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SPACE SHUTTLE SAFETY

Update on NASA's Progress in Revitalizing the Shuttle Workforce and Making Safety Upgrades

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Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today to discuss workforce and safety issues facing the National Aeronautics and Space Administration's (NASA) space shuttle program. As requested for this hearing, we have updated the information we provided to this Subcommittee in a March 2000 testimony and in an August 2000 report.¹ At the time, the space shuttle program was at a critical juncture: its workforce had declined significantly since 1995, its flight rate was to double over that of recent years to support the assembly of the International Space Station, and costly safety upgrades were planned to enhance the space shuttle's safe operation until at least 2012.

We reported that workforce reductions were jeopardizing NASA's ability to safely support the shuttle's planned flight rate. For instance, many areas critical to safety were not sufficiently staffed by qualified workers. Recognizing the need to revitalize the shuttle's workforce, NASA terminated its downsizing plans for the shuttle program in December 1999 and initiated efforts to hire new staff. Furthermore, we also reported that NASA faced a number of programmatic and technical challenges in its efforts to develop and begin equipping the shuttle fleet with a variety of safety and supportability upgrades over the next 5 years. These included a demanding schedule and undefined design and workforce requirements.

Today, I will discuss NASA's current progress in addressing these workforce and safety issues and the challenges still ahead. In brief, we found that NASA is making progress in revitalizing the shuttle program's workforce. NASA's current budget request projects an increase of more than 200 full-time equivalent staff through fiscal year 2002. NASA has also focused more attention on human capital management in its annual performance plan by outlining an overall strategy to attract and retain a skilled workforce. Even with these gains, however, there are still considerable challenges ahead. For example, because many of the additional staff are new hires, they will require considerable training, and they will need to be effectively integrated into the shuttle program. Also, NASA still needs to fully staff areas critical to shuttle safety; deal with critical losses due to retirements in the coming years; and, most of all,

¹ See *Space Shuttle: Human Capital Challenges Require Management Attention* (GAO/T-NSIAD-00-133, Mar. 22, 2000) and *Space Shuttle: Human Capital and Safety Upgrade Challenges Require Continued Attention* (GAO/NSIAD/GGD-00-186, Aug. 15, 2000).

sustain management attention to human capital reforms. NASA's workforce problems are not unique. Many agencies have also been contending with serious human capital shortfalls. We recently added strategic human capital management to our list of federal programs and operations identified as high risk. Moreover, while NASA is making strides in revitalizing its workforce, its ability to implement safety upgrades in a timely manner is uncertain. NASA is still assessing the full package of its planned improvements, and some projects have already encountered funding and scheduling problems. Overcoming challenges related to the upgrades is critical since NASA will be relying on the space shuttle longer than originally anticipated.

Background

The space shuttle is the world's first reusable space transportation system. It consists of a reusable orbiter with three main engines, two partially reusable solid rocket boosters, and an expendable external fuel tank. Since it is the nation's only launch system capable of carrying people to and from space, the shuttle's viability is important to NASA's other space programs, such as the International Space Station. NASA operates four orbiters in the shuttle fleet.

Space systems are inherently risky because of the technology involved and the complexity of their activities. For example, thousands of people perform about 1.2 million separate procedures to prepare a shuttle for flight. NASA has emphasized that the top priority for the shuttle program is safety.

The space shuttle's workforce shrank from about 3,000 to about 1,800 full-time equivalent employees from fiscal year 1995 through fiscal year 1999. A major element of this workforce reduction was the transfer of shuttle launch preparation and maintenance responsibilities from the government and multiple contractors to a single private contractor. NASA believed that consolidating shuttle operations under a single contract would allow it to reduce the number of engineers, technicians, and inspectors directly involved in the day-to-day oversight of shuttle processing. However, the agency later concluded that these reductions caused shortages of required personnel to perform in-house activities and maintain adequate oversight of the contractor.

Since the shuttle's first flight in 1981, the space shuttle program has developed and incorporated many modifications to improve performance and safety. These include a super lightweight external tank, cockpit display enhancements, and main engine safety and reliability

improvements. In 1994, NASA stopped approving additional upgrades, pending the potential replacement of the shuttle with another reusable launch vehicle.

NASA now believes that it will have to maintain the current shuttle fleet until at least 2012, and possibly through 2020. Accordingly, it has established a development office to identify and prioritize upgrades to maintain and improve shuttle operational safety.

