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Subcommittee on Space and Science

"NASA Accountability and Oversight"

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Thank you, Senator Hickenlooper, Senator Lummins, and Members of the Subcommittee for the opportunity to discuss the important topic of NASA accountability and oversight with you today.

I would like to begin by observing that while the U.S. space enterprise is facing many serious challenges, it is also in a better position than it was a decade ago after the difficult passage of the 2010 NASA Authorization Act. The Orion spacecraft is ready to carry humans into deep space. The Space Launch System is preparing for its first flight. The James Webb Space Telescope has successfully reached the L2 point beyond the Moon. The first helicopter beyond the Earth is operating on Mars, and NASA is preparing for humanity's first robotic round-trip to the red planet. Commercial providers are routinely transporting cargo and crew to the International Space Station – which remains a crown jewel in international space cooperation.

All of this has been made possible by the bipartisan support of Congress. In the space community, there is an old saying, "What makes the rocket go up? Funding." And what makes funding go up? Bipartisan support. American leadership in space continues to be a powerful symbol of our country at its best. This committee is crucial to future leadership.

Aerospace Safety Advisory Panel Report
In the aftermath of the 2003 loss of the Space Shuttle *Columbia*, NASA's Aerospace Safety Advisory Panel (ASAP) was tasked to submit annual reports on NASA's safety performance, management, and safety culture. In their most recent report, the ASAP observed that:

> *"…it will not be possible for NASA to single-handedly carry out all of the missions now envisioned. Considering its ambitious goals and constrained budget, for NASA--and hence the United States--to continue to play a strategic leadership role in space, the Agency must transform. … the Agency will need to operate differently--from strategic planning and how it approaches program management, to workforce development, facility maintenance, acquisition strategies, contract types, and partnerships."*

This is not a new observation as it has long been recognized that future U.S. human space exploration efforts would be unlikely to duplicate either Apollo or the Space Shuttle experiences. The 2017 Space Policy Directive 1 directed NASA to:

> *"Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations."*

SPD-1 recognized the centrality of commercial and international partners, which made the coming new era of space exploration and development different from those of the past. NASA is still in the process of working out what this new era means for how it manages programs and holds itself accountable to the Congress and the President. In examining current NASA management of human space flight development programs, the ASAP was critical of what it sees as a:

> *"…disaggregated, decentralized program structure between SLS, EGS, and Orion, with the view that it is a manageable alternative to the familiar and effective program framework that served it well for the Apollo, STS, and ISS programs, … In effect, NASA has accepted the disaggregated program structure as normal, and is now propagating this structure as a preferred business and risk management model, even though it is essentially an untried approach for an integrated systems engineering effort of this magnitude and complexity."*

I believe the ASAP makes a crucial observation here that has implications for NASA mission success and how the Congress should oversee the Agency and hold it accountable for public resources. However, I do not believe the choice is between doing nothing or replicating earlier government-industry conditions.

The Role of Government

For the most of the space age, governments determined what they wanted and then built hardware in government facilities or contracted with industry – specifying requirements to industry. With the strong growth of commercial space industries over the past two decades, NASA has the opportunity to buy commercial goods and services to achieve its missions. In fact, national space policies have long encouraged NASA to do so, to "the maximum extent practicable."

As with commercial firms, NASA needs to make "build or buy" decisions – on what capabilities to perform in-house and what capabilities should be outsourced to other government agencies, the commercial sector, and international partners. The scale and scope of NASA missions, combined with its relatively small budget, means that "build or buy" decisions represent major strategic choices. The Agency needs to exploit and leverage private sector capabilities such as launch, satellite production, communications, remote sensing, ground networks, and information services as much as possible. As a

basic rule, if NASA can buy or adapt an existing commercial service, it should. The commercial sector is a key strategic advantage for the United States. By exploiting the scale and scope of private sector activities relevant to space, the United States can outpace and out-innovate competitors and adversaries.

Relying on the commercial sector does not mean that NASA can outsource its responsibilities for mission success or being a steward of taxpayer monies. As a cautionary example, in the 1990s, the Department of Defense introduced an acquisition reform that was intended to reduce the cost and speed the delivery of major weapons systems, including major national security space systems. Known as Total System Performance Responsibility (TSPR or "tiss-per"), this reform removed many reporting requirements from contractors and allowed them to make trade-offs in how to best meet operational requirements. The government's role was focused on program direction, financials/budgeting, requirements determination, contract management, and security.

While plausible in theory, and successful on a few programs, overall it was a cost and schedule disaster as contractors struggled with systems engineering, trades among competing requirements, and managing technical risk. Under TSPR, the government was supposed to have a close "insight" role – rather than exercising "oversight" – but the necessary close working relationships with industry often did not occur and overall program performance suffered. One of the lessons from TSPR is that the government must retain technical expertise to be a good customer. In particular, the government needs to have strong system engineering skills in order to conduct "insight" as well as more traditional "oversight" functions.

