

**Statement of
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Before the

**Committee on Science, Space, and Technology
Subcommittee on Space and Aeronautics
U.S. House of Representatives**

Representative Beyer and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the status of plans and progress on the National Aeronautics and Space Administration's Artemis initiative.

As you know, the Aerospace Safety Advisory Panel is charged with advising both the NASA Administrator and the Congress with respect to the safety and risk of human space flight as well as other safety related matters at the Agency. In opening, I would like to emphasize that the Panel feels the responsibility to provide advice that promotes the minimization of risk to the lowest reasonable level while still accomplishing the mission. Space exploration is inherently dangerous; the environment is hostile, and the systems needed to survive in it are complex. Our charge is not to avoid any and all risks, but to provide advice and feedback for the intelligent management of those risks.

Since its creation on October 1, 1958, NASA has been responsible for some truly remarkable accomplishments in science, engineering, and exploration. As an organization, it is admired around the world, and it regularly wins awards such as "The Best Place to Work in the Federal Government." However, past achievement does not guarantee future success. NASA has also had its share of failures, some of which have come with costly lessons that must inform future choices. For NASA to continue its trajectory of success in the decades ahead, it must proactively plan for and manage its work in the presence of the numerous challenges, constraints, and risks inherent in the changing environment of the aerospace community.

How NASA conducts its human space flight programs has evolved. From its founding, and for much of its history, NASA took responsibility for defining, directing, and executing almost all of its major programs. Later, NASA made conscious decisions to share responsibility for managing significant portions of certain programs with industry. More recently, several of NASA's key programs have been almost entirely managed by industry. This evolution in who has what responsibility occurred in response to several drivers, including:

- The belief that it may allow for lower program costs.
- The potential to significantly shorten development schedules.
- A deliberate strategy to turn some activities over to industry to enable NASA to focus its efforts and its budgets on more challenging tasks, including exploration beyond low-Earth orbit (LEO).

The rebalancing of roles and responsibilities between NASA and industry has generally succeeded, but this trend has changed how NASA executes its mission. Specifically:

- For a significant portion of its program portfolio, NASA is no longer responsible for deciding how systems are designed, developed, and tested.
- Increasingly, NASA is becoming a customer rather than an owner/operator.
- Rather than directing all human spaceflight programs, NASA is more frequently engaging with—and relying on—industry and international partners.

Over the past several years, NASA has been adjusting to a changing role and set of responsibilities as it shifts from principally executing its programs and missions to commercially acquiring significant key elements and services. The Agency has gradually and tactically adapted and succeeded in meeting challenges as they arise. Regardless of their tactical achievements to date, the Panel firmly believes that it is critical at this time that NASA take more strategic scrutiny of the role the Agency should undertake going forward. How the Agency plans to evolve and transition to an organization that more frequently procures human space flight capabilities as services, while managing a safe and wholly new human exploration campaign, is a key strategic question that has the Panel's attention. We continue to emphasize the importance for NASA to strategically define its mission, its guiding principles, and its vision for the Agency's leadership role in the future in order to ensure that risk is managed appropriately. Once the Agency has clarified a vision and strategy, it should then make the decisions, and take the necessary actions, to enable it to accomplish the required transformation.

Regardless of how NASA chooses to strategically position itself for the future, funding an expanding exploration portfolio will obviously take considerable resources. However, history suggests (as shown in Figure 1) it is unlikely NASA's budget will ever again exceed 1% of the federal budget, as it did during the lead-up to the Apollo Program. Consequently, it will not be possible for NASA to single-handedly carry out all the missions now envisioned; it will need partners, both domestic and international. However, while private industry efforts are an ever more important factor in the U.S. government's future endeavors, the commercial sector alone has not, and will not, be the vehicle that drives national goals. 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. Drivers for the need to transform include:

- Missions to the Moon and Mars are significantly more complex than the objectives of previous programs, with multiple launches and a variety of vehicles required for each expedition.
- The increase in mission complexity requires considerably more integration “touchpoints” between supporting programs, leading to increased oversight and program expenses.
- Sustained lunar and Martian missions will involve significantly greater risk than NASA's previous human space flight experiences in the LEO regime. The global space community still has much to learn about supporting humans on other planetary bodies for long durations.
- The pace of technological change will almost certainly continue to increase, requiring designs and systems that are flexible enough to integrate advantageous advancements.
- The aerospace industry has become much more diverse and innovative, and companies are willing and able to make major contributions as contractors, service providers, or partners.
- Having benefitted from a positive experience with the International Space Station (ISS), the international community has made it clear that it would like to work with NASA on future exploration programs.

