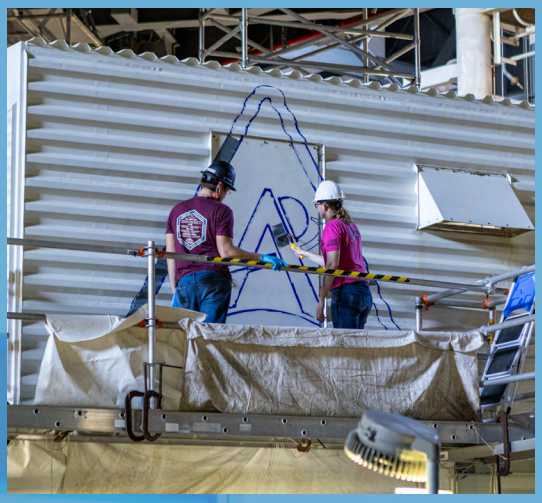
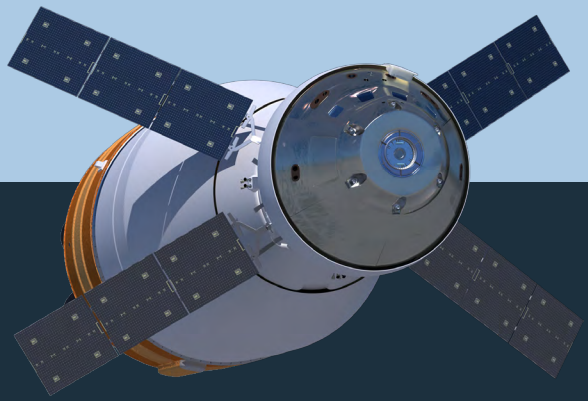
National Aeronautics and Space Administration



Aerospace Safety Advisory Panel

Annual Report 2025



NASA Aerospace Safety Advisory Panel

National Aeronautics and Space Administration
Washington, DC 20546

February 15, 2026

The Honorable Jared Isaacman
Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Mr. Isaacman,

Pursuant to Section 106(b) of the National Aeronautics and Space Administration Authorization Act 2005 (P.L. 109-155), the Aerospace Safety Advisory Panel (ASAP) is pleased to submit the ASAP Annual Report for 2025 to the U.S. Congress and to the Administrator of the National Aeronautics and Space Administration (NASA). The Report is based on the Panel's 2025 fact-finding and quarterly public meetings; direct observations of NASA operations and decision-making; discussions with NASA management, employees, and contractors; and the Panel members' past experiences.

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The Panel continues to characterize the International Space Station (ISS) as now entering the riskiest period of its operational life. The Panel's forward-looking focus on the transition of the ISS to commercial destinations and its safe deorbit in 2030 reflects the scale and complexity of decisions that must be made well in advance of deorbit execution. Finally, the Panel's recommendations repeatedly call for foresight, institutional discipline, and sustained investment to ensure that near-term pressures do not erode the foundations of safe and effective space exploration.

The Panel commends NASA for its impressive efforts in 2025 to strategically enhance the Agency's risk management posture despite turbulence in the Agency's organizational environment. We once again and very sincerely thank NASA's leaders and workforce for their passionate dedication to space exploration and their unwavering commitment to the safe pursuit of the Nation's lofty aims to the great benefit of the future of humankind.

I submit the ASAP Annual Report for 2025 with respect and appreciation.

Sincerely,

Lieutenant General Susan J. Helms, USAF (Ret.)
Chair, Aerospace Safety Advisory Panel

Enclosure

NASA Aerospace Safety Advisory Panel

National Aeronautics and Space Administration
Washington, DC 20546

February 15, 2026

The Honorable JD Vance
President of the Senate
Washington, DC 20510

Dear Mr. Vice President,

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Lieutenant General Susan J. Helms, USAF (Ret.)
Chair, Aerospace Safety Advisory Panel

Enclosure

NASA Aerospace Safety Advisory Panel

National Aeronautics and Space Administration
Washington, DC 20546

February 15, 2026

The Honorable Mike Johnson
Speaker
United States House of Representatives
Washington, DC 20515

