to be successful.

And, yes, sir, we can do a better job of explaining that, and we will.

Chairwoman GIFFORDS. Thank you, Mr. Griffith.

Mr. McCaul, please.

Mr. MCCAUL. Thank you, Madam Chair, and let me congratulate you and the Ranking Member on your new positions and——

Chairwoman GIFFORDS. Thank you.

GAO RECOMMENDATIONS FOR NASA'S FUTURE HUMAN SPACE FLIGHT

Mr. MCCAUL.—we are very excited to have you.

And you, Mr. Scolese, in your new position. I have two areas of questioning. The first I think one of the greatest—and NASA has many missions, but I think one of—the one with the greatest vision is the one of going to the moon, Mars and beyond. There is a proverbs quote up here, "Where there is no vision, the people perish." This is the greatest vision for mankind. It was Kennedy's vision.

This has been estimated to cost about $100 billion over the next 13 years, and the Chair of this committee, Bart Gordon, took a look at GAO's recommendations and said that they were common sense and hopes that you at NASA will take a look at these recommendations and implement them. And hopes that you will take these seriously.

I want to just get your initial—Ms. Chaplain, if you could just briefly summarize the recommendations as they pertain to that

specific mission, and Mr. Scolese, how you intend to work with GAO on that.

Ms. CHAPLAIN. Our recommendations have been pretty consistent across a lot of projects. Basically we would like to see NASA pushing technology is one thing, and they have, each project has two to five years to do that and to learn about what they are doing and to set requirements. But when they get to the point where they are ready to commit to Congress and get authorized to move ahead as a formal program, that is where we would like to see requirements get settled and technology to be understood.

If that happens, you have a very solid foundation for moving forward. So I don't want there to be a misunderstanding that GAO is saying there is a bad thing to have cost growth and lots of things going on when you are trying to learn to do something that hadn't done, been done before. We really encourage that to happen, but there is a time and place for that to happen. Once a program is ready to move forward, you do need stability to make it executable.

And I think, you know, across the board NASA has consistently agreed with these recommendations. It has built it into its policy. It is reflected in a lot of the actions it is undertaking right now. So the thing to do is just to sustain the attention to these improvement efforts and to adhere to these good practices that are reflected in their policies going forward, especially with these big ticket programs that are ready to enter these implementation phases, including areas of Orion, James Webb Telescope.

Mr. MCCAUL. Okay. Mr. Scolese.

Mr. SCOLESE. I think Cristina said it right. We are—we have taken those seriously. We are working on all of those. I would like to add one of the things that we are doing to make sure that we are, in fact, implementing that guidance or something that resembles that guidance, because we do conduct our independent reviews at each milestone to make sure that, in fact, we are doing what we said we were going to do, and we have independent people looking at it. And then we monitor that monthly to go off and make sure that all the pieces are still coming together.

One of the challenges that we have is the stability, and it is getting to the point where we can make that commitment. As you can imagine as you are maturing your requirements and maturing your technologies, there is a lot of people that want you to go faster and commit sooner. We can't take forever. We recognize that, but we need to be able to take the time to get that done, and the support that we can get to allow us to do that would be greatly appreciated.

And it typically takes, you know, sometimes two, three, and in some cases as in the JWST, James Webb Space Telescope, took us almost a decade to get to a point where we felt we had technologies mature enough to proceed, which we really just decided on this year.

Mr. MCCAUL. Now, I just want to let you know, we in the Congress support you in that effort and stay in close communication with us.

COST OVERRUNS IN CLIMATE CHANGE MISSIONS

Lastly on—in the stimulus bill there was money appropriated for the purpose of climate change. Can you, Ms. Chaplain, speak to

prior programs related to this, that particular mission and some of the cost overruns? Specifically I know the Glory Program had some cost overruns.

Ms. CHAPLAIN. Yeah. Several of the climate and environmental programs have had cost overruns. A lot of them have been attributable to contractor performance and not really recognizing that the contractor may not have had the expertise to develop some of the key sensors for satellites. What we would like to see is more attention paid up-front into what contractors can do and cannot do and to make sure you have a plan for dealing with any risks that you see in the contractor.

We also like to see with these programs more stability with requirements once they start, and we also would like to see not too many expectations placed on any one program. The NPOESS Program, for example, has more than ten sensors on it, makes it very difficult to design and execute that program with so many sensors and so many problems associated with each one of them and the integration process and so forth.

So there is a lot of risks associated with these kinds of satellites but a lot that can be done to mitigate those risks.

Mr. MCCAUL. Thank you, Madam Chair.

Chairwoman GIFFORDS. Thank you, Mr. McCaul.

Another terrific asset we have on this subcommittee is Ms. Edwards, who used to work at Goddard and now represents the interests of Goddard, so, please, five minutes.

Ms. EDWARDS. Thank you, Madam Chairwoman, and thank you to the panel.

CONTRACTOR PERFORMANCE CONTRIBUTES TO COST OVERRUNS

I just want to focus this morning on contractor performance and the ways in which contractor performance contributes to overrunning cost estimates, and so Mr. Scolese, I think you came to Goddard just as I was departing Goddard, and Ms. Chaplain, both of you in your testimony talked about that. And so I am wondering what there is about contractor performance and whether there are positive incentives and not just negative incentives to increase performance to contract and to avoid overruns, and then secondly, I wonder if you could speak to the internal capacity at NASA that actually might help us better oversee some of the highly-technical and scientific projects in which NASA is engaged.

Mr. SCOLESE. Yes. In regard to the contracts and what our mechanisms are, we do have positive feedback mechanisms. I mentioned earlier that many of our contracts have award fee provisions, and that allows us to reward performance periodically all the way up until in many cases the end of the planned mission life. So even if—after it is launched, we can still go off and say, if you performed well, you can get, you know, a fee on that performance.

So we have the positive incentives to go off and do that, and also it can serve as a negative incentive by getting lower scores. So we do try and find ways to motivate and reward, you know, performance. We do the same with our civil servants as you know, although it is not quite the same as that, with awards and metals and monetary awards when that is appropriate.

So I think we have, you know, many of the incentives in place, and of course, one of the biggest incentives for both the contractor and the team that is doing it is to see the successful performance of the mission. You know, oftentimes, you know, it is answering a scientific question that hasn't been asked before, and the results can yield as they did with COBE with a Nobel Prize. So there is some great rewards that come from the scientific discovers that can be made.

NASA'S CIVIL SERVANT CAPACITY TO PROVIDE TECHNOLOGICAL EXPERTISE

Ms. EDWARDS. But does—what I wonder, though, is internally within the civil servant component of NASA, of the Agency, do you have the capacity to provide the kind of technological expertise that is needed over these projects to ask the right questions of contractors over the lifespan of a project to ensure that we are, you know, tamping down on costs where necessary and estimating what the overall cost of the project will be?

Mr. SCOLESE. Yes. I do believe that we have that. We have, you know, a very good workforce. What we haven't always given them is the tools and the support that they needed. We have, as you well know, some of the brightest people around that are working these activities.

What we haven't always done is the things that I tried to outline here is give them a forum to speak up when they have issues, to give them the opportunity to speak with senior management who could do things, whether it is adding additional resources, additional people if the project needs additional people, additional technical expertise if we need additional technical expertise. We can reach into the Agency at other centers. That is often been a problem where centers don't know what each other's capabilities are. We have broken down those barriers with organizations like the NASA engineering and safety center so that we can go off and share resources amongst the centers.

We also have the ability to go outside of the Agency to organizations like Aerospace Corporation and others. So we made that more available to people.

In addition, by having, as I mentioned, and all the centers now do this, having monthly reviews or periodic reviews where you can bring up issues to senior management, we can take actions. They can be as simple as picking up the phone and calling a contractor and saying, you are not doing what we think you should be doing, and here is why and having the details. Or it could be, you know, more invasive than that.

NASA LIFE CYCLE PERFORMANCE

Ms. EDWARDS. Let me just interrupt you because I have probably just enough time for this last thing, and that is whether you are able to—are there interim assessments, and can you look at international agencies in addition to the Department of Defense to learn about where you can better assess over the life of the project whether you are meeting cost estimates. And so looking at like agencies or over the lifetime of a project, and you can think about

this later. I am looking, for example, at Landsat, and Landsat over a period of time, are there things that we have learned about those assessments that actually might help us for other projects.

Mr. SCOLESE. Yes. In fact, we are doing that. We have been doing that, and we are going to embark on a broader study to go off and look at performance of other agencies and other activities. I am not sure that we could get the information on the international ones, but we will certainly go off and look and see if that is doable.

Ms. EDWARDS. Thank you.

Chairwoman GIFFORDS. Thank you, Ms. Edwards.

Mr. Grayson.

FIRM-FIXED CONTRACTS INCENTIVE TO AVOID COST OVERRUNS

Mr. GRAYSON. Thank you, Madam Chair. Mr. Scolese, what percentage of NASA's contract dollars are spent on firm-fixed priced contracts?