The ASAP is vitally interested in this transformation. Changes in how NASA manages human space flight programs will have a significant impact on the risks associated with those programs. As one example, the overall strategy NASA decides to use for a particular program—whether to “make, manage, or buy”—has major implications for the kind of expertise and experience the Agency's workforce will need to successfully execute the program and manage the associated risks. The Panel believes that NASA's vision for the future, and a clear definition of how it will evaluate and make decisions related to risk (in addition to how it will manage and execute programs), are extremely important factors in ensuring human space flight safety.

As NASA continues to evolve and define its future role, it is important for the Agency and its stakeholders—Congress, other Executive branch entities, the private sector, and the taxpayers—to understand the context in which NASA has successfully operated for the past 50 years. By having a clear understanding of what drove, and continues to drive, Agency culture and thinking, NASA and its stakeholder community can work intentionally to chart a meaningful and impactful role for the Agency in the future. Ignoring the external forces and environment in which the Agency must function will place NASA in a tenuous position going forward, which in turn will impact how safely and successfully it will be able to carry out U.S. government missions in space.

In addition, as NASA adapts internally to remain successful in its changing external environment, the expectations of its stakeholder communities—specifically Congress and the Executive Branch—must also adapt. The Panel has stressed the importance of constancy of purpose and its role in the ability of the Agency to manage risk intelligently and proactively. Not only do consistency and clarity of objectives help the Agency plan more efficiently, but they also send a clear message to the workforce about the Agency's direction, providing focus and background for decision-making at all levels. Constant and abrupt changes in direction create inefficiencies in planning and execution that create confusion and uncertainty in the workforce and dilute the focus in decision-making, all of which increase cost and risk. Importantly, over the

past two Administrations, the Moon has remained steady as a primary mission. Prior transitions were not as smooth, however.

Disruptive changes in direction not only decrease the ability of the Agency to operate efficiently, but they also shape internal NASA culture. To illustrate, as the Space Shuttle program was ending, the Constellation program gave the Agency a clear mandate to return to the Moon. When the Constellation program was cancelled, after an Administration-level review of program performance, the Agency was redirected to an asteroid landing mission, an objective that made less technical sense for a long-term development of interplanetary capability. When the asteroid objective lost traction within a few years, it created a ripple of uncertainty and the loss of a strong mission focus in the workforce that echoes to this day. The abruptness of these changes in direction for NASA's primary touchstone program caught the whole community—but especially the NASA workforce—by surprise. Confusing communication about the Administration's rationale and the lack of supporting technical data for the asteroid mission, especially for an agency that bases its very successes on a strong technical culture, created a lack of trust. And, to many in the NASA workforce, the Moon then became a forbidden subject of consideration, even though the Moon was rightly perceived as the next technically advantaged step and logical risk management choice in human exploration.

The cultural dynamics prompted by the instability of purpose and the disconnect between purpose and technical rationale now appear to be normalized into the organizational culture. NASA leaders, unable to discuss a comprehensive lunar program, were driven to create tools and capabilities outside the traditional program context the Agency had always used to manage complex integrated capabilities throughout its history. Consequently, the Exploration Ground Systems (EGS), Orion, and the Space Launch System (SLS) were established as three individual programs, each with their own processes, structures, and management approaches, rather than being integrated as what previously would have been a single program. These three individual programs were then distributed across the three major NASA human space flight centers to make the resource allocation equitable and to satisfy stakeholder requirements.

Unfortunately, this approach left a critical gap in the system-of-systems integration process that is usually filled by having a single overarching program umbrella with requisite program authorities and integration responsibilities. In the absence of a formal program umbrella, NASA Headquarters created a bottom-up integration effort, which required the individual programs to negotiate among themselves. This is a difficult proposition for managing design and operational changes that allocate risk to different elements, which then impacts individual program cost and schedule. The Panel notes that such an approach often prioritizes consensus, rather than decision-making by an accountable leader, which makes resolution of tough integration, resource, and risk management issues even more challenging.

In adopting this 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, NASA has seemed to overlook the negative impacts to cohesive integrated risk management. In essence, it appears that the cancellation of the Constellation program has led to a cautious stance among NASA leaders driven by the assumption that having an Apollo-like program now is a problematic political

optic, and like Constellation, a possible target for cancellation by a future Administration. 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.

