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NASA Cost and Schedule Overruns: Acquisitions and Program Management Challenges

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Chairman Babin, Ranking Member Bera, and Members of the Subcommittee:

The Office of Inspector General (OIG) is committed to providing independent, aggressive, and objective oversight of NASA programs and projects, and we welcome this opportunity to discuss the Agency's challenges in meeting project cost, schedule, and performance goals.

Throughout its 60-year history, NASA has been at the forefront of aeronautics, science, and space exploration, responsible for numerous scientific discoveries and technological innovations. However, many of NASA's largest projects cost significantly more to complete and take much longer to launch than originally planned. Finding ways to better manage its projects – many of which are one-of-a-kind and first-of-their-kind – remains an ongoing challenge for the Agency.

Over the past 8 years, our office has examined NASA's successes and failures in project management on two levels: first, by examining the historic challenges the Agency faces in meeting cost, schedule, and performance objectives and the processes it has developed to address these shortcomings. Second, by assessing the effectiveness of NASA's use of these project management tools through dozens of audits of discrete projects, including development of science satellites such as the Surface Water and Ocean Topography (SWOT) mission, rover missions to Mars, construction of rocket test facilities, human space flight vehicles such as the Space Launch System (SLS) rocket and Orion crew capsule, and aeronautics research to integrate unmanned aerial vehicles in the national airspace. My testimony today is informed by the findings and recommendations of these OIG reports.

NASA's Historic Challenges to Meeting Cost, Schedule, and Performance Goals

NASA's storied history evidences a unique agency with spectacular accomplishments. For example, since its launch in 1990 the Hubble Space Telescope (Hubble) has helped scientists determine the age of the universe, identify quasars, and prove the existence of dark energy. Hubble's successor, the James Webb Space Telescope (JWST), will study the birth and evolution of galaxies while the Mars Science Laboratory (MSL), which successfully landed its Curiosity rover in August 2012, produced last week's blockbuster announcement of the presence of organic molecules and methane – important clues into whether the Red Planet is or has ever been able to support life.

Unfortunately, in addition to their scientific accomplishments these projects and many others at NASA share another less positive trait – significant cost and schedule overruns. For example, in 1977 NASA estimated that it would complete development of Hubble by 1983 at a total cost of $200 million; however, the telescope was not completed until 2 years later at a cost of approximately $1.2 billion. And even when launched, a flaw in its mirror required multiple repair and servicing missions that, while successful, added billions of dollars to the project's overall cost. MSL also launched 2 years behind schedule with development costs that increased 83 percent from $969 million to $1.77 billion. In 2009, NASA estimated JWST would cost $2.6 billion to develop and launch in 2014; however, its price tag now exceeds $8 billion and its launch date has slipped to approximately May 2020.

Our office's foundational examination of NASA's project management challenges identified four factors that present the greatest challenges to successful project outcomes: NASA's culture of optimism, underestimating technical complexity, funding instability, and development and retention of new and experienced project managers.[1]

Culture of Optimism. Exemplified by the Agency's greatest achievement – landing humans on the moon and safely returning them to Earth – NASA's ability to overcome technological and scientific obstacles to accomplish a given objective has become part of the Agency's culture and has helped foster a belief that NASA can accomplish anything. Indeed, it was this "can-do attitude" that enabled NASA to bring the ailing Apollo 13 safely back to Earth, find a way to fix Hubble's flawed mirror in orbit, and land the Curiosity rover on Mars using a supersonic parachute/sky crane combination. However, our past work has found that this outlook causes NASA to view the success of projects primarily in technical rather than cost and schedule terms. More specifically, NASA's at times overly optimistic culture contributes to development of unrealistic plans and performance baselines, particularly with respect to its largest programs and projects. Subsequent technological success – at a significantly greater cost than originally estimated – reaffirms a mindset that project costs and adherence to schedule are secondary considerations to achieving operational success. In fact, many people we interviewed raised the "Hubble Psychology" – an expectation among Agency personnel that projects that fail to meet initial cost and schedule goals will receive additional funding and subsequent scientific and technological success will overshadow budgetary and schedule problems.

Our work over the past 8 years has identified three related ways excessive optimism can create cost and schedule challenges:

1. measures of project success do not include cost and schedule factors,

2. establishment of unrealistic cost and schedule baselines, and

3. an expectation that additional funding will be made available if a project runs "short."

In addition, NASA project managers are often overly optimistic about the effort required to mature critical technologies and frequently underestimate the cost and schedule reserves needed to address known and unknown risks, optimistically assuming that most risks will not materialize. However, when they do they result in significant cost, schedule, and performance problems.