Dear Mr. Speaker,

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Chair, Aerospace Safety Advisory Panel

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NASA Aerospace Safety Advisory Panel

National Aeronautics and Space Administration
Washington, DC 20546

February 15, 2026

The Honorable Ted Cruz
Chairman
Committee on Commerce, Science and Transportation
United States Senate
Washington, DC 20510

Dear Mr. Cruz,

Pursuant to Section 106(b) of the National Aeronautics and Space Administration Authorization Act 2005 (P.L. 109-155), the Aerospace Safety Advisory Panel (ASAP) is pleased to submit the ASAP Annual Report for 2025 to the U.S. Congress and to the Administrator of the National Aeronautics and Space Administration (NASA). The Report is based on the Panel's 2025 fact-finding and quarterly public meetings; direct observations of NASA operations and decision-making; discussions with NASA management, employees, and contractors; and the Panel members' past experiences.

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Lieutenant General Susan J. Helms, USAF (Ret.)
Chair, Aerospace Safety Advisory Panel

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NASA Aerospace Safety Advisory Panel

National Aeronautics and Space Administration
Washington, DC 20546

February 15, 2026

The Honorable Maria Cantwell
Ranking Member
Committee on Commerce, Science and Transportation
United States Senate
Washington, DC 20510

Dear Ms. Cantwell,

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Lieutenant General Susan J. Helms, USAF (Ret.)
Chair, Aerospace Safety Advisory Panel

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NASA Aerospace Safety Advisory Panel

National Aeronautics and Space Administration
Washington, DC 20546

February 15, 2026

The Honorable Brian Babin
Chairman
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Babin,

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Chair, Aerospace Safety Advisory Panel

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NASA Aerospace Safety Advisory Panel

National Aeronautics and Space Administration
Washington, DC 20546

February 15, 2026

The Honorable Zoe Lofgren
Ranking Member
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Lofgren,

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Lieutenant General Susan J. Helms, USAF (Ret.)
Chair, Aerospace Safety Advisory Panel

Enclosure

Front Cover *(left to right)*

1. *Technicians conduct blanket closeout work on NASA's IMAP (Interstellar Mapping and Acceleration Probe) observatory at the Astrotech Space Operations Facility near NASA's Kennedy Space Center in Florida on Friday, August 15, 2025. Credit: NASA/Kim Shiflett*

2. *NASA astronauts Mike Fincke (left) and Zena Cardman (right), the pilot and commander of NASA's SpaceX Crew-11 mission to the International Space Station, are pictured during a training session at Launch Complex 39A at NASA's Kennedy Space Center in Florida. Credit: SpaceX*

3. *Technicians lift NASA's IMAP (Interstellar Mapping and Acceleration Probe) spacecraft onto a work stand inside the high bay at the Astrotech Space Operations Facility near the agency's Kennedy Space Center in Florida on Thursday, May 29, 2025.*

4. *Technicians at the Astrotech Space Operations Facility near NASA's Kennedy Space Center in Florida install the two-panel solar array on Thursday, July 17, 2025.*

5. *From left, Sean McCrary and Katie Mortensen, mechanical engineering technicians, paint NASA's Artemis logo on the White Room connected to the crew access arm and mobile launcher inside the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida on Thursday, December 4, 2025.*

6. *Technicians with NASA's Exploration Ground Systems team use a crane to lift NASA's Orion spacecraft off a KAMAG transporter to prepare for integration on top of the SLS (Space Launch System) rocket in High Bay 3 of the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida on Friday, October 17, 2025, for the agency's Artemis II mission.*

7. *Seen here is an image of the SLS Exploration Upper Stage with the Orion Space craft on its way to a deep space mission.*

Back Cover *(left to right)*

8. *The Space Launch System (SLS) rocket and Orion Spacecraft roll out of the Vehicle Assembly Building (VAB) to Launch Pad 39B at NASA's Kennedy Space Center in Florida for the first time on March 17, 2022.*

9. *A crane returns NASA's Artemis II Orion spacecraft to the Final Assembly and System Testing (FAST) cell inside the Neil A.*