Mr. SCOLESE. I will have to get you the exact details on that. I don't have that off the top of my head, but I can tell you that where we can do firm-fixed price we do, and I can give you a couple of examples here and then for the record I will provide you with more details.

On the tracking and data relay satellite system, communication satellites, those were fixed-price contracts. For portions of the GOES satellite that we do for NOAA, those were fixed price. For many of our small Explorer missions the spacecraft bus is often a fixed-price bus.

What percentage of our contracts beyond—in precise terms I can't give you off the top of my head and will get that to you.

Mr. GRAYSON. Well, for firm-fixed price contracts, the contractor pays 100 percent of the cost of overruns. Correct?

Mr. SCOLESE. If it is caused by them. That is correct. Yes.

Mr. GRAYSON. And for cost reimbursement contracts, the contractor is not legally obliged to pay any part of the cost overrun. Is that correct?

Mr. SCOLESE. That is correct.

Mr. GRAYSON. So is it fair to say that if NASA did more firm-fixed price contracts we would be giving the contractor an incentive, a real incentive to avoid cost overruns?

Mr. SCOLESE. We look very carefully at what type of a contract we use to try and balance the risk that is going to be in there. Typically we do firm-fixed price contracts when we understand the requirements so that a contractor will, in fact, bid on it and know that they have a chance of being successful.

We use cost reimbursement type contracts when there is some uncertainty in the, in either the requirements that we have or in the ability to perform. So we do a very careful risk benefit relationship. Where possible and as often as possible we try and use fixed-price contracts. But that isn't the only remedy that we can use.

Mr. GRAYSON. Mr. Scolese, it seems that have here two extremes. We have one condition where the contractor pays all the cost of overruns. The other condition where the contractor is legally

obliged to pay none of the cost of overruns. Wouldn't it be useful to have something in-between?

Mr. SCOLESE. Well, in fact, we actually do try and work that way, and I just want to, you know, on the firm-fixed price, if we change something, we pay. If they can't meet the original specification, they pay. And, yes, I mean, we actually try and work those cost reimbursable contracts where we have negotiations, they will not be reimbursed for all the costs if we feel it was their fault to cause it. We can't guarantee that at the beginning of the contract or we can't guarantee that at the beginning of the negotiations. But we do work hard to try and make that stick and to assign responsibility where responsibility lies.

Mr. GRAYSON. What percentage of NASA's contracts, if any, are awarded under invitations for bids, sealed bids, rather than through competitive proposals?

Mr. SCOLESE. I don't have the answer to that. Most of our stuff is done competitively, but there may be some institutional activities that are done by sealed bids. I can't answer that off the top of my head.

Mr. GRAYSON. Now, when there are competitive proposals which I am sure you will agree is the predominant form of NASA's contracting, when there are competitive proposal's, there is a cost technical tradeoff in those proposals. Correct?

Mr. SCOLESE. Yes.

Mr. GRAYSON. All right. Now, you can correct me if I am wrong, but I believe that there is nothing in the statutes that indicates to NASA what that tradeoff should be. Is that correct?

Mr. SCOLESE. What the tradeoff between the cost and the technical should be?

Mr. GRAYSON. Right. How much of an emphasis should be put on cost versus technical?

Mr. SCOLESE. No. We—there isn't a statute for that. We determine that before the contract is released for bid.

Mr. GRAYSON. Right. But the Agency determines that in its sole discretion without any guidance from us. Correct?

Mr. SCOLESE. Yes. That is correct.

Mr. GRAYSON. Now, if we were trying to save money, it seems that one way we could try to do that would be to emphasize cost more in this cost technical tradeoff. Is that a fair statement?

Mr. SCOLESE. Well, we do emphasize cost. It is a fair statement, but we have to manage the cost and the schedule and the risk and the technical performance. All of those factors have to be considered. Yes.

Mr. GRAYSON. Now, returning again to the tradeoff between having a firm-fixed price contract where the contractor bears the risk and the cost reimbursement contract where the contractor legally bears none of the risk, apart from the question of whether we should have something between those two, would you agree with me that now it is the Agency that makes that decision and not Congress?

Mr. SCOLESE. Yes. I would agree with that.

Mr. GRAYSON. All right. Now, again, if we were trying to avoid cost overruns, do you think it might be a good idea for us to give you some direction about when to use a cost reimbursement con-

tract and when to have the contractor bear the risk of the cost overrun?

Mr. SCOLESE. No, sir. I think, you know, those are very difficult decisions that have to be made as we are developing our requirements, and you know, when we have very stable requirements, firm-fixed price contracts are absolutely the right thing to do. And that determination, as was mentioned earlier, comes after we have done some definition of what it is that we want to achieve. And as I tried to mention earlier, we do, in fact, do that. Many of our spacecraft for the small Explorers as an example are, in fact, firm-fixed price because we understand our requirements very well. And we have good performance there.

So I think it is going to be, it would be very difficult to look at each and every one of our missions to try and determine which should be firm-fixed price, which should be cost plus, and which portion of the mission should be firm-fixed price and which portion should be cost plus. Because in any given mission you will have different types of contracts for different components that are being delivered.

Mr. GRAYSON. Thank you. I will look forward to receiving the information that you promised.

Thank you, Madam Chairwoman.

Chairwoman GIFFORDS. Thank you, Mr. Grayson.

Now we have Ms. Kosmas with us, also a Central Floridian, representing the Kennedy Space Center.

MORE COST OVERRUNS FLEXIBILITY IN HUMAN SPACE FLIGHT

Ms. KOSMAS. Thank you. I am honored to be here. Thank you, Madam Chair, and thank you to the panel for being here.

I want to start by saying I am very excited to be representing the Kennedy Space Center and thrilled to have been a neighbor and watched the launches for 35 years in my time in Central Florida.

I want also to echo the comments made by Parker Griffith, my colleague here, about how it is very important to me that we maintain the U.S. supremacy in man space exploration specifically and also the other areas in which we use space exploration, whether it is for national defense, whether it is for environment, whether it is for weather prediction, or whatever the use might be, but man space flight, of course, is of a high interest to me.

So with reference to the comments made by Congressman Grayson and the cost analysis, would you say that you put a greater emphasis or that you allow a greater latitude or flexibility in terms of cost overruns when there is a significant safety factor involved, particularly with regard to human space flight?

Mr. SCOLESE. Well, certainly that goes exactly to the risk discussion that we were just talking about. Clearly, if we have a mission, we err on the side of safety. There is no question about that. Clearly we can't allow it to go so far beyond what our ability to pay is, and we would have to take a step back and see if we are doing it the right way and ask that question. But clearly we are not going to scrimp when it comes to safety.

Ms. KOSMAS. Well, good. I mean, I assumed that to be the case, but I thought it needed to be pointed out perhaps——

Mr. SCOLESE. Thank you.

A FIXED DATE TO END THE SPACE SHUTTLE INCREASE COST STABILITY

Ms. KOSMAS.—that that is an area in which cost overruns maybe are—we have learned from experience that certain things require greater care in terms of the safety risk factor.

Which brings me to the second part of my question which has to do with, in my district, of course, we are concerned about the end of the Shuttle launch and the beginning of the Constellation Program and the difficulties that that poses for us in maintaining a professional workforce in the area. And wanted to ask you with regard to the safety aspect of putting a hard and fast date on the end of the Shuttle Program, do you think that that is a wise thing to do?

Mr. SCOLESE. I won't comment on the wise part, but I will say that clearly that having a fixed date adds to the, one of the things that we mentioned earlier, which is stability. We need that same workforce, portions of that same workforce, to go off and build the next system, design the next system, test the next system. So we need to move some of those talented people over to that activity. They are doing a wonderful job in flying the Shuttle, but we also need them in other areas as well. So we need to start transitioning some of those people over.

We also need some of those facilities. As you know, you were down there just recently, and you saw the three lightening towers going up on 39B. We need to have those facilities available to begin launching the new systems.

So from a stability standpoint, from a risk standpoint, having a fixed date to allow us to start transitioning those people and those resources is important to us, and I think 2010, is a reasonable date for us to go off and do that by. We have, as you know, we have the hardware to get us there. We would have to build additional external tanks to go beyond that, but so I think 2010, is a reasonable date, and it provides us a reasonable risk posture to proceed.

Ms. KOSMAS. You think it does provide a reasonable risk posture——

Mr. SCOLESE. Yes.

Ms. KOSMAS.—for you to proceed? Okay.

Mr. SCOLESE. Yes.

Ms. KOSMAS. Given the flexibility shall we say and time for rocket launches to take off and that provides a flexibility in time, how much flexibility do you think would be reasonable past 2010?

Mr. SCOLESE. You mean to fly the Shuttle or to——

Ms. KOSMAS. Yes. To fly the Shuttle.

Mr. SCOLESE. We will have to get back to you on that. We have a report actually that is coming in on——

Ms. KOSMAS. Okay.