Progress and Challenges in Revitalizing the Shuttle Workforce

Last year, we reported that several internal studies showed that the shuttle program's workforce had been negatively affected by downsizing.² These studies concluded that the existing workforce was stretched thin to the point where many areas critical to shuttle safety—such as mechanical engineering, computer systems, and software assurance engineering—were not sufficiently staffed by qualified workers. (Appendix I identifies all of the key areas that were facing staff shortages). Moreover, the workforce was showing signs of overwork and fatigue. For example, indicators on forfeited leave, absences from training courses, and stress-related employee assistance visits were all on the rise. Lastly, the program's demographic shape had changed dramatically. Throughout the Office of Space Flight, which includes the shuttle program, there were more than twice as many workers over 60 years old than under 30 years old. This condition clearly jeopardized the program's ability to hand off leadership roles to the next generation.

According to NASA's Associate Administrator for the Office of Space Flight, the agency faced significant safety and mission success risks because of workforce issues. This was reinforced by NASA's Aerospace Safety Advisory Panel, which concluded that workforce problems could potentially affect flight safety as the shuttle launch rate increased.

NASA subsequently recognized the need to revitalize its workforce and began taking actions toward this end. In October 1999, NASA's Administrator directed the agency's highest-level managers to consider

² Several workforce studies had been completed since 1996, including *Independent Assessment of the Shuttle Processing Directorate Engineering and Management Processes*, NASA Human Exploration and Development of Space Independent Assessment Office, (Nov. 4, 1999); *Annual Report for 1999*, Aerospace Safety Advisory Panel (Feb. 2000); and *Report to Associate Administrator, Office of Space Flight, Space Shuttle Independent Assessment Team* (Mar. 7, 2000).

ways to reduce workplace stress. The Administrator later announced the creation of a new office to increase the agency's emphasis on health and safety and included improved health monitoring as an objective in its fiscal year 2001 performance plan.³ Finally, in December 1999, NASA terminated its downsizing plans for the shuttle program and initiated efforts to begin hiring new staff.

Following the termination of its downsizing plans, NASA and the Office of Management and Budget conducted an overall workforce review to examine personnel needs, barriers to achieving proper staffing levels and skill mixes, and potential reforms to help address the agency's long-term requirements. In performing this review, NASA used GAO's human capital self-assessment checklist.⁴ The self-assessment framework provides a systematic approach for identifying and addressing human capital issues and allows agency managers to (1) quickly determine whether their approach to human capital supports their vision of who they are and what they want to accomplish and (2) identify those policies that are in particular need of attention. The checklist follows a five-part framework that includes strategic planning, organizational alignment, leadership, talent, and performance culture.

Recent Actions Taken by NASA

NASA has taken a number of actions this year to regenerate its shuttle program workforce. Significantly, NASA's current budget request projects an increase of more than 200 full-time equivalent staff⁵ for the shuttle program through fiscal year 2002—both new hires and staff transfers. According to NASA, from the beginning of fiscal year 2000 through July 2001, the agency had actually added 191 new hires and 33 transfers to the shuttle program. These new staff are being assigned to areas critical to shuttle safety—such as project engineering, aerospace vehicle design, avionics, and software—according to NASA. As noted earlier, appendix I

³ The Government Performance and Results Act of 1993 requires agencies to prepare annual performance plans. The purpose is to improve the efficiency of all federal agencies, under the goals of improving management, effectiveness, and public accountability; improving congressional decision-making on where to commit the nation's fiscal and human resources; and improving citizens' confidence in the government's performance.

⁴ See *Human Capital: A Self-Assessment Checklist for Agency Leaders* (GAO/OCG-00-14G, Sept. 2000).

⁵ Full-time equivalent is a measure of staff hours equal to those of an employee who works 40 hours per week in 1 year. Thus, a measure of 200 full-time equivalent staff does not necessarily represent the actual number of new hires.

provides a list of critical skills where NASA is addressing personnel shortages.

NASA is also focusing more attention on human capital management in its annual performance plan. The Government Performance and Results Act requires a performance plan that describes how an agency's goals and objectives are to be achieved. These plans are to include a description of the (1) operational processes, skills, and technology and (2) human, capital and information resources required to meet those goals and objectives. On June 9, 2000, the President directed the heads of all federal executive branch agencies to fully integrate human resources management into agency planning, budget, and mission evaluation processes and to clearly state specific human resources management goals and objectives in their strategic and annual performance plans.

In its Fiscal Year 2002 Performance Plan, NASA describes plans to attract and retain a skilled workforce. The specifics include the following:

- Developing an initiative to enhance NASA's recruitment capabilities, focusing on college graduates.
- Cultivating a continued pipeline of talent to meet future science, math, and technology needs.
- Investing in technical training and career development.
- Supplementing the workforce with nonpermanent civil servants, where it makes sense.
- Funding more university-level courses and providing training in other core functional areas.
- Establishing a mentoring network for project managers.