10. *NASA's KAMAG transporter carries the agency's Artemis II Orion spacecraft from the Neil A. Armstrong Operations and Checkout Building to the Multi-Function Facility at Kennedy Space Center in Florida on Saturday, May 3, 2025.*

Front and Back Cover

11. *This image captures a group of people, employees and officials from NASA and Boeing, involved in the Flight Readiness Review of the Boeing Crew Flight Test (CFT) mission on May 6, 2024.*

Contents

I. Preface

Congress established the Aerospace Safety Advisory Panel (ASAP or Panel) in 1968 to provide advice and make recommendations to the National Aeronautics and Space Administration (NASA) Administrator and Congress on safety matters. The Panel holds quarterly fact-finding and public meetings and visits to NASA Field Centers and other related sites. It reviews safety studies, operation plans, and management activities, and advises the NASA Administrator and Congress on risks and hazards related to proposed or existing facilities and operations, safety standards and reporting, safety and mission assurance aspects of ongoing and proposed programs, and managerial and organizational culture issues related to safety. Although the Panel may perform other duties and tasks as requested by either the NASA Administrator or Congress, the ASAP members normally do not engage in specialized studies or detailed technical analyses.

The issues, concerns, and recommendations articulated in this report are based on fact-finding and quarterly public meetings; insight visits and meetings; direct observations of NASA operations and decision-making; and discussions with NASA management, employees, and contractors during 2025. Though the particular issues on which the ASAP focuses and the findings it reports often address specific technical concerns, the ASAP also surveils organizational culture, governance, program formulation, and resources as they affect safety and the Agency's management of risk more generally. Ultimately, the Panel may offer recommendations as formal advice to the Agency and Congress.

The report synthesizes observations and deliberations arising from its work over the year. For reference, the full text of the recommendations submitted to the Administrator during 2025 are included as Appendix A, along with the Panel's open recommendations from prior years.

II. Introduction

The ASAP's charter directs the Panel to evaluate safety performance and provide advice about risk management and culture related to safety. NASA, by its very nature as a space agency, exists in an environment pervaded by risk—the dynamism of emerging commercial space endeavors, the aging International Space Station (ISS) and its future replacement systems, and the ambitious Artemis program are a few striking sources of substantial programmatic and technical risk. Risk is also generated by strategic decisions, operational requirements, acquisitions approaches, resource allocations, the actions and incentives of commercial and international partners, and a multitude of other dimensions of NASA's mandate, responsibilities, and daily work. Identifying and assessing these risks, recognizing how they interact, understanding how they affect safety, and managing them systematically, deliberately, and exhaustively is no small challenge.

While we scrutinize policies, procedures, and programs specifically related to risk assessment and decision-making—and NASA has some very excellent programs—much of the Panel's attention to the cultural dimensions of safety is embedded throughout our fact-finding engagements with pivotal leaders and prominent stakeholders such as the Astronaut Office. When the Panel refers to culture, we mean the modeled and expected behaviors of both leaders and team members at all levels in and outside the Agency. In every interaction with NASA, regardless of topic, we routinely ask how NASA discusses, assesses, and reconciles

matters related to risk. And, in fact, the Agency's leaders naturally volunteer their perspective on risk and safety culture as widely held "top-of-mind" concerns. Often, knowledgeable managers offer new avenues of inquiry about risk and safety. Consequently, over the past year, candid conversations with many key leaders have allowed the Panel to acquire and maintain awareness of salient safety issues and to assess the organizational cultural context of those conversations.

With a new NASA Administrator at the helm, we reiterate our contention—noted in our *2024 Annual Report*—that the Agency's ability to effectively manage complex and deeply interdependent safety risks within its aerospace portfolio heavily depends on several factors, most especially:

- The strength of its governance processes to evaluate and mitigate risk and direct the necessary strategic resource decisions,
- The vital guidance necessary to build and retain a viable workforce with the knowledge and skills to meet future challenges,
- An effective, unambiguous organizational and procedural construct able to manage highly complex spaceflight campaigns of extraordinary risk, and
- An integrated and balanced acquisition and development strategy that ensures the Agency retains the necessary controls over safety-related development and operational decisions, risk management, and mission assurance.