When NASA began the commercial crew program, it faced a dilemma on how it would work with industry. Imposition of traditional human-rating certification processes would limit potential innovations and cost savings. On the other hand, there was no track record of successful operations to assure NASA that its astronauts would be safe. When NASA chose to fly astronauts on Russian boosters, clearly not built to NASA specifications, those boosters had demonstrated several hundred successful flights. The answer for commercial crew development was for NASA to have insight into the vehicles being built, but to a level that was far deeper than for Russian boosters, as hundreds of design decisions and trade-offs had to be made before the first flight. While the risks were great, NASA developed the kind of close partnership with industry that had not occurred with many TSPR-era programs.

Today, NASA aims to move beyond the experiences of commercial crew and cargo. Those programs were challenging, but bounded to the provision of safe and reliable services to the International Space Station. For the Artemis program, NASA has traditional "programs of record" such as Orion and the Space Launch System, while it seeks to develop the Human Landing System (HLS) as a public-private partnership. In the latter case, private firms are asked to commit significant resources of their own and NASA requires deep insight for crew safety. The HLS is not merely a continuation of the commercial crew/cargo model, however. It represents a larger role of the private sector in creating the larger architecture of human spaceflight beyond low Earth orbit. It is part of

this “disaggregated” approach that raises ASAP concerns about how Artemis will be managed and executed.

The evolution of U.S. international space cooperation provides an analogy to what is occurring today. The Apollo program was a U.S.-only endeavor, intended to demonstrate what the United States alone could do. The Space Shuttle was also a U.S. program that includes international augmentations, such as the robotic arm and a Spacelab. The Space Station began in a manner similar to the Shuttle, but became an international partnership with the addition of Russia in 1993. Today, non-binding fora such as the International Space Exploration Coordination Group are where international space agencies share their ideas and plans for deep space exploration. In the specific case of Artemis, the United States has not been telling other countries what it requires from them, but inviting them to participate in the foundational planning discussions, creating interoperable standards and protocols, and proposing what they want to contribute. U.S. leadership today is about getting others to want to join us rather than going alone. Similarly, for the commercial sector, NASA should encourage industry to join and augment space exploration and development efforts. NASA should be open to new ideas and proposals from outside the Agency.

Adapting NASA to a New Era of Exploration

The challenges NASA faces in delivering on the Artemis program, transitioning low Earth orbit operations after the International Space Station ends, and integrating international and commercial capabilities into efforts to better understand the Earth, are immense. NASA’s budget has recently increased in real terms, but has not yet recovered from the reductions experienced after the end of the Cold War. But perhaps the greatest risks for NASA are in the quality and skills of its workforce.

The management challenges ahead are just as serious as the technical challenges. Unlike Apollo, which built multiple vehicles to accomplish a particular mission, or Shuttle and Station, which were singular capabilities used for multiple missions, Artemis requires multiple capabilities for multiple missions, with the involvement of international and commercial partners. These partners are not mere subcontractors, but will be engaged in space activities of their own at widely varying scales – from hitchhiker cubesats, to pressurized rovers on the lunar surface.

The good news is that the U.S. space industrial base is more capable, sophisticated, and agile than ever before. The difficulty is that NASA has not been able to fully capture, grow, and retain the people with the necessary skills to manage complex, multi-partner programs. The Science Mission Director has done relatively well with projects of varying sizes, and in-house opportunities for research, developing new missions, and conducting operations. Human spaceflight has been good at research and operations, but the decades long time-scales for development have meant fewer opportunities for NASA engineers and managers to train and prove themselves on flight projects (as distinct from just flight operations).

NASA lacks a world-class systems engineering and integration (SE&I) capacity for large scale developments. In particular, this is a problem given the challenges NASA has in conducting long-term, sustainable, and multi-stakeholders endeavors. SE&I activities within separate projects (e.g., Space Launch System, Orion, Exploration Ground Systems, Gateway) are generally good. However, cross-system integration or "enterprise integration" has been lacking. There have been efforts to stand up a separate SE&I organization in recent years. However, it lacked proper "top cover" to address culture issues, resources, purpose or integration with the Centers. NASA has lost much of its enterprise SE&I capability and should consider creating an enterprise SE&I capability near NASA Headquarters, supplemented by Federally Funded Resource and Development Center (FFRDC) and leading industry resources. The would be similar to the successful "Bellcom" model used during the Apollo program.