Mr. SCOLESE.—the answer specifically that question.

Ms. KOSMAS. Okay. Thanks very much.

How New Contracting Procedures Will Effect NASA

Chairwoman GIFFORDS. Thank you, Ms. Kosmas. That completes our first round of the questions. We know that votes will be called very shortly, but we are going to attempt to do a second round.

So with that, Mr. Scolese, President Obama yesterday singed a Presidential memorandum to overhaul the way the government does its contracting. He indicated that your agency would be working with other agencies as well as OMB to come up with new procedures and practices.

Can you tell us today anything about the impact this overhaul will have on NASA contracting?

Mr. SCOLESE. Actually, we took a quick look at it, and we think that we are largely in line with the provisions in there, the utilization of fixed-price contracts as we discussed earlier. We do that where that is appropriate on space hardware as well as, you know, institutional items. So we are certainly going to look at it and see where we can improve.

The other provision to use competition we regularly use competition and require competitive activities. We require a justification when we do not use competitive bids, so we do that where there is one supplier, for instance, as is the case for large solids, the first stage of the Ares vehicle. There is only one supplier of large solids, so we had to do fixed price or, I mean, sole source there.

But predominantly we use competition, and then as far as the A–176, we have had some experience with that but not as much, and that requires a little bit more of our looking at it. But it is along the lines of the way we have proceeded to maintain inherently governmental responsibilities within the government.

NASA Addresses Launch Conflicts and Increased Cost

Chairwoman GIFFORDS. Thank you, and our subcommittee will likely have you come back and report on how things are going.

I also understand that NASA is very concerned as is indicated by your testimony earlier about the crowded manifest for launch vehicles in 2011, and the fact that the Mars Science Labs launch window that year will be very tight. Evidently NASA needs to contend not only with the Juno Mission to Jupiter but also with DOD launches as well.

However, this is not the first time that this has happened. As you know, launch delays increase project costs. We have heard a bit about that, but what is NASA doing to mitigate launch conflicts?

And also, Mr. Pulliam, based on the Aerospace Corporation's work at DOD, what can NASA do better to mitigate launch conflicts, and is this problem going to get better, or is it going to get worse?

Mr. SCOLESE. Well, what we are doing to resolve the problem is, of course, we are working with United Launch Alliance, we are working with our colleagues in the Department of Defense and Department of Commerce to try and make sure that we have a manifest that is doable, and we—and that we can have confidence in. We are behind right now. There is no question about it. The launch

manifest as you mentioned is backed up, causing some missions to slip.

What the exact way to fix that problem is going to take some time. We are also looking within NASA, I am certain you have heard about the COTS activities and about our launch vehicle on-ramps for the NASA launch services, we are also looking at other suppliers as they come online to fly our vehicles. And where partnerships make sense we use international launches on a not-for-fee basis. That is their contribution to us.

So we are looking at all three of those things; working with our colleagues in Defense Department and ULA to improve the manifest, improve the capability to launch more frequently, we are encouraging the development of other launch vehicles, particularly the medium-class launch vehicle that will end when the Delta II stops producing, which carries most of our science payloads, and we also, where it makes sense and where it is beneficial to the United States, are looking at international launches as well.

Mr. PULLIAM. I would agree with the statements Chris has made. You know, we see the clogging of the manifest just from inside the DOD perspective even before you integrate the NASA launches into that. So it is clear, and that clogging of the manifest comes and goes as missions encounter these difficulties we have talked about and perhaps move into a new area of the launch manifest where maybe it wasn't so bad before. Now it is worse than you thought.

So it is an ever-changing game. So even though we see a clogged manifest in the future, that will change some as we approach it as well.

I think the answers to it are as they are with most of these other problems. It requires a very close interaction between NASA and the DOD on which instruments need to go when. If it is a planetary mission, then surely we need to hold onto those windows, lest we lose two years. If the DOD has a mission that is more important to national security, then perhaps that takes the precedence, and I think we do that now. So that coordination and cooperation needs to continue.

And then finally I would say we need to look at what is on the critical path as we try to use our facilities in the most efficient way. Is it just the physical turn of the pad? Does it have something to do with range capabilities? You know, what is it that could be viewed from a multi-user perspective to see if we want to operate at the maximum efficiency? Are we doing that now? Are there upgrades that are required? Is there infrastructure that we don't know have, and to look far enough in advance to know what that is so that we don't wind up just accepting whatever capacity there happens to be, perhaps based on a time when the demand wasn't quite so high.

Chairwoman GIFFORDS. Thank you.

Mr. Olson.

Mr. OLSON. Thank you, Madam Chairwoman, and Mr. Scolese, give you a little break.

Mr. Pulliam——

Mr. PULLIAM. My turn.

Mr. SCOLESE. Thank you.

Mr. OLSON. Spread the love a little bit so to speak.

Mr. PULLIAM. Okay.

Mr. OLSON. Just wanted to talk about NASA and in comparison to the Department of Defense, and in your testimony you compared NASA with the National Security Space Community. You said NASA was far less, received requests far less overall support from the Aerospace Corporation but proportionately more programmatic in budgeting support.

Mr. PULLIAM. Yes.

COMPARISON BETWEEN NASA AND DOD ON COST ESTIMATING, BUDGETING, AND PROGRAMMATIC CONTROL

Mr. OLSON. And so between NASA and the National Security Space Community, who in your view does a better job with cost estimating, budgeting, maintaining programmatic control over their programs? What are the differences, and why do you think those differences exist?

Mr. PULLIAM. Thank you. It is true that the predominant customer for the Aerospace Corporation is the Department of Defense Space Program. That is why we were created back in 1960. NASA is the company's third largest customer right behind DOD and NRO. So we are privileged to work with them, and we did want to make the point that—and we think it accrues to NASA's credit while the Air Force typically uses Aerospace more for the in-line, hardcore technical and scientific kinds of things that we are expected to do, NASA has that capacity more capably in its organic workforce, so they turn to Aerospace as we would expect federal agencies to do to see what we have that serves them in the accomplishment of their national mission.

And that has turned out to be this body of work and cost estimating, looking at the parameters that go into that, and we think NASA in partnership with Aerospace is doing some things that other agencies frankly aren't doing. And it is going to pay off, and we are going to see the dividends of that.

Which organization is doing best? We can cite examples across both agencies where there have been spectacular failures of managing costs and schedule. We did find that the causes and fundamental elements seem to be about the same. The Department of Defense uses other very capable contractors to help them with their cost estimating, so we are not as deeply involved with them as we are with NASA in trying to figure out the doctrine and the managerial techniques.

But I think it sounds a bit like a cop-out, but I think the agencies have essentially the same problems, and they are running at similar kind of overhead rates. NASA can say, yeah, but we had this mission that really pushes the science in a way that no other mission has. DOD can respond by saying, yeah, but we have this multi-military user community that requires things to change in technology and schedule and growth.

So it just needs to be managed uniquely from each agency's perspective, but in full appreciation of best practices that might be out there, and if I could just take one more moment, there is a lot of really fine work being done that was begun at the GAO and has migrated into NASA and to the Aerospace Corporation in looking at major acquisition milestones called key decision points.

And looking in advance of those at the kind of knowledge one needs to have in order to be ready for those milestones, and those milestones play directly into cost and schedule. I know NASA and the Aerospace Corporation and GAO are all very interested in continuing to define what it takes to be successful at every part of the program, and that is going to pay off as well.

MSL Dramatic Cost Estimate Change

Mr. Olson. Thank you very much for that answer.

Mr. Scolese, I couldn't let you get away clean free. I just want to talk very briefly about the Mars Science Lab, and it is my understanding that the original cost estimate for the Mars Science Lab was in the $600 million range. And that NASA's initial confirmation estimate was closer to $1.6 billion. That first estimate did not come from NASA as I understand it. And you have, NASA has recently announced a two-year delay in the MSL with a cost increase of $400 million.

I just wanted you to elaborate on how those numbers were obtained and what is being done to eliminate unrealistic estimates.

Mr. Scolese. Yes. That first number that you mentioned, the roughly $600 million, came out of what is called a decadal survey that we do with the National Academies where they look at our objectives in the future, and they try and prioritize them and say these are the science goals that you really should think about doing. And we work with them to try and accomplish those goals.

The Mars Science Lab was one of those, and at that time it was estimated at $600 million. When we went off and did our studies, as was mentioned here, we did the work to mature the technologies to get a better understanding of it, we estimated the cost to be $1.6 billion. Clearly, we still underestimated the complexity of it, and we should and could and can and will do better in the future.

We are also working with the National Academy to help them improve their earlier cost estimates that you see there, because it often gets out, you know, one way or the other that, you know, somebody thought this was going to cost whatever was said at the earliest phase. So we are working with them to help them obtain the tools and to get resources, and the Academy is doing it as well. So we are doing it together, and we are doing it willingly so that we can go off and have a better understanding of what those missions would cost so they can better establish priorities.