Grounded in this awareness, this year's report reflects the Panel's focus on the strategic dimensions of NASA's risk management and safety culture in today's environment of space commercialization. Four years ago, recognizing that NASA was poised at a strategic inflection point, our *2021 Annual Report* highlighted the need for the Agency to evaluate its approach to safety and technical risk and to evolve its role, responsibilities, and relationships with private sector providers and international partners to align with new realities. Even as the roles of commercial providers and international partners in human spaceflight architectures and operations expand, future exploration is, by law and national policy, a NASA mission. Thus, the Agency will remain accountable for safety, mission assurance, and integrated risk management. Today's complex relationships, evolving business processes, and workforce dynamics within and beyond NASA have profound risk implications and strain assessment and management systems, making vigilance about safety even more crucial.

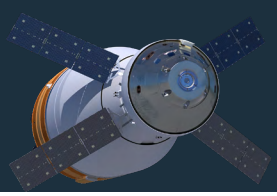
Of particular concern are the risks surrounding the development, integration, and execution of the Artemis campaign, and this year, the ASAP has formally recommended that NASA rebaseline and redistribute the level of risk associated with the Artemis III and follow-on missions. NASA's mandate for deep space exploration to Mars and beyond is supremely challenging and fraught with uncertainty. A critical steppingstone in the development of human interplanetary travel capabilities and space hardware—and ultimately safe operations and overall mission success—is the safe return to the Moon. The Moon offers both the opportunity to gain experience operating on a planetary surface and a nearby test bed with an extreme environment akin to Mars. Yet, as the Panel has said in prior reports, NASA will face myriad daunting challenges, including budgetary, industrial, geopolitical, technical, and health and medical constraints as it both executes the Artemis campaign

and maintains the Nation's presence in Low-Earth Orbit (LEO) throughout the coming decade. Our fact-finding this year has driven the ASAP to the conclusion that the Artemis III mission, as baselined, cannot be accomplished with appropriate margins of safety. Nor is the Panel convinced an integrated risk management strategy to govern the complexities of the Artemis architecture is in place.

In 2025, in our quest to better understand NASA's practical adaptation to the new space economy, the Panel also engaged in detailed fact-finding about how NASA has used commercial contracts as a tool to garner financial efficiencies, increase mission agility and resilience, and improve safety for human spaceflight. Our discoveries led us to conclude that NASA has considerable room for improving its current acquisition and contracting approaches and procedures. While the Commercial Resupply Services contract can be considered successful in many respects, the Commercial Crew Program (CCP)'s experience with the Commercial Crew contract revealed that, among other issues, NASA's own responsibilities and accountability for risk management of a human spaceflight system in development was at times at odds with the "services contract" mentality and culture attendant to the contracting strategy. In the case of the CCP Starliner program, the vehicle may have met the requirements of the contract but ultimately did not fully fulfill NASA's own risk management responsibilities with the necessary performance and technical data, especially for crisis situations such as the Loss of Control during the docking phase. As a result, this Panel has made a new, forward-looking formal recommendation to NASA regarding the need for broad realignment of how the Agency engages the space economy to support NASA's risk and safety requirements.

The Starliner Crew Flight Test (CFT) mission concluded in 2024, but its consequences and extensive post-flight analysis continued throughout 2025. The Agency sought to understand the technical anomalies that rendered the Starliner too risky to use as a return vehicle and worked to clarify organizational dynamics that clouded the authorities between the Agency and the contractor. In particular, the Panel is greatly troubled by the lack of organizational clarity about the state of the crew's safety during the Starliner docking event, revealed through our engagement with leaders, the crew, and other key personnel. Therefore, we have presented in this year's report a formal recommendation that NASA strengthen the requirement to declare and communicate mishaps or close calls for human spaceflight missions involving NASA personnel.