Thus, behavior that was instantiated as a coping mechanism for unstable political guidance has become institutionalized—as has the embedded uncertainty in risk management. Furthermore, the Agency is attempting to manage the risk in the structure it has adopted without deliberately assessing why the structure is at least equivalent to, if not an improvement to, risk management, and whether it should be advanced as a wholly new program approach.

And finally, the national budget formulation process influences NASA's ability to operate more efficiently, and directly impacts risk and safety, just as it does other agencies. Like other agencies, NASA receives its budget allocation annually. For the last decade, that process has been routinely delayed, requiring the Agency to work in a constant environment of budget uncertainty. Although it is well understood that the budget profile for a complex engineering system requires significantly more up-front investment during the design and development phase, NASA must manage its programs with essentially flat line spending profiles from year-to-year. In an uncertain and constrained budget environment, engineering decisions are driven by short-term cost considerations that have long-term consequences for operations, safety, and risk posture. For example, integrated testing programs developed early on for sound technical reasons may get trimmed due to schedule and resource pressures, which increases operational risk. Optimal design solutions may be discarded to contend with immediate cost concerns, and thus thwart the opportunity to realize long-term savings and promote operational risk mitigation. Simply addressing the uncertainties and suboptimal phasing that are inherent in the current budget processes would go far toward allowing the Agency to manage risk better and make the difficult strategic decisions necessary to operate more efficiently.

Turning now specifically to the Artemis initiative, NASA, as a global leader in human spaceflight, has had tremendous successes throughout its history, and much of that success has stemmed from strategic, coherent program management, expert leadership, and clarity of purpose and process from the top down. As with many of this nation's most successful strategic efforts, NASA placed priority on program management approaches that valued clear lines of authority, a coherent resource management approach, and a transparent yet comprehensive roadmap for integrated risk management. For reasons stated previously, however, NASA has deviated from previous program management "best practices" that have been hallmarks of successful strategic programs. During this past year, the Panel had numerous opportunities, during quarterly meetings as well as special discussions, to better understand how the myriad programs and projects that collectively contribute to the objectives of Artemis will be brought together as a cohesive campaign, and the Panel now notes several deviations from NASA's history that give cause for concern.

First, there is no top-level Artemis program—and therefore no Artemis Program Manager—to provide comprehensive and aligned integrated guidance that directs resources of all Artemis programs and projects in a cohesive manner to manage the overall risk.

As I've noted, the EGS, Orion, and the SLS were set up as three individual programs, each with their own processes and structures—rather than what previously would have been an integrated single program. Ordinarily, the resulting critical gap in systems integration would have been filled by a single overarching program. Since this does not exist, the Agency is attempting to manage the systemic risks of the Artemis enterprise in the structure they have adopted without deliberately assessing whether that structure is best suited for the necessary purposes of broad integration and enterprise risk management. Specifically, at this point, the Artemis campaign is not established formally as an "Artemis program"—there is no designated Program Manager who has program management authority over all aspects of Artemis developments across the enterprise. Although NASA used a well-developed program management structure for the Apollo, Space Shuttle, and ISS programs of the past, there is no similar unifying and comprehensively aligned program framework for the Artemis enterprise. In other words, there is no clearly defined leader of the enterprise, transparently endowed with the ultimate authority, responsibility, and accountability to direct all Artemis-related programs and ensure full synchronization and integration of effort.

Instead, NASA has undertaken a number of new integrating efforts in an attempt to fill the void. There is an integrating manager who has created various processes that primarily rely on a broad series of boards and panels to perform a "bottom-up" review process, designed to raise issues and resolve integration questions as they arise through day-to-day program work. The sheer number of programmatic efforts within the enterprise make it unclear whether the critical integrated risk management outcomes are fulfilled by this approach. In particular, the ASAP is concerned about the heavy reliance on lower-level workers to raise integration concerns across sub-programs. Without a comprehensive and accountable approach to integrated risk management from the enterprise level, the workforce responds to a large bureaucracy of panels and boards, without authoritative guiding principles (e.g., an Artemis Systems Engineering and Integration Plan) and transparent direction on roles, responsibilities, and authorities for sub-program risk integration. As key resource decisions that may affect integrated risk are made, it is unclear who is accountable—who specifically is accepting that risk.