Mr. Olson. Thanks for that answer, and Madam Chairwoman, I yield back my time.

Chairwoman Giffords. Thank you. We have with us Mr. Rohrabacher, and of course, votes have been called, but we are going to have some minutes to hear.

Bad Judgment and Irrational Optimism Affects Cost Estimates

Mr. Rohrabacher. Thank you very much. I apologize for being late to the hearing. As usual we had two important hearings at exactly the same time.

I would like to ask a general question just—when we take a look at this Mars Science Lab and we take a look at, I guess it is NPOESS, I guess.

Mr. SCOLESE. NPOESS.

Mr. ROHRABACHER. NPOESS. I have never been able to pronounce that right, and I have been looking at this for years, but with that said, you know which project I am talking about.

Mr. SCOLESE. Yes.

Mr. ROHRABACHER. When we look at that and we look at this whole Mars issue today, are we talking about basically—and these other problems, are we basically talking about intentional wrongdoing in terms of lying about a bid. You know, when you are offering, intentionally offering a bid that you cannot handle, that is a lie, and that is an intentional wrongdoing. Then you have another option. Bad judgment, you know, unintentionally doing something that ends up causing harm like miscalculating what you really can accomplish for a certain degree. Or are we talking about systematic flaws?

Because we have had consistently over the years examples after-example after example after example of overruns and of people not really being able to fulfill the obligation they have taken on when a contract has been issued. So what are you talking about? Are we talking about a systematic flaw? Should we be doing something else? Are we talking about just bad judgments that were made but with no ill, nothing, you know, wrong. People do make bad judgments at times. Or are we talking about intentional wrongdoing?

Mr. SCOLESE. Well, let me start off by saying NPOESS isn't a NASA project, so I can't comment, you know, in any degree of detail on that, but your question is broader than that. And I don't believe that intentional wrongdoing is there ever. I suspect it probably happens occasionally, but that is not what we see. It is more in your second one, which is, you know, bad judgment, although I would like to call it optimism.

Mr. ROHRABACHER. All right.

Mr. SCOLESE. The people that are proposing these missions that want to do them are extremely enthusiastic about it, and they are optimistic about the technologies that are out there, they are optimistic about their ability to do the job.

Mr. ROHRABACHER. Irrational optimism can be very costly.

Mr. SCOLESE. Yes, it can. Yes, sir. And that is why get to this, to the third part, which is really the answer to your question, which is it is systematic. And that is what we were trying to talk about here, what we are doing, and that is what the GAO has pointed out that we need to do.

It is not one thing that is going to improve our performance. It is many things that are going to improve our performance. We have to train our people, and we do, and we are improving our training process so that they will be able to recognize their optimism as well as others optimism. We have to monitor the performance of what is going on so that we can see if optimism is driving the estimate or if, in fact, poor performance is causing us to have some overruns. We have to put those tools in place so that we can catch them early enough so that they don't become, you know, surprises for sure but they don't become large cost impacts because we

can then apply additional resources without maybe having to increase the budget or change the schedule.

Mr. ROHRABACHER. So training, monitoring oversight, but let me add one other word here that I over the years that I just never hear and that is accountability, and if someone has a bad judgment or if someone is in, especially if someone is intentionally doing something wrong, I have not found the ability of people to be fired or to be charges being brought against people. And I just, especially if they are within the system and making a bad judgment as compared to a contractor from the outside. Shouldn't, isn't there a problem with accountability here?

How many people do you know have been fired from their job at NASA?

Mr. SCOLESE. If you mean by fired sent away from NASA——

Mr. ROHRABACHER. Yeah.

Mr. SCOLESE.—you mean for wrongdoing, you know, they violated the law, I wouldn't have the names but I——

Mr. ROHRABACHER. Well, I wouldn't say violated the law. If someone just has very bad judgment, I remember with Hubble Telescope there was a bad decision made somewhere there where they sent it up and the mirrors weren't exactly right, and it was, it cost the taxpayers a lot of money.

We should—I know my time is up, so I will just say that we need to be holding people more accountable for bad judgments, irrational optimism. I know you are going to go to work on the systematic problems as well.

Mr. SCOLESE. And we do the other, we do take into account those types of things. We do hold people accountable, and we have, in fact, replaced project managers, project personnel, other personnel if they are not performing. But we also have to recognize what caused them not to perform, and if it was certainly their fault, we do remove them. To say that we fire them, I can't necessarily say that, because oftentimes these people have performed spectacularly in other areas, so we will remove them from their current job and move them to another.

Mr. ROHRABACHER. Okay. Thank you very much.

Chairwoman GIFFORDS. Thank you, Mr. Rohrabacher. Thank you, Mr. Scolese. Just in closing, I know that a lot of the work that NASA has done in the budgetary areas were not reflected in this GAO report. So when do you expect the Congress to be able to see the result of the work that you have done?

Mr. SCOLESE. Well, as the GAO report said, you know, these tools have been put in place in the last couple of years. Our missions typically last or our mission cycle is typically three to five years, so you should be seeing some of the results soon. I think you will see our estimates, you know, better, but probably you will see the real benefit of what we are doing in the next couple of years, the next one to two years as we start delivering on those missions that we started this process on about two years ago.

Chairwoman GIFFORDS. Thank you. Before we bring the hearing to a close, I want to thank the witnesses for testifying before the Subcommittee today. I want to thank my Ranking Member as well for our first successful hearing and also as you saw there is a real passion for space in this subcommittee, and a lot of Members, new

Members to the Congress represent NASA's interests, the American people's interests. So I look forward to a fruitful, productive next couple of years.

The record will remain open for two weeks for additional statements from Members and for answers to any of the follow-up questions the Subcommittee may ask of our witnesses. The witnesses are excused, and the hearing is now adjourned. Thank you.

[Whereupon, at 11:37 a.m., the Subcommittee was adjourned.]

Appendix:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Christopher J. Scolese, Acting Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. NASA has noted on several occasions that problems with contractor performance have led to cost overruns and schedule delays. What corrective actions is NASA undertaking to ensure better contractor performance and improve its contractor oversight for major acquisition projects?

A1. NASA has instituted a multi-pronged approach to strengthen acquisition planning and execution, increase management oversight, and assess and address root causes for problems with contractor performance. NASA has re-visited forums and metrics used to monitor, track and report contract performance. NASA also is taking a closer look at how contractor performance contributes to program and project performance success.

As outlined in NASA Policy Directive 1000.5, "Policy for NASA Acquisition" (issued January 2009), and NASA Procedural Requirements 7120.5D, "NASA Space Flight Program and Project Management Requirements," the Agency has instituted a strategic acquisition planning and authorization process designed to strengthen program and project formulation. This process begins with an Acquisition Strategy Planning (ASP) Meeting, which approves a new or substantially changed program or project triggered by Agency requirements or legislative direction. The ASP is followed by an Acquisition Strategy Meeting (ASM) to ensure program planning is in place and validates make/buy rationale and any partnership decisions. The process culminates in a Procurement Strategy Meeting (PSM) to approve the procurement strategy for individual procurements. PSMs are conducted in accordance with Federal Acquisition Regulations for each contract within a Project and focus on the procurement process. These events are part of the normal program and project formulation and implementation activities and lay a strong foundation from which contracts will be managed.

Further, the Agency has instituted a forum to monitor the Agency's largest and most complex contracts at a Senior Management Review of program and project performance. On a monthly basis, all large contracts from NASA's major projects are tracked for current value compared with original value, award fee status, current and upcoming significant procurement actions (including undefinitized contract actions, restructures, etc.). Planned procurements that are within a six-month horizon are also highlighted and discussed. Each NASA Mission Directorate program and project is reviewed quarterly and their associated contracts are addressed in more detail. This forum and the data reviewed allow the Agency to focus on contract management and proactively address issues, which should lead to project cost and schedule growth.

Q2. You state in your testimony that NASA has initiated a number of changes that address common issues such as optimism in cost estimates and schedules and unrealistic assumptions on technology maturity, just to name a few. How do you plan to ensure that current and future major acquisition projects do not exceed the Congressionally-mandated cost and schedule thresholds?

A2. NASA will apply improved assessment and reporting processes to the current missions, but also recognizes that a number of these baseline commitments were made prior to the introduction of these changes, and we anticipate that it will be some time prior to realizing the full results of the changes. If cost and schedule growth do occur in the interim, NASA believes that our improved reporting processes will better enable timely notification on the issues. NASA will continue to take the steps necessary to rebalance the Agency portfolio to accommodate those problems. It is anticipated that these initiatives will continue to improve cost and schedule performance in the future.

Q3. You highlight in your testimony the use of Standing Review Boards to provide an unbiased assessment of project performance at key decision points. However, the independence of some of the discipline experts on past boards has been questioned by the Agency's own Inspector General. What is NASA doing to ensure that organizational conflicts of interest no longer occur with Standing Review Board members?