In summary, this report presents our assessment of NASA's progress in 2025 and readiness to execute its mission and complex set of programs in 2026. We begin at the strategic level, with a discussion of key issues related to governance. We then present our assessment of the Artemis program and the CCP, with a focus on the recent Starliner CFT mission, as well as our growing concerns about the ISS. We present our view of NASA's plans for a viable, persistent presence in LEO after the decommissioning of the ISS. Finally, we offer the Panel's perspective on solutions Congress can influence and risks it can mitigate.



III. Strategic Vision and Governance

Over the past four years, the ASAP has consistently reiterated its advice that NASA establish an Agency vision and strategy rooted in safety to guide Agency priorities, planning, and mission execution. This strategy should be implemented deliberately and intentionally by NASA's senior leaders—Center Directors and other key officials—functioning together as a "board of directors" that advances the Agency's mission holistically rather than parochially prioritizing the agendas of individual offices, programs, or Centers. Such a construct is urgent in an environment fraught with uncertainty and resource constraints that otherwise incentivize leaders to protect their workforces and capital resources instead of making investment and divestment choices that support overall Agency needs and priorities. The Panel formalized this advice in recommendations 2021-05-01 and 2021-05-02, to facilitate NASA's organizational transformation and alignment with national priorities, the evolving capabilities of the present-day space private sector, and global geopolitical realities. The intent of these recommendations was to prompt NASA to pursue the Agency's strategic goals through a coherent set of actionable plans, for which leaders at Headquarters and across all Centers would be held responsible and accountable for execution.

Recommendation 2021-05-01: NASA should develop a strategic vision for the future of space exploration and operations that encompasses at least the next 20 years, including potential alternative scenarios, that is driven by how the Agency is going to understand and manage risk in the more complex environment in which it will be operating.

- The vision should describe the role that NASA intends to play during that period and how it plans to engage with both commercial and international partners.
- NASA should assess the workforce, including the number, types, skills, experience, and responsibilities that will be required, and the infrastructure facility requirements, with a plan for managing changes needed to meet those requirements.
- NASA should also propose general criteria for evaluating "make, manage, or buy" decisions on future programs or projects.
- All aspects of the strategic vision and its implementation should be clearly and unambiguously communicated throughout the Agency.

Recommendation 2021-05-02: As a part of an overall risk management approach and in order to develop and execute its strategic vision for the future of space exploration, NASA should establish and provide leadership through a "board of directors" that includes the Center Directors and other key officials, with the emphasis on providing benefit to the Agency's mission as a cohesive whole, and not to the individual components of the Agency. The Board should act to identify the strategic risks and obstacles that NASA may encounter in executing its mission, evaluate Agency-level mitigation approaches, and align the efforts of all Centers to ensure desired outcomes.

Throughout 2024, NASA worked to drive real change through "NASA 2040," its strategic initiative launched in June 2023, to realize a long-term vision for the Agency's future to "be the preeminent agency for research, engineering, and technology to lead science, aeronautics, and space exploration for humanity." NASA 2040 focused centrally on institutional capability alignment, addressing key questions such as how NASA should shape its workforce and infrastructure, how to strengthen safety and risk management to include application of technical authority, and how to use acquisition and contracting tools in support of "make, manage, or buy" decisions for safe and effective execution of future programs and projects. NASA 2040 had been described as "an [A]gency strategic initiative that accelerates and aligns planning for the necessary workforce, infrastructure and technology capabilities necessary to meet the bold mission requirements of tomorrow." As the ASAP described in last year's Annual Report, NASA made notable progress towards transformational goals and actions in 2024 with a focus on nine organizational functional workstreams—Mission, Structure, Front Door, Technology, People, Process, Infrastructure, Budget, and Independent Research and Development.

At the end of 2024, each NASA 2040 workstream team delivered a detailed implementation plan to accomplish NASA 2040's goals, and then NASA discontinued the individual teams. As Figure 1 shows, these plans were delivered under formal decision memoranda to the appropriate organizations for implementation, beginning this calendar year. Although the implementation plans were detailed, appeared impactful, and potentially transformational, it is unclear to the Panel how much of these plans were operationalized in 2025.