Ensuring that NASA employees clearly understand roles, responsibilities, and authorities surrounding the Artemis enterprise has been an ongoing concern, and led the Panel to make the following recommendation:

NASA should manage Artemis as an integrated program with top-down alignment, and designate a Program Manager endowed with authority, responsibility, and accountability, along with a robust bottom-up, collaborative feedback process for both Systems Engineering and Integration (SE&I) and risk management.

Secondly, there is no Artemis prime integrating contractor in support of the NASA workforce. Artemis is by far the most complicated human space flight endeavor that NASA has ever attempted. Sub-programs across the entire Agency, along with international partners, and contractual arrangements for highly complex services such as the Human Lander System (HLS) are spread across multiple centers and encompass countless SE&I points across the enterprise. In the past, NASA has heavily leveraged a single integrating contractor who works across all

elements of the system (e.g., USA for the Space Shuttle program and Boeing for the ISS program) to perform the critical aspects of managing the SE&I across sub-programs and projects, and to ensure there is consistency of standards, practices, and development outcomes for NASA's human space flight programs. At this point in the Artemis campaign, each sub-program has designated its own integrating contractor, and there is no support contractor who has the "whole picture view" of how the entire campaign must come together with consistent risk management approaches. In addition, it is unclear how much NASA may be paying for duplication of effort across programs, projects, and centers, or whether the work myriad integrating contractors perform is consistent or in conflict. Since a Prime Integrating Contractor has often been responsible for risk management integration throughout development in previous programs, the Panel advises NASA to gain clarity on how this deviation from previous program practices is achieving equivalent risk management outcomes.

Thirdly, the unprecedented mix of acquisition approaches presents risk management challenges. Best practice dictates that an acquisition "life cycle" should encompass transparent and unambiguous authorities, responsibilities, and a chain of accountability for the entire development cycle, across all entities participating in the development. Contractual instruments should then clarify these authorities and responsibilities. An overarching blueprint for acquisition, oversight requirements, and insight should thus be aligned to a well-defined, comprehensive NASA risk management strategy and promulgated to all contracts in such a way as to ensure that overall integrated risk management—from project-to-project, program-to-program, and mission-to-mission—is clear, consistent, and coherent. Every acquisition, whether a contractor supporting a NASA in-house program such as SLS, or a "service contract" such as HLS, should have a consistent, unambiguous approach to risk management that spans the entire enterprise. The public's trust in NASA as the Nation's steward of human space flight demands that the Agency ensure accountability for risk management to be very clear.

To date, NASA has settled on a broad mixture of acquisition approaches to achieve the outcomes of the Artemis campaign, but it is unclear whether these contracts are synchronized to ensure responsibilities are consistently explained, authorities are cogently defined, and accountabilities are applicable for a highly complex, Systems Engineering and Integration context. Regardless of whether a partner-approach or an acquisition-approach is used, consistent expectations of transparency and data-driven risk discussions are required. The same standards must apply to all partners and private companies that are involved in NASA missions, regardless of contract structure or partner type.

In summary, I will reiterate some consistent themes of advice the Panel has offered:

- First, we have long maintained that mission success requires a constancy of purpose, a sustained commitment, and a clear understanding of objectives.
- Second, a key issue, repeated year after year, is the importance of setting challenging but achievable schedules, and not allowing undue schedule pressure to lead to decisions that adversely impact safety and mission assurance.
- Third, it is important to establish technical baselines and schedules that are mutually consistent, realistic, and achievable—supported by adequate and stable resources.

- And, we have continuously maintained that while NASA should never lose sight of the fundamentals in risk management for successful program execution, there is no one approach that dictates success, and there should be an openness to learning and accepting alternative means to understanding and controlling margins.

The space sector, both domestically and internationally, is rapidly transforming. More nations are engaged in space activities than at any point in history, and private industry is recognizing the economic value of the space domain. Sixty years of NASA's efforts and U.S. government investments have been instrumental in the establishment of the foundational knowledge leveraged by the world. As NASA looks to the future and moves to expand human knowledge and operational capabilities beyond LEO, it must recognize and adapt to the new environment and decide strategically how to forge humanity's path outward while managing the risks in an appropriate manner. We encourage the Agency, in partnership with the Congress, to hold fast to the foundational standards of risk management while embracing new approaches and not fear alternative methodologies to achieving those fundamentals.

Thank you. I look forward to your questions.