A3. NASA is updating the Agency policy "NASA Space Flight Management Requirements" (NPR 7120.5D) with a NASA Interim Directive (NID) that will establish the

Standing Review Board handbook as the source of guidance for establishing Standing Review Boards and assessing members for potential organizational or personal conflict of interest. The NASA Office of the General Counsel has reviewed the policy and procedures in the NPR 7120.5D, and the Standing Review Board handbook, which guides the establishment of Standing Review Boards to ensure that they will be established in a manner consistent with federal law. The handbook includes procedures that ensure identification of Standing Review Board members who have conflicts of interest.

The handbook includes NASA's procedures to determine whether nominees are employed by companies performing work for the program or project under review. Ethics officials will verify Standing Review Board participant independence. For those individuals determined to have conflicts of interest, and whose value to the Board's work is viewed by the convening authorities as critical, a waiver will be submitted to ethics officials to request consideration to allow that individual to participate on that Standing Review Board. As described in the handbook, eligibility of Standing Review Board members, with regard to their independence, will be reviewed on an annual basis.

The NASA Inspector General has accepted these updates as responsive to their concerns.

Q4. Why is NASA's cost cap for the Joint Dark Energy Mission (JDEM) lower than the National Research Council panel that reviewed the mission thinks is realistic? Please provide a specific rationale for the lower cost cap.

A4. NASA agrees with the National Research Council (NRC) that JDEM is a >$1 billion-class mission. However, NASA does not expect to pay the entire cost of the mission. NASA has been working in partnership with the Department of Energy and is now engaged in discussions with the European Space Agency (ESA) with the goal of achieving an exciting and productive dark energy mission with our combined resources. NASA and its partners have much work to do before establishing a firm cost commitment at a formal mission confirmation review.

Q5. Pursuant to the NASA Authorization Act of 2005 *(P.L. 109–155), on May 1, NASA notified the Committee that the MSL project would exceed the Baseline development cost by 15 percent or more. The Act further requires NASA to notify the Committee after NASA makes a determination that the development cost has exceeded the Baseline by 30 percent. Has MSL reached the 30 percent cost growth threshold? If so, when was this determination made? If not, do you anticipate that the project will reach the 30 percent cost growth threshold and if so, when?*

A5. In its letter of December 4, 2008, NASA informed the Committee of its decision to defer launch of MSL to the 2011 launch window. NASA noted MSL would require additional funding of approximately $400 million to support this schedule slip. While the letter does not describe this prospective budget requirement in percentage terms, this communication represents a determination that MSL will exceed its baseline budget requirement by more than 30 percent by virtue of the additional estimated funding required to accommodate the schedule slip to 2011. NASA is preparing a formal detailed report pursuant to the requirements of the *NASA Authorization Act of 2005* and plans to submit this report immediately following release of the FY 2010 budget request. It should be noted that NASA will continue to review the MSL program consistent with it program management processes and further refinements can be expected as the review process progresses.

Q6. The Aerospace Industries Association recently advocated that DOD budget for an 80 percent probability of success. From NASA's perspective, what are the pros and cons of using a higher confidence level than the 70 percent probability currently used by NASA?

A6. Prior to making the decision to adopt a 70 percent confidence level, NASA evaluated the use of higher confidence levels and concluded that the use of the 70 percent level allowed the optimal balancing of risk across the Agency budget portfolio.

Q7. Should there be a reasonable level of reserves included in the estimated cost of a program, and if so, what would you define as "reasonable"? What are the pros and cons of a higher level of reserves?

A7. The Agency has changed its approach to project estimating and reserves. The use of probabilistic estimation represents a major shift in the methods utilized to size and manage project and program resources. This new paradigm requires that the Agency provide resources and schedule sufficient to assure a specified prob-

ability of success for the project and program. The probabilistic estimates are to be sized to provide for all requirements, both anticipated and unanticipated.

Q8. An analysis by the Aerospace Corporation concluded that cost growth problems would continue until project managers were given greater control. What are the pros and cons of giving project managers greater control?

A8. The study suggested that the project manager needed to have full authority to control costs (e.g., decline to allow the Center Director to assign additional human resources to the project). The roles and responsibilities of the Center Director and project manager differ. The project manager's role is to assure success of his project within budget and schedule. This role might lead the project manager to make decisions that were good for the project at the expense of maintaining Agency capability. The Center Director, on the other hand, is responsible for maintaining the skills necessary to support all current and projected projects that are to be executed by the Center.

This split and balancing of roles and responsibilities is purposeful and important. These sometimes conflicting roles were specifically created to encourage a balancing of short-term (project) needs with longer-term institutional needs. Finally, as a check and balance, decisions on allocating human capital are approved by NASA leadership at the Mission Directorate, Associate Administrator, and Administrator levels.

Q9. In his questioning during the hearing, Rep. Grayson raised the issue of the contrasting approaches of having vendors be responsible for overruns in fixed price contracts and not being obliged to pay for cost growth in cost reimbursement contracts. In your response to Mr. Grayson, you acknowledged that NASA uses fixed price contracts when the Agency understands the requirements "so that a contractor will, in fact, bid on it and know that they have a chance of being successful." *In contrast, you said that NASA uses cost reimbursement type contracts when there is some uncertainty in the requirements. Since NASA's program management process fully recognizes that a project usually starts with uncertainty but then matures through success design reviews, could NASA use a cost reimbursement contract for the work up conducted through the Preliminary Design Review (PDR) or Critical Design Review (CDR) and then subsequently utilize a fixed price contract? Has such a hybrid approach ever been taken, and if so, what were the results?*

A9. NASA's goal is to ensure that the cost risk for each requirement is properly allocated between NASA and industry. Cost-reimbursement award-fee contracts are generally most appropriate for use on NASA's high-risk and complex science missions and Design, Development, Test and Evaluation (DDT&E) contracts. During the development phase of a project, NASA should take on the cost risk because of the difficulty of developing firm estimates for the cost of the work to be performed. Use of fixed price type contracts under these circumstances would invariably result in contractors proposing significantly higher prices to compensate for the high-risk. In order to mitigate the Government's risk under these cost type contracts, NASA utilizes incentive arrangements (i.e., award fee incentives, performance fee incentives, etc.) in conjunction with our cost-reimbursement contracts. The incentive tee arrangements contain clear and unambiguous evaluation criteria that are linked to cost, schedule, and technical performance requirements of the contract that provide contractors with distinct incentive to control costs and develop a high quality product. These practices are in line with the White House memorandum on Government Contracting, dated March 4, 2009, and demonstrate NASA's commitment to contract oversight and risk mitigation.

NASA program and project offices work together to develop requirements and workload projections with the goal of moving toward fixed price contracts as soon as possible. As products and services mature, NASA considers a movement toward fixed price contracts for production and operations. For fixed price contracts, payment amounts can be based on performance as measured by standards and metrics. NASA will have examples of such an approach once a system is fully developed and going into maximum production. At this time, the hybrid approach involving costs-reimbursement and fixed price contracts has not yet been tested.

Question submitted by Representative Ralph M. Hall

Q1. Given the long experience of schedule and cost growth in complex missions, why not simply impose higher cost and schedule reserves at the project's outset, instead of trying to operate with a too-small reserve when the project encounters difficulties?

A1. NASA has undertaken a number of initiatives intended to improve the quality of initial cost and schedules. These initiatives are documented in the NASA High-Risk Corrective Action Plan and have been reviewed in the recent GAO QuickLook Report. In particular, the NASA transition to the use of joint confidence level calculation at a 70 percent confidence level will essentially increase the "set point" for project cost and schedule estimates. Probabilistic estimating provides NASA with an approach that fully integrates technical, cost, and schedule plans and risks to develop both an understanding of the sensitivity of parameters to each other and the most likely estimate. Using this approach allows NASA to understand and document how the mitigation of technical risks would enable an increase in the project confidence level. Conversely, the introduction of a budget reduction would have the effect of increasing technical and schedule risks and thus lower the confidence level for the project. The use of probabilistic estimates also generates baseline values that include funding to address impacts associated with contingencies and uncertainties, such as industrial base, partner performance and technology optimism. By controlling the confidence levels at the program (rather than just project) level, NASA intends to be more vigilant in evaluating the state of the program's portfolio prior to undertaking additional projects. NASA expects that these steps will enable NASA to better control the tendency to undertake too much with too little.

Questions submitted by Representative Pete Olson

Q1. When NASA experiences large cost increases without advanced warning it damages the Agency's credibility and reputation with stakeholders including Congress. Would you detail for us the actions the Agency has taken to improve its ability to forecast increases earlier so problems can be more readily managed and solutions more easily implemented?

A1. NASA has undertaken a number of initiatives intended to forecast and mitigate problems as early as possible. These initiatives include increased ongoing performance monitoring and more extensive review at key life cycle decision points, supported by expert, independent assessments.