Lastly, many project managers admitted to an expectation that projects that fail to meet initial cost and schedule goals, especially the larger projects, will receive additional funding and that subsequent scientific and technological success will overshadow budgetary and schedule problems. Past examples of this phenomena include Hubble, while current examples include JWST, the Orion crew capsule, and the SLS rocket. Although a few projects in NASA's recent past were cancelled because of poor cost and schedule performance, a "too big to fail" mentality pervades Agency thinking when it comes to NASA's larger and most important missions. While understandable given the heavy investment of Agency resources, these cost overruns can result in delays to other NASA missions as funding is reprioritized.

Underestimating Technical Complexity. The technical complexity inherent in NASA projects remains a major challenge to achieving cost and schedule goals, with project managers attempting to predict the amount of time and money needed to develop one-of-a-kind, first-of-their-kind technologies, instruments, and spacecraft. NASA historically has underestimated the level of effort needed to

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[1] NASA OIG, "NASA's Challenges to Meeting Cost, Schedule, and Performance Goals" (IG-12-021, September 27, 2012). For this review, we interviewed 85 individuals including the NASA Administrator, Deputy Administrator, Associate Administrators, Center Directors, project managers, project staff, former NASA Administrators and staff, and external parties.

develop, mature, and integrate these technologies, as well as account for the extensive pre-launch testing required to reduce risk and increase the likelihood that the technologies will operate as designed in space.

Our work has shown that NASA can take several actions to mitigate this challenge. First, projects need to mature critical technologies early in the project life cycle, preferably before establishing their baseline cost and schedule. Establishing the level of effort needed to incorporate the technology in an operational system reduces risk and provides greater transparency at the project's "buy-in" point for decision makers.[2] Second, the amount and availability of reserves needs to be commensurate with a project's technical risk to cover expenses associated with work managers did not plan for at the beginning of the project but almost inevitably will need due to the complexities inherent in developing space flight projects. Lastly, managers need to control project scope and requirements "creep" that can occur when engineers, scientists, or other advocates suggest functionalities greater than the instrument's original requirements to increase its technical capabilities.

Funding Instability. Funding instability includes situations in which a project receives less money than planned or when funds are disbursed on a schedule different than planned. Such instability results from congressional or Agency-directed actions and can require deferring critical tasks to later phases of development or de-scoping or discontinuing lower priority tasks to keep project costs within a revised budget profile, leading to cost increases and schedule delays. To this point, since 1959 NASA has received its annual appropriation at the start of a fiscal year only seven times, often resulting in weeks- or months-long continuing resolutions (CR) that generally set funding at the prior year's level. The current fiscal year is a striking illustration of this phenomena: five CRs were required before NASA (and the rest of the Federal Government) received its annual appropriation – at the half-year mark.

Development and Retention of Experienced Project Managers. We also identified a number of issues related to developing project managers' experience that could affect NASA's ability to manage its projects effectively in the future. First, most project managers and senior officials we spoke with said that experience and on-the-job training were keys to a project manager's ability to manage cost, schedule, and performance goals. In that regard, managers described NASA's small projects as invaluable for developing management skills and learning the key elements of project management, including making appropriate trade-offs among cost, schedule, and performance goals when necessary. To that end, they said it was vital that NASA maintain a balanced portfolio that continues to provide these learning opportunities.

Interviewees also expressed concern about a lack of in-house development opportunities, with some expressing the view that as NASA has increasingly relied on contractors to support project development, the Agency's in-house capabilities have declined. Moreover, they expressed concern that because NASA contracts the majority of its hardware and software development efforts to private industry, Agency engineers spend most of their time overseeing contractor efforts rather than building spaceflight components, thereby limiting opportunities for NASA engineers to gain practical "hands-on" experience. Finally, interviewees raised concerns that NASA will not be able to attract and retain recent graduates or experienced engineers seeking opportunities to design and build spaceflight systems. Instead, these

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[2] In an address to the American Astronautical Society Goddard Symposium in March 2008, former NASA Administrator Michael Griffin described the problem this way: "[T]here have been many instances where proponents of individual missions have downplayed the technical difficulty and risk of their individual mission, or grossly underestimated the cost and effort involved to solve the problems, in order to gain 'new start' funds for [a] particular project. Everyone knows that, once started, any given mission is nearly impossible to cancel, so the goal becomes that of getting started, no matter what has to be said or done to accomplish it."

individuals may choose positions in private industry and as a result, NASA will lose core competencies as experienced Agency engineers retire.

Efforts to Address Project Cost and Schedule Growth

NASA has implemented a number of initiatives over the years with mixed success to help project managers avoid cost and schedule overruns.