Workstream Deliverables Handoff to Implementing Organizations

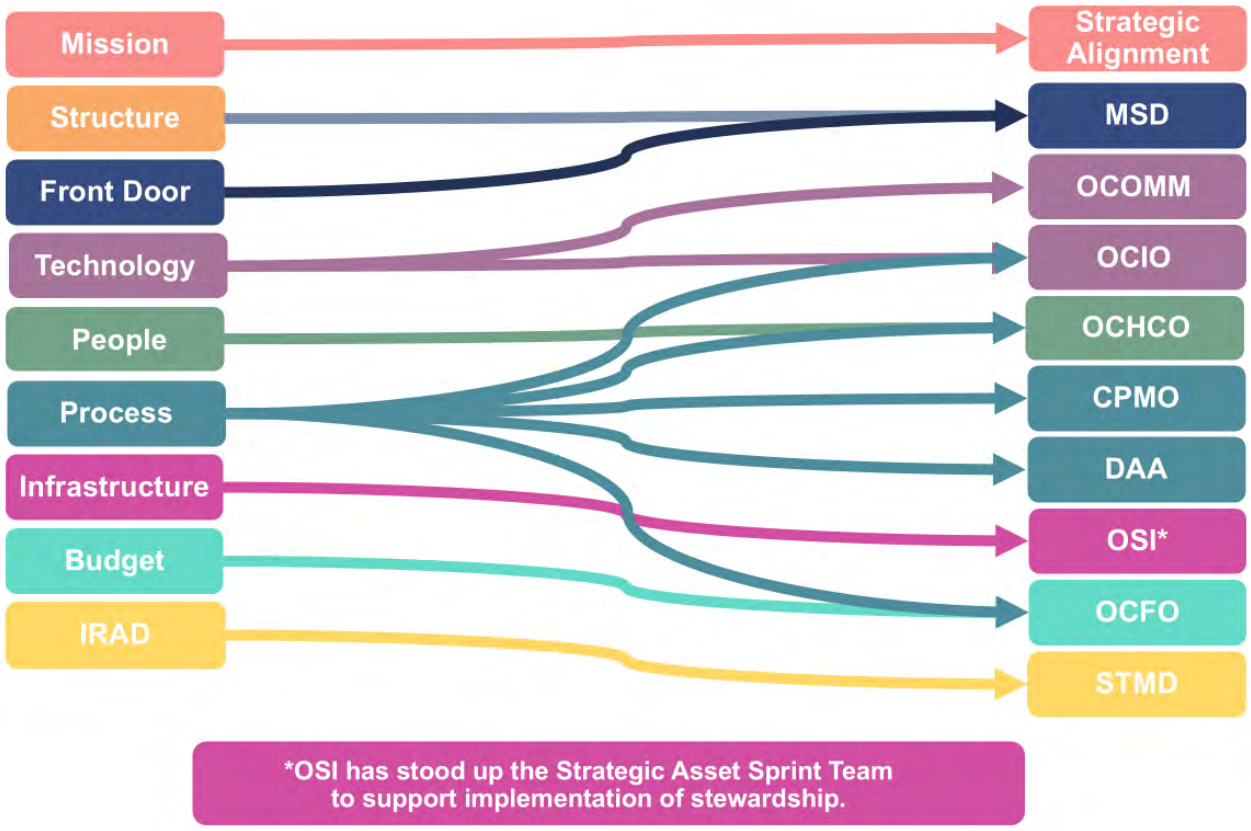


Figure 1. Workstream Deliverables Handoff to Implementing Organizations.

It is worth noting that the body of work from the NASA 2040 initiative provided valuable preparation for the new administration's Department of Government Efficiency initiatives as the Agency was able to rely on current data and recently formulated plans. Even so, the pressures of rapid, unplanned, and unsystematic changes in 2025 (such as incentivized retirements, hiring freezes, reorganizations, and lab closures) raise concerns about the potential for safety and risk management gaps at NASA. In 2026, the Panel intends to examine the state of NASA, guided by these questions:

- Are the strategy and vision NASA has communicated over the past three years still relevant?
- Does NASA have a leadership model and structure to ensure strategic initiatives can be implemented consistently, deliberately, and persistently across its Headquarters and the Centers with limited and declining budgets and resources?
- With the myriad of unprecedented changes during 2025, what safety and technical gaps have been exposed, particularly regarding leadership, engineering expertise, and technical authority?