NASA has an ongoing performance review process to ensure that it can forecast increases, as early as possible, and work a solution. NASA uses several methods of tracking cost, schedule and science/technical requirements, and at multiple management levels.

NASA projects employ various tools, including Earned Value Management, to monitor progress toward the baseline cost, schedule and technical deliverable. Center and Mission Directorate management review progress on a monthly or quarterly basis. Additionally, the Baseline Performance Review (BPR) process was implemented in 2007. The BPR is a monthly review, which assesses all Agency programs, with Agency Senior Management. On a quarterly basis, each Mission Directorate is spotlighted, providing a more in-depth assessment of its portfolio. This process provides not only individual program assessment but also a method to identify and address systemic programmatic and institutional issues that may affect multiple programs.

In addition, the Agency implemented Key Decision Points (KDPs) with the release of NASA Procedural Requirements, NPR 7120.51D, NASA Space Flight Program and Project Management Requirements (effective March 2007). KDPs serve as gates through which programs and projects must pass before proceeding to the next phase. Each KDP is preceded by one or more project or program-level reviews. Standing Review Boards are established to provide an expert, independent assessment throughout the Programs and Project's life cycle. These assessments are provided in support of the KDPs, with their views and recommendations.

Questions submitted by Representative Charles A. Wilson

Q1. Experience has shown that there are major risks to program cost and schedule when insufficient large scale testing is performed during hardware development. What are NASA's plans for Orion and Ares I for large scale acoustic, vibration, thermal vacuum, and electromagnetic interference testing?

A1. Both Orion and Ares I will conduct testing starting at the component level, through system testing and then to large-scale testing. All component and systems will undergo acoustics, vibration, thermal, vacuum and electromagnetic interference and compatibility (EMI/EMC) testing for flight qualification. There will be vehicle specific (Orion-only, Ares-only) testing as well as integrated testing, including integrated vehicle (Orion and Ares) and ground systems as well as flight vehicle testing.

For large-scale testing to support qualification, Orion will undergo a complete suite of integrated qualification tests for (EMI/EMC) at the Integrated Environmental Test Facility at Glenn Research Center's Plum Brook Station in Ohio. The facility is undergoing modifications to support this testing.

For Ares I, the size of the launch vehicle dictates a different hardware qualification flow. The components and systems will be tested to the established environmental (acoustics, vibration, thermal, and vacuum) as well as EMI/EMC requirements. The Ares I project is planning to use several full-scale Structural Test Articles to qualify the stage and tank structure. An entire Integrated System Test Article, including flight avionics, will be built. This test article will undergo a complete test firing. For the Ares I First Stage, three qualification motor firings are planned.

An integrated Orion/Ares stack will undergo a mated Integrated Vehicle Ground Vibration Test at Marshall Space Flight Center in Alabama. Plans are also being developed to conduct a complete Flight Element Integration Test on the integrated Orion/Ares I stack at Kennedy Space Center in Florida.

And finally, the Constellation test program will culminate with the Orion 1 flight test. Orion 1 is an un-crewed, fully functional orbital vehicle which will be launched on the Ares I. This flight has been designed to test and evaluate the integrated systems, exposed to the natural and induced environments experienced through the entire mission.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Cristina T. Chaplain, Director, Acquisition and Sourcing Management, Government Accountability Office (GAO)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. In your latest review, you say that NASA has attributed many of the issues on its projects to contractor performance. The identification of contractor performance issues begs the question of whether NASA undertakes adequate contractor oversight.

a. Do you have observations on the level of oversight of contractors that NASA provides?

b. In your opinion, is NASA doing enough up-front thinking and communication about the project and its requirement in order to clearly lay out for the contractor what work needs to be accomplished?

A1. Our assessment of selected large-scale NASA project focused on the status of major projects and the level of knowledge being attained at critical junctures. While we discussed management and oversight issues with both project managers and contractors, we did not specifically seek to measure the level of oversight NASA provided to its contractors. However, we observed instances where contractor capabilities were overestimated and could have been better understood up-front. For example, the Dawn contractor had no experience in deep space missions and more specifically, in ion propulsion systems for such missions, and officials from the company acknowledged they had difficulty developing the ion propulsion system for the spacecraft. In addition, it appeared to us that the contractor NASA used for the Glory and NPP projects overestimated its capacity to provide the work when promised, which was exacerbated when it closed one development facility and had difficulty hiring experienced staff at its new facility. In both these cases, the contractors cited communication gaps with NASA when their projects were experiencing problems. Given these and other instances, we believe NASA could do more up-front assessments about contractor capabilities and better plan for potential problems when contractors have not had prior experience with particular technologies or types of missions.

Q2. What steps can Congress take to improve its oversight of NASA's acquisition of major projects in an effort to help address some of the issues identified by the GAO?

A2. The Congress has laid a good foundation for acquisition oversight by requiring NASA to establish baselines for major programs and report back when certain thresholds are breached. It can continue to build on this foundation by continually examining factors behind cost and schedule growth. Moreover, Congress can also support change though its own decisions about whether to authorize and appropriate funds for a program or project that is not performing well. Specifically, decisions to move projects into implementation should be based on whether a sound business case has been established, i.e., there is sufficient knowledge that requirements can be achieved within available time, funding, technology, workforce, and industrial base constraints.

Q3. What corrective actions already undertaken by NASA show the most promise for dealing with cost management issues?

A3. Since NASA only recently issued its Corrective Action Plan, it is too early to determine whether any of these actions shows more promise than others. If these corrective actions are implemented in the spirit intended, they all have merit. Moreover, the success of any one improvement effort, such as cost estimating reform, depends on the success of others, such as those focused on producing more attention and oversight from senior leadership. GAO remains very interested to see NASA's commitment to following through on this plan and we await the results.

Q4. Your prepared statement indicates similarities between what NASA faces with cost and schedule issues and what has been experienced by DOD and other federal agencies in their acquisition of space systems. Are some of the corrective actions undertaken by NASA of possible benefit to other agencies who conduct space acquisitions? Conversely, are there any "lessons learned" from those other agencies?

A4. It is difficult to determine which actions the Department of Defense and others can benefit from because NASA is still implementing its plan and not enough time

has passed to determine impact. In addition, the DOD and National Reconnaissance Office space communities are implementing some similar reforms, notably in the area of cost estimating. In fact, cost estimators from all three communities have been sharing lessons learned in this regard. All three communities also seem to recognize the need to build knowledge about technologies and other resources before making long-term commitments to programs. Whether they can sustain the commitments they are making in this regard, however, remains to be seen.

Q5. Your statement points out the MSL, "which was already over budget recently announced a two-year launch delay," *which you indicate will increase the cost of the mission. While that is accurate, would GAO recommend that NASA should have done something other than take the two-year launch delay? What would GAO do differently at this point in the project?*

A5. Clearly, at the time NASA announced the delay, it had no alternative but to delay the launch two years, and to fund the delay by diverting funding from other programs, or to cancel the program altogether. Our recommendations focus instead on preventing NASA from being faced with a similar situation in the future. Had the Mars Science Laboratory program followed a best practice approach, it would have had more knowledge about the technologies—both critical and heritage—it was pursuing at the time it estimated cost and schedule. There would have also been more robust planning for potential risks and more oversight from the Agency if cost, schedule, and performance issues did surface.

Q6a. How successful have other agencies been at using confidence levels?

A6a. It is still too early to tell. NASA has just started to implement this policy and so has the FAA, DOD and other agencies.

Q6b. Has this technique mitigated cost growth?

A6b. We do not know yet. Other agencies, including DOD, have only recently begun applying higher confidence levels to estimates of space and other complex programs. It is too early to determine their success in mitigating cost growth. It should be stressed, however, that higher confidence levels will not work as a practice if estimates are being made when there are significant unknowns about technologies, contractors' capabilities, funding availability, and requirements, among other factors. Moreover, higher confidence levels will not work unless they consider project risk assessments as well as cost and schedule risk analyses that capture the effects of funding cuts and lack of contractor capabilities.

Q6c. Do you agree with NASA's choice of 70 percent confidence level or do you advocate a higher or lower level?

A6c. We have not made a recommendation or analyzed how high a confidence level should be for space programs but are encouraged that there is a desire to increase the confidence in estimating and that there are efforts underway to do so. Experts agree that technically risky programs that push the edge of technology should be funded at higher confidence levels (above 50 percent) since there are so many unknowns. Some experts have recommended that funding be at the 80 percent level for new endeavors where no historical data exists to cover the "unknowns" (e.g., going to Mars).

Q7. Why is NASA acquisition management still characterized by GAO as a high-risk area after 18 years?

A7. Historically, high-risk areas have been so designated because of traditional vulnerabilities related to their greater susceptibility to fraud, waste, abuse, and mismanagement. Since we designated NASA contract management as high-risk in 1990, our high-risk reports have focused on a variety of aspects related to controlling costs and risks in large-scale efforts—including, for example, definitizing contracts, implementing a new financial management system, and improving cost estimating. The underlying constant has been that programs are consistently over cost and behind schedule though the extent of cost growth had been hard to track until recently because of frequent re-baselining. Because cost growth and schedule delays persist due to much more than risks inherent in spacecraft development, this area—now titled acquisition management because of the scope of issues that need to be resolved—remains high-risk.