Joint Cost and Schedule Confidence Level (JCL). Beginning in 2006, NASA incorporated progressively more sophisticated cost and schedule estimating techniques into Agency policy, culminating in 2009 with formal adoption of a JCL requirement for projects with life-cycle costs greater than $250 million. A JCL analysis, completed during the final portion of the project's formulation phase and required as part of the Agency's decision to move the project into the implementation phase, calculates the likelihood a project will achieve its objectives within budget and on time. A properly executed JCL not only provides a percentage likelihood the project will be developed at a particular cost and on a particular schedule, but also identifies associated cost and schedule reserves needed to back-up the plan. Unless senior management approves an exception, projects are funded at a minimum of the 50 percent confidence level (the Management Agreement) and budgeted at the 70 percent confidence level (the Agency Baseline Commitment or external commitment) – the difference between the two figures being the reserves.

The JCL process uses software models that combine cost, schedule, risk, and uncertainty to evaluate how expected threats and unexpected events may affect a project's cost and schedule and help managers' assess whether a project has an executable plan moving forward. To generate this data, project managers develop comprehensive project plans, inputs, and priorities that integrate costs, schedules, risks, and uncertainties. NASA officials believe gathering this data encourages better communication among project personnel; improves cost, schedule, risk, and uncertainty analyses; and fosters an understanding of how different project elements impact one another.

However, as we wrote in a September 2015 report, the JCL is not a one-stop solution for ending cost overruns and schedule delays.[3] Rather, we found the process was unevenly applied across various projects and has inherent limitations in that it does not fully address the issue of predicting "unknown/unknowns" or other root causes of NASA's project management challenges such as funding instability and underestimation of technical complexity. Moreover, we found that while success when using this process relies on the expertise of risk managers, cost estimators, and schedulers, NASA had a shortage of people with this experience. Furthermore, although NASA policy requires JCL calculations to include consideration of all risks whether or not funded by the project, we found that NASA routinely leaves out risks "external" to the project such as involvement of international partners and risks associated with selection and timely delivery of launch vehicles. While NASA has embraced JCL and implemented it across its space flight project portfolio, applying lessons learned from successful projects and enhancing training on its use will increase its value as a project management tool.

Contracting. NASA has multiple contracting mechanisms available for acquiring goods and services, including fixed-price and cost-reimbursement contracts. In a fixed-price contract, the contractor agrees to deliver a product or service at a price not to exceed an agreed-upon amount. Fixed-price contracts are generally used when costs and risks can be clearly defined – for example, when purchasing commercially available items such as laptop computers. In contrast, under cost-reimbursement

[3] NASA OIG, "Audit of NASA's Joint Cost and Schedule Confidence Level Process" (IG-15-024, September 29, 2015).

contracts NASA agrees to pay all allowable costs the contractor incurs in delivering the service or product. Cost-reimbursement contracts involve increased risk for the Government and are generally more appropriate when it is difficult to accurately estimate specific costs in advance. Given the nature of the projects developed at NASA, cost-reimbursement contracts are very common at the Agency.

Contracts may also include incentives in which a predetermined amount of money is set aside for the contractor to earn above the contract's base price based on performance. Properly structured and executed, incentive contracts can reduce the risk of cost overruns, delays, and performance failures by providing a well-performing contractor the opportunity to earn additional money.

NASA has also used its "other transactions" authority provided by the National Aeronautics and Space Act of 1958 for large-scale development projects, most significantly to encourage development of commercial cargo and crew delivery capabilities to resupply the International Space Station (ISS or Station).[4] Under these Space Act Agreements, NASA agrees to provide funding, goods, services, facilities, or equipment that the partner uses to accomplish stated objectives. In return, the partner may advance technologies that support NASA's mission, share information, or reimburse NASA for the support provided. With respect to the development of commercial cargo and crew services, contractors were required to commit significant amounts of their own funds while NASA paid the companies when they met predetermined milestones. While providing financial benefits to the Agency, the use of funded Space Act Agreements decreases the level of NASA oversight and control compared to traditional procurement contracts.

Regardless of approach, our work has highlighted multiple examples of contracting costs, benefits, and challenges at NASA. Since 2011, we have issued eight reports examining acquisition strategies used by NASA for commercial cargo and crew transportation services to access the ISS. While NASA's costs to develop these services using Space Act Agreements are generally perceived as significantly less than if the Agency had used traditional contracting mechanisms, cargo services still were not provided until 3 years later than planned and crew services have yet to be demonstrated and are 3 years beyond initial expectations. Furthermore, several of our reports identify specific issues in NASA's commercial cargo contracts where it could save money by modifying contract terms and agreements.