- With a clear and immediate shift to the commercial space sector, and the Agency's past experience with service contracts, do NASA acquisition and contracting offices clearly understand how to structure and execute "make, manage, buy" efforts to the benefit of risk and safety management?

In sum, the Panel's 2021 recommendations aimed to help NASA better align its strategies and their implementation with emergent space industry and technological changes, particularly through the lens of risk management. Since then, NASA addressed these recommendations through the NASA 2040 initiative, though significant progress in workforce, infrastructure, budgeting, and contracting reform has been gradual. In 2025, transformation accelerated but appeared disorderly and lacked clear results, raising Panel concerns about potential safety and risk issues, particularly in three important areas: 1) contracting approach and discipline, 2) human capital, and 3) technical authority capacity and capability. The following sections provide a more detailed discussion of these.

A. Make, Manage, Buy: NASA's Approach to Commercial Contracts

Four years ago, the ASAP advised NASA to reassess and better define its approach to capability planning and acquisition decisions given its development and procurement trajectory and the active and robust space industrial base. Specifically, the Panel recommended that NASA "propose general criteria for evaluating 'make, manage, or buy' decisions on future programs or projects" and also outline "how it plans to engage with both commercial and international partners" (ASAP Recommendation 2021-05-01). This recommendation sought to prompt NASA to review and harmonize future contracting actions—including clauses and structures—with the government-provider relationships, roles, and responsibilities necessary for effective execution of the agency's mission in its modern context. As the Panel said then:

> ***"The rapid changes occurring in space technology, investment, and operations—and the growth of a commercial sector interested in pursuits beyond those driven by government requirements—define an inflection point for the space sector. In the past, space activity was primarily sourced directly by government-defined missions. In the future, the government will be only one of many customers, and industry will develop and bring to bear an increasingly broad and technologically sophisticated set of capabilities."***
>
> *2021 ASAP Annual Report*

Since 2021, the ASAP has observed NASA's efforts to exploit important opportunities but also its struggle with contracting discipline and management of its commercial providers. In general, the use of commercial contract structures has directly influenced NASA and industry behavior, shaping investment choices, verification posture, transparency, and, at times, confusing accountability for safety and risk acceptance.

The consequences and implications of NASA's choices about how to organize for "commercialization" are driven by the characteristics of the various industry "models" that support NASA's work. Annex A describes these models and their attributes, impacts, advantages, and disadvantages. It is intended as a reference and context for the discussion that follows. Understanding these models helps illuminate the challenges NASA has faced and can inform advisable approaches to acquisition going forward.

NASA's transition from traditional government-directed development to commercially oriented partnership models has enabled new prospects for innovation, but simultaneously exposed structural weaknesses across acquisition strategy, safety assurance, organizational culture, risk management, and overall program execution. These challenges are apparent in the CCP, the Agency's initiative to use private companies for ISS crew transport with Boeing's Starliner and SpaceX's Dragon as the main vehicles, and Human Landing System (HLS), where the Agency has contracted with SpaceX for the initial system (Starship) and is pursuing multiple human landing system providers. For CCP and HLS alike, an added complication has been the Agency's application of "service" contracts and their associated clauses applied to development end-items. As an example, CCP's original acquisition strategy envisioned a two-phase contract award, but this approach was revised because NASA did not receive sufficient appropriations. Instead, CCP continued using Space Act Agreements to maintain competition among multiple providers. As a result, NASA had less opportunity to influence provider designs than it would have under the originally planned contract structure. The early application of Firm Fixed Price (FFP) contracts to developmental human-rated systems also misaligned expectations, confused roles and responsibilities between the Agency and providers, and eroded NASA's ability to maintain adequate technical oversight.