Q8. What must NASA do to warrant removal from GAO's high-risk list?

A8. NASA has taken significant steps in this direction but still faces substantial work on difficult initiatives where risks remain high. NASA has laid out a broad plan for reducing acquisition risk and taken steps to reflect best practices in poli-

cies. The plan specifically seeks to strengthen program and project management, increase accuracy in cost estimating, facilitate monitoring of contractor cost performance, improve agency-wide business processes, and improve financial management. Much work remains to achieve this plan. Some of the potentially most important initiatives in reducing cost growth and schedule slippage, and some of the most difficult parts of some initiatives have yet to be addressed. This will be difficult given the pressures the Agency is facing as it moves forward with the Ares I, Orion, and other expensive, highly anticipated programs such as the James Webb telescope. For instance, the desire to close the gap in human space flight may pressure NASA to move ahead with its Ares and Orion programs while there are still unknowns about technologies, design, and producibility, and to defer testing that is important to reducing cost and schedule risk. Coming off the high-risk list would also require NASA to find ways to better anticipate and mitigate what it currently believes is outside a program's control. For example, potential delays due to a crowded launch manifest could be better analyzed and factored into schedule estimates. Contractor capabilities could also be better understood up-front. NASA could work with the DOD on both issues, in fact, to develop more strategic approaches to problems in the launch manifest and the space industrial base.

Q9. During the hearing, Rep. Grayson raised the issue of contrasting approaches of having vendors be responsible for overruns in fixed-price contracts and not being obliged to pay for cost growth in cost-reimbursement contracts. Since NASA's program management process fully recognizes that a project usually starts with uncertainty but then matures through successful design reviews, could NASA use a cost-reimbursement contract for the work conducted through the Preliminary Design Review (PDR) or Critical Design Review (CDR) and then subsequently utilize a fixed-price contract? Has such a hybrid approach ever been taken, and if so, what were the results?

A9. We do not know of instances where the hybrid approach described has been used for NASA or other space systems. For the hybrid approach to work, the contracts would need to be applied at a point where there is a high degree of certainty about technology, requirements, funding, etc. In DOD space programs, this is often not considered to occur until two satellites have been built. While we believe NASA can reduce critical unknowns about programs before programs enter implementation, there are other uncertainties that could unfairly impact a contractor under a fixed-price contract, such as a late delivery of a satellite component by one of NASA's international partners or an unforeseen problem with a launch vehicle. Moreover, in applying the hybrid approach, the government would need to be willing to stop programs that did incur cost increases, as a contractor would be unlikely to be willing to sustain long-term losses. This has been difficult to do in the past. For example, when it became apparent that contractors were sustaining losses for DOD's advanced extremely high frequency satellite program as well as the evolved expendable launch vehicle, the government did not stop the programs but rather converted to cost-plus arrangements. Conversely, when NASA stopped fixed-price arrangements under the X–33 and X–34 programs, it lost several years in its efforts to develop a successor to the Space Shuttle. Another caution is that a number of space programs that have tried to use fixed-price approaches in the past assumed that there would be a commercial market that would create a future demand for the outcome of their work with the government, which in turn, created an incentive for a company to work under a fixed price arrangement. However, this assumption later proved to be erroneous.

Question submitted by Representative Ralph M. Hall

Q1. Given the long experience of schedule and cost growth in complex missions, why not simply impose higher cost and schedule reserves at the project's outset, instead of trying to operate with a too-small reserve when the project encounters difficulties?

A1. We would encourage NASA to do so given the history of cost and schedule problems, though NASA would need to concurrently ensure that programs are not incentivized to use up all of their reserves. Ultimately, establishing higher reserves may mean starting fewer programs—an approach the Administration, Congress and the many communities involved with NASA's major programs would need to support.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Gary P. Pulliam, Vice President, Civil and Commercial Operations, The Aerospace Corporation

Questions submitted by Chairwoman Gabrielle Giffords

Q1. In your statement, you speak of teams wanting to put their best foot forward when being faced with the competitive pressure of initiating a mission at the lowest cost. You go on to say that, in some cases, underestimated content or complexity is often the result. How can we incentivize NASA teams to be realistic in identifying both their requirements and resource needs?

A1. Realism in identifying both the requirements and resource needs of a mission requires the proper balance between the complexity of science proposed for a mission and the risk of growth in cost and schedule for this mission.

For NASA missions proposed through the Announcement of Opportunity (AO) process, the complexity of science that the proposer will pursue is decided by the proposing team, led by the Science Principal Investigator. Because of the open-ended nature of the science request for AOs, the proposer is incentivized to provide the maximum science capability within a fixed cost and schedule constraint. In order to capture the opportunity, the proposer typically pushes the envelope of performance within this cost and schedule cap, without proper regard to the likelihood of the mission exceeding the cost and schedule "box." Too often the result is cost and schedule growth as the design matures and the concept is determined to be more difficult to develop than originally envisioned.

For competed NASA missions, a selection that balances risk with science value has the potential to significantly reduce cost and schedule growth. A mission that has robust technical margins and is clearly within the cost and schedule envelope should experience limited cost and schedule growth. A selection such as this would be considered a low risk selection. If NASA solicitations promoted low risk missions and selected missions that were considered low risk, then the likelihood cost and schedule growth would be reduced. Further, it is expected that these NASA actions would incentivize the proposing teams to be more realistic about their requirements and resources needed.

It must be understood, however, that if NASA selects only low risk missions, the potential science value of these may be reduced as well. It is hard to argue that a mission like Kepler, which is attempting to discover Earth-like planets, is not exciting science. At the same time, Kepler experienced significant cost and schedule growth. If not for that allowance of cost and schedule growth, the Kepler mission could not have been developed.

One way to potentially balance cost and schedule risk versus science value is to employ a strategy that matures a technology through a focused technology development program prior to becoming a candidate NASA project. A generally accepted risk avoidance practice is to fund focused technology development prior to system development. However, due to budget constraints, NASA has recently reduced technology development funding in many areas.

Q2. Your statement indicates similarities between what NASA faces with cost and schedule issues and what has been experienced by DOD and other federal agencies in their acquisition of space systems. Are some of the corrective actions undertaken by NASA of possible benefit to other agencies who conduct space acquisitions? Conversely, are there any "lessons learned" from those other agencies?

A2. The DOD-initiated Cost Analysis Requirements Descriptions (CARD) inspired the NASA Cost Analysis Data Requirement (CADRe) effort. The CADRe effort that NASA has initiated is an excellent method to capture the cost, schedule, and technical data in a uniform way throughout the life cycle of a mission. Placing this data in a central repository, which is accessible by the community, is a significant step forward in terms of documenting and sharing data. CADRe allows NASA to perform detailed studies within a program as well as across NASA programs. CADRE also provides the comprehensive information required for the prediction of cost, schedule, and performance. The DOD could use a similar approach to share program development data among its acquisition community.

The concept of budgeting to a confidence level, which NASA has recently implemented, was first adopted by the DOD. DOD also pioneered the use of Earned Value Management (EVM) on all of its acquisitions, and NASA followed with the requirement of EVM for developments over a certain dollar threshold. Although implementation of budgeting to a confidence level and the use EVM does not assure success,

it should reduce the likelihood and magnitude of cost and schedule growth. In 2007, NASA again followed DOD's lead in introducing Key Decision Point (KDP) processes and criteria into the NASA Project development life cycle. The purpose of KDP processes is to use explicit criteria to decide whether a particular program or project is ready to move on to the next phase in its life cycle.

Q3. You state in your prepared statement that: "the project must manage to a valid baseline estimate." *You further note that* "One area of concern for the NASA project managers is the relevance and utility of independent cost estimates they do not own. Different methodologies are used by the project and independent estimates such that there is not a common understanding of the basis for estimate for each." *You note that* "greater transparency into the basis of estimate for each approach is important." *Could you please elaborate on your concerns about independent cost estimate at NASA and what specific types of actions NASA might take to ensure transparency in its estimates?*

A3. NASA independent cost estimates are typically conducted with cost models using input parameters that are not fully understood by Project Managers. Consequently, Project Managers often have limited insight into how an independent cost estimate is developed, and thus its validity, relevance, and utility. Furthermore, it is often difficult for NASA cost analysts to communicate the intricacies of their estimate to the project team. The project team uses a different cost methodology, estimating the effort of tasks from the bottom-up, based on the knowledge of the individuals working on the project. These differences in assumptions and methodologies make reconciliation of cost estimates difficult.