There is nothing in the current Federal Acquisition Regulations, or in the tools available through Other Transaction Authorities and Space Act Agreements, that necessitates slow and rigid acquisition decision-making. Barriers arise from culture and management practices, often in response to historical problems, not the law itself. Leadership by capable and confident managers, with real-world experience and political top cover, can still make a difference. Leadership is necessary to creating a sense of urgency and regular flight test opportunities that can clarify which decisions need to be made and when. If there is not a sense of urgency and regular, real-world feedback in the service of national objectives, the natural tendency of organizations is to prioritize their own internal incentives. This is how you get proposed strategies like "capability-driven evolution" where the Agency gets around to conducting missions with whatever it has on-hand, however long it takes.

Competency and confidence in leaders can only partly be taught. It is most effectively grown through experiences, particularly in flight test and real missions. There is no substitute for learning humility from hardware. Again, the space science community and commercial communities have been able to do this through a regular cadence of development programs. The Space Development Agency is leveraging the skills of commercial satellite builders and launches through a steady cadence of spiral developments. The task for NASA is not just in getting the right human capital for the Artemis program, but in ensuring the development of talent and career paths commensurate with a competitive global space industry. This task also applies to other parts of the Agency that impact development, such as the Office of the Chief Engineer (OCE), and the Office of Safety and Mission Assurance (OSMA), to ensure they are just as capable and on the same page with Exploration Systems Development.

Recommendations for NASA Headquarters

NASA Headquarters is where the policy and technical leaderships meet. It is where the needs of the field centers are balanced with the needs of the Mission Directorates. And it is the linkage point between NASA and its stakeholders in the White House and the Congress. The Office of the Administrator needs its own access to independent studies and analysis teams that can perform architecture trades, cost and schedule analysis, budget trades, and program/project reviews. As a former head of Program Analysis and

Evaluation (PA&E), I am partial to having a PA&E and the associated Agency governance model, but results can be achieved in other ways. The important thing is responsive support to the Administrator and his or her leadership team with the best, most objective advice possible.

An immediate priority for the Agency, and not just the Exploration Systems Development Mission Directorate, would be an architecture study and campaign plan encompassing NASA activities from low Earth orbit to the lunar surface for the next 10-15 years. When Mike Griffin became Administrator, one of the first tasks PA&E was given was an Exploration Systems Architecture Study (ESAS) to determine how we would go from completing the ISS and ending the Shuttle program to landing humans on the Moon and building the capability to go to Mars. One can argue about the content that became the Constellation program, but we had a detailed understanding of the performance requirements, technical risks, costs, and schedule drivers for returning to the Moon and enabling human missions to Mars.

I am not suggesting a return to the Constellation architecture, which was optimized for a particular time and place. I am, however, arguing for having that kind of detailed understanding and insight to make sound decisions about where NASA will exercise direct oversight and where it will rely on others. For example, the HLS is being developed as a public-private partnership – a decision I supported while in government and a decision I support today. However, it was disappointing that there were insufficient funds for two awards. ISS experiences such as the *Columbia* accident, reliance on Russian launchers, and the development of commercial cargo and crew capabilities, have driven home the value of "dissimilar redundancy" in operating complex space facilities. Having such redundancy is valuable and even worth paying a premium for, as opposed to relying on a single supplier. In practical terms, however, NASA cannot pay an arbitrarily high premium. If a second HLS source cannot be found by market competition, then the Agency will need to consider using more traditional contracting.

Regardless of whether NASA is exercising oversight or insight, it is critical for Level 1 systems engineering responsibility to be held at Headquarters, along with cost reserves (also termed unallocated future expenses), and milestone approval authority. In this regard, the Apollo form of management and systems engineering is a "best practice" that can be tailored to include new relationships with commercial and international partners. In the early days of a development program, it may even be necessary to hold Level 2 requirements at Headquarters until the field centers demonstrate they can take on that responsibility. Personnel in senior technical management positions should have "gotten their hands dirty" during their careers, with responsibility for delivering products, and making tradeoffs involving cost, risk, schedule, and performance. As in the Military Services, experiences as a pilot or operator do not directly translate into development and acquisition expertise as the cultures are vastly different.

The central need is for a strong systems engineering capability in human spaceflight, tight control of high-level requirements and interoperability standards, and the ability to do technical, cost, schedule, and risk trades within the Agency. With this in mind, I would

recommend that NASA adopt a form of the Apollo program management approach rather than the Shuttle/Space Station approach. Technical authority should not be delegated to the Centers as this introduces unneeded layers of bureaucracy, costing both time and money. The Associate Administrator for Exploration Systems Development should be accountable for exercising overall architecture development and implementation with approval at the senior Agency level. This in turn requires an integration function at Associate Administrator level for developing requirements and assuring program requirement/verification alignment.

I would also expect the Associate Administrator for Exploration Systems Development to have a direct line to the Chief Engineer and Chief Safety and Mission Assurance Officer for day-to-day Mission Directorate activities and decisions. These individuals should have delegated technical authority to act and obtain immediate support across entire Agency whenever needed. While acknowledging the valuable flexibility of remote working, the OCE and OSMA leadership need to be resident at NASA Headquarters and readily available for resolving agency-level issues.