We will provide a more detailed assessment of the agency's progress in achieving its human capital goals as part of our review of NASA's Fiscal Year 2002 Performance Plan requested by Senator Fred Thompson.

Alongside these initiatives, NASA is in the process of responding to a May 2001 directive from the Office of Management and Budget on workforce planning and restructuring.⁶ The directive requires executive agencies to determine (1) what skills are vital to accomplishing their missions, (2) how changes expected in the agency's work will affect human resources, (3) how skill imbalances are being addressed, (4) what challenges impede the

⁶ *Workforce Planning and Restructuring*, OMB Bulletin No. 01-07 (May 8, 2001).

agency's ability to recruit and retain high-quality staff, and (5) what barriers there are to restructuring the workforce. NASA officials told us that they have already made these assessments. The next step is to develop plans specific to the space flight centers that focus on recruitment, retention, training, and succession and career development.

Remaining Workforce Challenges

If effectively implemented, the actions that NASA has been taking to strengthen the shuttle workforce should enable the agency to carry out its mission more safely. But there are considerable challenges ahead. For example, as noted by the Aerospace Safety Advisory Panel in its most recent annual report, NASA now has the difficult task of training new employees and integrating them into organizations that are highly pressured by the shuttle's expanded flight rates associated with the International Space Station.⁷ As we stressed in our previous testimony, training alone may take as long as 2 years, while workload demands are higher than ever.

The panel also emphasized that (1) stress levels among some employees are still a matter of concern; (2) some critical areas, such as information technology and electrical/electronic engineering, are not yet fully staffed; and (3) NASA is still contending with the retirements of senior employees. Officials at Johnson Space Center also cited critical skill shortages as a continuing problem. Furthermore, NASA headquarters officials stated that the stress-related effects of the downsizing remain in the workforce. Addressing these particular challenges, according to the Aerospace Safety Advisory Panel, will require immediate actions, such as expanded training at the Centers, as well as a long-term workforce plan that will focus on retention, recruitment, training, and succession and career development needs.

Human Capital Shortfalls—A Governmentwide Problem

The workforce problems we identified during our review are not unique to NASA. As our January 2001 Performance and Accountability Series reports made clear, serious federal human capital shortfalls are now eroding the ability of many federal agencies—and threatening the ability of others—to

⁷ See *Annual Report for 2000*, Aerospace Safety Advisory Panel.

economically, efficiently, and effectively perform their missions.⁸ As the Comptroller General recently stated in testimony, the problem lies not with federal employees themselves, but with the lack of effective leadership and management, along with the lack of a strategic approach to marshaling, managing, and maintaining the human capital needed for government to discharge its responsibilities and deliver on its promises.⁹ To highlight the urgency of this governmentwide challenge, in January 2001, we added strategic human capital management to our list of federal programs and operations identified as high risk.¹⁰

Our work has found human capital challenges across the federal government in several key areas.

- First, high-performing organizations establish a clear set of organizational intents—mission, vision, core values, goals and objectives, and strategies—and then integrate their human capital strategies to support these strategic and programmatic goals. However, under downsizing, budgetary, and other pressures, agencies have not consistently taken a strategic, results-oriented approach to human capital planning.
- Second, agencies do not have the sustained commitment from leaders and managers needed to implement reforms. Achieving this can be difficult to achieve in the face of cultural barriers to change and high levels of turnover among management ranks.
- Third, agencies have difficulties replacing the loss of skilled and experienced staff, and in some cases, filling certain mission-critical occupations because of increasing competition in the labor market.
- Fourth, agencies lack a crucial ingredient found in successful organizations: organizational cultures that promote high performance and accountability.

⁸ See *Performance and Accountability Series—Major Management Challenges and Program Risks: A Governmentwide Perspective* (GAO-01-241, Jan. 2001). In addition, see the accompanying 21 reports (numbered GAO-01-242 through GAO-01-262) on specific agencies.

⁹ See *Human Capital: Taking Steps to Meet Current and Emerging Human Capital Challenges* (GAO-01-965T, July 17, 2001).

¹⁰ See *High-Risk Series: An Update* (GAO-01-263, Jan. 2001). In addition, see *Human Capital: Meeting the Governmentwide High-Risk Challenge* (GAO-01-357T, Feb. 1, 2001).

Progress and Challenges in Making Shuttle Safety Upgrades

At this time last year, NASA planned to develop and begin equipping the shuttle fleet with a variety of safety and supportability upgrades, at an estimated cost of \$2.2 billion. These upgrades would affect every aspect of the shuttle system, including the orbiter, external tank, main engine, and solid rocket booster.

Last year, we reported that NASA faced a number of programmatic and technical challenges in making these upgrades.