NASA cost analysts must do a better job of demonstrating how their estimates compare with historical cost data in order to provide Project Managers confidence that their models are predictive. The collection of CADRe data provides the basis for such a comparison. NASA cost analysts must also fully explain the methodology, as well as the data inputs, to Project Managers. In particular, when subjective data inputs are introduced into the cost models, and used in a certain manner, NASA cost analysts must provide Project Managers with a full understanding of the basis for using these inputs. This increased transparency would likely result in Project Managers having an increased understanding and confidence in the independent cost estimates.

Q4. In describing what else needs to be done, your testimony highlights the need to strengthen the connection between an independent cost estimate and the project estimate to include the effects of risk and risk mitigation. Why is the project's ownership of the cost estimate so important?

A4. The project must "own" the independent cost estimate if it is expected to manage to it. The project must believe that the baseline cost estimate is valid and achievable so that they can steadfastly work toward executing the plan. Too often, the independent cost estimate is unrelated to project risk management results, and there is a disconnect between the risk identification process and the cost estimate. It is critical to link these two processes.

Projects use risk identification to measure their robustness. Furthermore, an economic assessment can determine if a project should implement a risk mitigation effort. The identification of risk and risk mitigation activities helps the project to fully understand how the baseline plan would be affected by certain risks. Space system development projects have processes for identifying and managing risks, such as the 5 x 5 matrix process that classifies likelihood and consequences for each risk. A probabilistic cost estimate approach that incorporates all discrete risks may be a way to ensure that the Project Manager and the independent cost estimate team have a common language and understanding of risk.

Q5. Your testimony refers to NASA's recent requirement to develop budgets with a 70 percent confidence level. Your statement also notes that "The validity of this approach, however, depends on the stability and soundness of the baseline" *budget. What is needed to ensure that the requirement for a 70 percent confidence level in developing NASA budget estimates will be effective?*

A5. A stable baseline budget is critical to the development of a project plan that can be effectively managed and executed. A sound, stable baseline plan requires the development early in a project of the 70 percent confidence level that assesses all potential outcomes and incorporates all potential risks. The development of the 70 percent confidence level entails identifying the potential risks and quantifying their potential impact in terms of cost or schedule growth. The development of this comprehensive risk plan and a robust confidence level assessment allows for a stable and comprehensive baseline plan.

Note that Earned Value Management (EVM) is much more effective if the measurement of progress is based on performance against a stable plan. Multiple replanning or re-baselining activities make EVM significantly less effective. Replanning and/or re-baselining are sometimes necessary due to subsequent project changes. However, a stable, robust baseline plan from the outset should reduce the need for replanning and lead to a more efficiently managed project.

Q6. How successful have other agencies been at using confidence levels? Has this technique mitigated cost growth? Do you agree with NASA's choice of a 70 percent confidence level or do you advocate a higher or lower level?

A6. Many Blue Ribbon panels advocate creating a program reserve by budgeting to a higher confidence level as good practice. However, it is too early to tell how effective budgeting to a higher confidence level is in controlling cost and schedule growth. The DOD started using cost confidence levels to improve program budgeting about eight years ago. It has not been uniformly applied across DOD space programs; and given the long development timelines for major space programs, there are few completed programs that were initiated using this budget approach. In addition, the resulting increased funding from budgeting to higher confidence levels have not been consistently applied within the programs. Since several factors contribute to a project's cost and schedule growth, it may be difficult to determine if solely setting a cost confidence level has reduced cost growth in the DOD until more data becomes available.

Q7. In the past year, we have seen a growing number of protests associated with NASA contract awards. To what do you attribute this growing number of protests? Are there some steps NASA could take to minimize vendors' need to file such protests? Is this phenomenon unique to NASA or are you observing a similar trend at DOD?

A7. Since Aerospace has not participated in a NASA source selection that has lead to protests, we cannot speak to specific experience on the subject. It could be postulated, however, that as mergers occur and fewer and fewer contractors are competing for fewer and fewer missions, it is inevitable that more protests would be filed. Many elements of NASA proposal evaluations are subjective in nature and, therefore, are open to debate and potential protest. For example, it is difficult to determine objectively the relative science value of a mission visiting an asteroid vs. one that visits a planet. Even with more objective evaluation criteria, such as those for DOD procurements, there still may be an incentive for a company to file a protest if it believes that its proposal has been misinterpreted.

Q8. During the hearing, Rep. Grayson raised the issue of contrasting approaches of having vendors be responsible for overruns in fixed price contracts and not being obliged to pay for cost growth in cost reimbursement contracts. Since NASA's program management process fully recognizes that a project usually starts with uncertainty but then matures through success design reviews, could NASA use a cost reimbursement contract for the work up conducted through the Preliminary Design Review (PDR) or Critical Design Review (CDR) and then subsequently utilize a fixed price contract? Has such a hybrid approach ever been taken, and if so, what were the results?

A8. Given the nature of NASA's primary objective, which is to develop missions that provide first-of-a-kind, world-class science, it is our opinion that using a fixed price contract structure would not be appropriate for the majority of NASA's contracts. The commercial communications industry, which has a continuing product line and very well defined and stable requirements from the customer, uses this approach with great success. As stated in the written testimony, however, since NASA does not typically have a mature design and stable requirements until late in the design process, a fixed price contract structure must be applied with great caution and only in certain circumstances. For projects where uncertainty is high and the potential risks are significant, a fixed price contract would not be beneficial either for NASA or its contractors.

Q9. Should there be a reasonable level of reserves included in the estimated cost of a program and, if so, what would you define as "reasonable"? What are the pros and cons of a higher level of reserves?

A9. Aerospace was involved in a previous study which suggested nominal reserve levels based on historical data for a specific set of robotic science missions. These nominal reserve levels were not intended to provide a hard and fast rule for specifying a percentage of reserves that all projects should carry. Aerospace recommends that the level of reserves should be commensurate with a given project's risks and

criticality. Reserves could be defined by the confidence level requirement of the budget (i.e., the higher the confidence level, the greater the magnitude of the reserves). Budgeting using confidence levels allows the magnitude of a project's reserves to vary proportionately with each project's 70 percent confidence level, thus reflecting each project's unique risks.

It is critical that NASA hold funds in reserve to manage its portfolio of missions. A project will use its available funding, including reserve, in order to mitigate risks and ensure mission success. This it is imperative to allocate some portion of the reserve funding at a higher level, such as to a Program, which is a collection of Projects, or to NASA Headquarters (HQ). This tiered reserve allocation allows funding at the Program or HQ level to be quickly allocated to other Projects that exceed their initial allocation. It also provides for a more flexible portfolio management approach, allowing less reserve to be held for any single project.

Question submitted by Representative Ralph M. Hall

Q1. Given the long experience of schedule and cost growth in complex missions, why not simply impose higher cost and schedule reserves at the project's outset, instead of trying to operate with a too-small reserve when the project encounters difficulties?

A1. Since mission success is the objective of Project Managers, projects tend to use all of the cost and schedule reserves that they control in order to reduce mission risk. Hence, any additional project cost and schedule reserves provided would typically be used to further reduce mission risk through performing additional testing, developing additional testbeds, purchasing additional spare hardware, etc. Having higher project cost and schedule reserves may decrease perceived cost and schedule growth; however, in the end, the actual cost and schedule of missions may be greater. Given NASA's fixed annual budget, the approach of imposing higher cost and schedule reserves for could lead to a reduction in the number of missions that NASA is able to develop.

To be able to effectively manage its portfolio of missions, however, it is critical that NASA hold funds in reserve. Assuming that a project will use its available funding including reserve, it is imperative that NASA allocate some portion of the reserve funding at a higher level, such as to a Program, which is a collection of Projects, or to NASA Headquarters (HQ). This tiered reserve allocation allows funding at the Program or HQ level to be allocated to those Projects that exceed their initial allocation. This approach also provides for a more flexible portfolio management approach, allowing less reserve to be held for any single Project. A tiered reserve, which distributes reserves at different organizational levels, represents a balanced approach. While it provides some reserves for the Project Managers to rapidly address development problems before their costs escalate, it does not release all reserves to the Projects where the funds would most likely be used up-front to plan additional mission risk reduction activities.

Questions submitted by Representative Pete Olson

Q1. Are there valid reasons why it might be necessary for a project to enter the implementation phase without having fully matured critical technologies? And if so, are there ways to compensate for the increased risk?

A1. For the majority of NASA missions, it is prudent for NASA to fully develop its critical technologies prior to the start of the implementation phase. However, NASA may be required to start mission implementation without having fully matured critical technologies if the timeliness of a mission is such that it must be fielded on a highly expedited schedule. Although such a timeliness requirement is more prevalent in national security space systems, NASA could have a compelling need (e.g., a rescue or replacement of a critical NASA satellite or capability) that requires such timeliness. When a project must enter the implementation phase without having fully matured critical technologies, the project should compensate for the increased risk by developing alternative technologies in parallel. Then if a critical technology is not ready, an alternative technology could be implemented. Note that developing alternative technologies in parallel to compensate for increased risk may result in higher mission cost and decreased mission capability.