Likewise, a November 2013 OIG report examined NASA's use of award-fee incentive contracts and questioned its methodology for motivating and incentivizing contractors' performance.[5] In particular, we found that overly complex award-fee formulas and a contract clause designed to hold contractors accountable for the quality of the final product that disregards interim performance evaluations have diminished the effectiveness of the Agency's award-fee contracts. For example, if JWST produces the science expected after its eventual launch, the Agency has the ability under the contract to award the contractor all of the award fees it could have earned over the past 15 years – even though NASA previously denied payment of some of those fees due to poor contractor performance.

Finally, a May 2017 report detailed how fixed-price contract costs increased on NASA's construction of two test stands at Marshall Space Flight Center that will be used to test SLS components.[6] Because the stand designs were based on preliminary specifications from the SLS program, the requirements and capabilities needed were not fully understood when the construction contract was awarded.

[4] 51 U.S.C. § 20113(e), "National Aeronautics and Space Act of 1958" (2010).

[5] NASA OIG, "NASA's Use of Award-fee Contracts" (IG-14-003, November 19, 2013).

[6] NASA OIG, "Construction of Test Stands 4693 and 4697 at Marshall Space Flight Center" (IG-17-021, May 17, 2017).

Subsequently, NASA was required to modify the contract to meet changing requirements, added extra features, and made other modifications that raised the contract price by $20.3 million. Further, NASA did not establish adequate funding reserves to cover these changes and therefore had to secure $35.5 million in additional funding over the planned budget.

As NASA increasingly relies on the private sector to leverage its capacity, innovation, and competitiveness, the Agency must ensure that the contracting mechanisms it chooses are best suited to maximize its significant investments.

Partnerships. Partnerships, both domestic and international, are playing an increasingly important role in NASA's programs and projects. These collaborations can reduce NASA's required investment through sharing of capabilities, expertise, and scientific research while cultivating positive working relations among nations. As NASA missions become more complex and costly, it will be difficult for the Agency to achieve its ambitious goals at current funding levels without leveraging such partnerships, particularly for human exploration beyond low Earth orbit.

While NASA currently manages more than 750 international agreements with 125 different countries, it faces challenges in maintaining or expanding its use of such partnerships. For example, a May 2016 OIG audit found NASA sometimes experienced difficulty gaining agreement approval from the Department of State, as well as overcoming cumbersome U.S. export control regulations, restrictions on NASA employees' attendance at international conferences, and geopolitical realities that limit expansion of such partnerships, particularly with the Russian and Chinese space agencies.[7]

That said, international partnerships come with their own challenges. For example, in September 2016 we reported on likely launch schedule delays for Orion due to the European Space Agency's late delivery of the European Service Module needed for Exploration Mission 1.[8] More recently, our work in January of this year noted that the SWOT mission is dependent on about $400 million in instruments and other contributions from the French and Canadian space agencies – contributions critical to mission success.[9] Unfortunately, the French contribution is late and has forced project management to delay completion of a major life-cycle review that could potentially impact the launch schedule.

Looking toward the future, NASA hopes to leverage the emerging commercial spaceflight industry by forming public-private partnerships to further its space exploration and science research goals, particularly with respect to operation of the Station. According to NASA, such public-private partnerships will enable it to share the financial risk with private industry to better leverage Government investments.

Conclusion

NASA should rightly be proud of its six decades of significant achievements exploring space, helping understand the Earth and other planets' evolution and environment, and conducting fundamental research in aeronautics. However, consistently managing the Agency's largest science and space exploration projects to meet cost, schedule, and performance goals remains elusive.

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[7] NASA OIG, "NASA's International Partnerships: Capabilities, Benefits, and Challenges" (IG-16-020, May 5, 2016).

[8] NASA OIG, "NASA's Management of the Orion Multi-Purpose Crew Vehicle Program" (IG-16-029, September 6, 2016).

[9] NASA OIG, "NASA's Surface Water and Ocean Topography Mission" (IG-18-011, January 17, 2018).

Our work has shown that Agency leaders and stakeholders must temper NASA's historic culture of optimism by demanding realistic cost and schedule estimates, well-defined and stable requirements, and mature technologies early in project development. In addition, they must ensure that funding is adequate and properly phased and that known funding risks are identified and accounted for in mitigation strategies. Finally, they must be willing to take remedial action – up to and including termination – when these critical project elements are not present.

In our judgment, meeting these challenges can only be accomplished through a "unity of effort" that includes strong, consistent, and sustained leadership by the President, Congress, and NASA management. Articulating a clear, unified, and sustaining vision for the Agency and providing the necessary resources to execute that vision is critical to ensuring that project managers are best positioned to complete projects within cost and on schedule.