- First, several upgrade projects had not been fully approved, creating uncertainty within the program.
- Second, while NASA had begun to establish a dedicated shuttle safety upgrade workforce, it had not fully determined its needs in this area.
- Third, the shuttle program was subject to considerable scheduling pressure, which introduced the risk of unexpected cost increases, funding problems, and/or project delays. Specifically, the planned safety upgrade program could require developing and integrating at least nine major improvements in 5 years—possibly making it the most aggressive modification effort ever undertaken by the shuttle program. At the same time, technical requirements for the program were not yet fully defined, and upgrades were planned to coincide with the peak assembly period of the International Space Station.

Since then, NASA has made some progress but has only partially addressed the challenges we identified last year. Specifically, NASA has started to define and develop some specific shuttle upgrades. For example, requirements for the cockpit avionics upgrade have been defined. Also, Phase I of the main engine advanced health monitoring system is in development, and Friction Stir Welding on the external tank is being implemented.

In addition, according to Shuttle Development Office officials, staffing for the upgrade program is adequate. Since our last report, these officials told us that the Johnson Space Center has added about 70 people to the upgrade program, while the Marshall Space Flight Center has added another 50 to 60 people. We did not assess the quality or sufficiency of the added staff, but according to the development office officials, the workforce's skill level has improved to the point where the program has a "good" skill base.

Nevertheless, NASA has not yet fully defined its planned upgrades. The studies on particular projects, such as developing a crew escape system, are not expected to be done for some time. Moreover, our previous

concerns with the technical maturity and potential cost growth of particular projects have proven to be warranted. For example, the implementation of the electric auxiliary power unit has been delayed indefinitely because of technical uncertainties and cost growth. Also, the estimated cost of Phase II of the main engine advanced health monitoring system has almost doubled, and NASA has canceled the proposed development of a Block III main engine improvement because of technological, cost, and schedule uncertainties.

Compounding the challenges that NASA is facing in making its upgrades is the uncertainty surrounding its shuttle program. NASA is attempting to develop alternatives to the space shuttle, but it is not yet clear what these alternatives will be. We recently testified before the Subcommittee on Space and Aeronautics, House Committee on Science on the agency's Space Launch Initiative. This is a risk reduction effort aimed at enabling NASA and industry to make a decision in the 2006 time frame on whether the full-scale development of a reusable launch vehicle can be undertaken.¹¹ However, as illustrated by the difficulties NASA experienced with another reusable launch vehicle demonstrator—the Lockheed Martin X-33—an exact time frame for the space shuttle's replacement cannot be determined at this time. Consequently, shuttle workforce and upgrade issues will need to be considered without fully knowing how the program will evolve over the long run.

In conclusion, NASA has made a start at addressing serious workforce problems that could undermine space shuttle safety. It has also begun undertaking the important task of making needed safety and supportability upgrades. Nevertheless, the challenges ahead are significant—particularly because NASA is operating in an environment of uncertainty and it is still contending with the effects of its downsizing effort. As such, it will be exceedingly important that NASA sustain its attention and commitment to making space shuttle operations as safe as possible.

Mr. Chairman, this concludes my statement. I would be happy to answer any questions that you or Members of the Subcommittee may have.

¹¹ See *Space Transportation: Critical Areas NASA Needs to Address in Managing Its Reusable Launch Vehicle Program* (GAO-01-826T, June 20, 2001).

Contact and Acknowledgement

For further contact regarding this testimony, please contact Allen Li at (202) 512-4841. Individuals making key contributions to this testimony included Jerry Herley, John Gilchrist, James Beard, Fred Felder, Vijay Barnabas, and Cristina Chaplain.

Appendix I: Space Shuttle Program Skill Shortfall Areas

In December 1999, the National Aeronautics and Space Administration (NASA) completed an internal workforce assessment focusing on the Office of Space Flight, which includes the shuttle program. That assessment identified work areas in which NASA was experiencing skill shortfalls. At our request, NASA provided a listing of skill shortages in the shuttle program. The areas the agency identified follow:

- Program/project management/project engineering
- Aerospace vehicle design and mission analysis
- Avionics
- Guidance, navigation, and control systems
- Materials analysis
- Mechanical engineering
- Thermal control
- Structural dynamics
- Vehicle dynamics
- Aircraft ground systems
- Human factors
- Environmental controls
- Robotic systems
- Computer systems
- Fluids (liquid propulsion systems)
- Information technology security
- Aerospace systems test engineering
- Software (applications and systems)
- Sensors and transducers
- Electrical engineering
- Software assurance engineering
- Flight assurance
- Quality engineering
- Reliability engineering
- Safety engineering
- Flight controls