Returning to my earlier comment on the need for an integrated architecture and exploration campaign plan, such a document is important not only for NASA but for NASA's stakeholders in the White House, Congress, U.S. industry, and the international community. This was something NASA was tasked to create by the National Space Council in the past administration. While plans for the first Artemis missions were provided, I did not see a plan comparable to what we had for Constellation. An integrated exploration campaign plan does not have to be perfect. It must be open to discoveries as we learn along the way. Near term endeavors, e.g., returning to the Moon, should be very detailed, while the plan to achieve a sustainable lunar exploration program will be less detailed but provide stakeholders a framework of goals and strategies against which milestones can be assessed. The plan should convey a sense of urgency with periodic and frequent flight test opportunities that are aggressive but achievable to: (1) show progress to stakeholders; and (2) provide the NASA workforce meaningful development that instills confidence while retiring risk. This is similar to the approach of the Apollo program.

Why it Matters

NASA authorizations and appropriations are political choices – a reflection of what we value about space exploration as a society. In today's environment, sustaining discretionary expenditures for civil space exploration will be challenging unless there is a clear rationale linking such efforts to broader national interests that can be supported in a bipartisan manner over many years. The seemingly separate threads of human, robotic, civil, commercial, and national security space activities are in fact deeply intertwined with each other, both politically and technically. A multinational program to explore the Moon, as a first step, is both a symbolic and practical means of creating a broader international framework for space cooperation with benefits for security, diplomacy, and the economy.

While at the National Space Council, we developed a document to explain the overarching rationale for the various Executive Orders, Space Policy Directives, and the National Space Policy. This document, "A New Era for Space Exploration and Development" might be thought of as similar to a conference report that explains legislation in more detail. With your permission, I would like to close with a quote:

> *Establishing U.S. capabilities to operate routinely in cis-lunar space and beyond will deliver strategic assets not only for ourselves, but for all like-minded nations who share our values – liberty, democracy, the rule of law, and free market economic principles. Exploration is fundamental to the American spirit, and space exploration is the modern embodiment of early frontier expeditions. It is the next step in a never-ending quest to explore and develop the unknown, while securing benefits for the American people.*
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> *Space exploration and development are not confined to one-time missions or any single destination. Rather, the effort described here is one of continually expanding human activity beyond the Earth. Close to home, the United States will encourage commercial activities to lower the public burden of maintaining and enhancing space capabilities. As the United States journeys into deep space again, it will do so with commercial and international partners as they are willing to participate and capable of participating. At the frontiers of exploration, the United States will continue to lead, as it has always done, in space. If humanity does have a future in space, it should be one in which space is the home of free people.*

Thank you for your attention. I would be happy to answer any questions you might have.

Scott Pace

Dr. Scott Pace is the Director of the Space Policy Institute and a Professor of the Practice of International Affairs at George Washington University's Elliott School of International Affairs. His research interests include civil, commercial, and national security space policy, and the management of technical innovation.

Dr. Pace rejoined the faculty of the Elliott School of International Affairs in 2021 after serving as Deputy Assistant to the President and Executive Secretary of the National Space Council from 2017 to 2020. He previously served as the Associate Administrator for Program Analysis and Evaluation at NASA from 2005 to 2008 and Deputy Chief of Staff for the NASA Administrator from 2002 to 2003. Prior to NASA, he was the Assistant Director for Space and Aeronautics in the White House Office of Science and Technology Policy. From 1993 to 2000, he worked for the RAND Corporation's Science and Technology Policy Institute, and from 1990 to 1993, he served as the Deputy Director and Acting Director of the Office of Space Commerce, in the Office of the Deputy Secretary of the Department of Commerce. He received a Bachelor of Science degree in Physics from Harvey Mudd College in 1980; Masters degrees in Aeronautics & Astronautics and Technology & Policy from the Massachusetts Institute of Technology in 1982; and a Doctorate in Policy Analysis from the RAND Graduate School in 1989.

Dr. Pace received the Office of the Secretary of Defense, Group Achievement Award in 2020, the Wernher von Braun Space Flight Trophy from the National Space Club in 2018, the NASA Outstanding Leadership Medal in 2008, the U.S. Department of State's Group Superior Honor Award, *GPS Interagency Team*, in 2005, and the NASA Group Achievement Award, *Columbia Accident Rapid Reaction Team*, in 2004. He was a private sector advisor to the U.S. Delegation to the UN Committee on the Peaceful Uses of Outer Space, in Vienna, Austria 2009, 2011-2017; a member of the UN expert group on regulatory regimes, Committee on Peaceful Uses of Outer Space, 2011-2014; and a member of the U.S. Delegation to the International Telecommunications Union World Radiocommunication Conferences in 1997, 2000, 2003, and 2007.