Based on Panel interviews, NASA appears to have placed significant confidence in both contractors to execute under this contract structure for different reasons: SpaceX due to its successes as a contractor for the Commercial Resupply Contract and Boeing due to its long-standing record of success as a prime contractor for human spacecraft and services. Regardless, NASA's decision to apply a commercial contract approach to its program management structure directly affected CCP's engineering staffing, quality assurance expectations, and internal insight mechanisms. Examination of the Starliner development program reveals the effects of misalignment between NASA's expectations and industry incentives and culture. This case analysis is offered here to illuminate the challenges NASA has faced and the contract-driven reasons for them.

Boeing Starliner: The Impact of Contract Structure

Boeing operates Starliner under NASA's Commercial Crew Transportation Capability (CCtCap) contract, originally awarded in 2014 as an FFP contract for the design, development, testing, and certification of integrated Crew Transportation Systems for ISS crew transport. The CCtCap contract type was directed by the FY2011 Presidential Budget Request (PBR) after the cancellation of the Constellation Program. Specifically, the PBR stated "The Commercial Crew Program will provide $6 billion over the next five

years to support the development of commercial crew transportation providers to whom NASA could competitively award a crew transportation services contract analogous to the Cargo Resupply Services contract for ISS." This direction had important impacts on the decisions NASA and its provider subsequently made and actions they took both during vehicle development and before and during the CFT mission, a mission that garnered significant national attention in the summer 2024 when in-flight propulsion issues ultimately resulted in a decision to return the spacecraft uncrewed and bring the crew home on a SpaceX Dragon over nine months later. As the Panel learned through post-flight interviews, the directed approach hindered NASA from vigorously asserting its unique responsibility and accountability for managing risk and ensuring crew safety as development of the spacecraft design progressed. Instead, NASA adopted a "shared assurance" stance that shifted its adjudication of safety and risk.

The effects of contract structure are evident in the verification and validation process. As one example, following the Mission Elapsed Timer anomaly on Orbital Flight Test 1 (OFT-1), neither NASA nor Boeing produced a formal, public lessons-learned package, even though NASA Policy Directive 7120.4E requires agencies to collect and institutionalize such knowledge. US Government Accountability Office (GAO 02-195 and GAO 01-1015R) and NASA OIG IG-25-009 both observed this omission, assessing that the absence of structured learning contributed to repeated verification and software integration gaps. In fact, Boeing lacked a fully integrated "iron bird" system-level testbed for prototyping and integration early in the program, a deficiency that contributed to the OFT-1 software timing anomaly that was not identified by NASA's oversight teams until late. According to Panel interviews, NASA had mistakenly interpreted the Avionics Software Integration Lab as a completely integrated systems environment—revealing a fundamental misunderstanding of contractor test infrastructure versus actual engineering maturity. Looking forward, when leveraging commercial contract approaches, NASA should position itself to retain the authorities for contractual checks and balances appropriate for a crewed developmental NASA spacecraft.

It also appears to the ASAP that NASA adopted an overly supportive orientation toward Boeing. That is, NASA tends to view its contractors as "partners" and is thus less skeptical and less intrusive in its risk management. For example, NASA relied on contractor systems as a substitute for Government inspection and testing even though no comparable commercial human spaceflight product or market existed at the time of direction to justify that approach. This observation is consistent with interviews in which the crew noted hesitancy to report concerns that might appear unsupportive of

contractor "partners"—a worrisome indicator of a suppressed safety culture reminiscent of the dynamic identified after the loss of Space Shuttle Challenger.

At the same time, Centers Johnson, Kennedy, and Marshall often applied insight provisions differently, leading Boeing to describe the experience to the panel as "working with three different companies." This speaks to a more general concern that oversight approaches are inconsistent across NASA Centers, a fragmentation documented in NASA Office of Inspector General (OIG) 2024 Top Management and Performance Challenges, the ASAP 2023 Annual Report, and Starliner CFT crew debriefs from 2025.

Ahead of and during the CFT flight, organizational and cultural issues inside NASA further exacerbated these risks. CFT contingency planning was colored by lack of clarity about who possessed final authority for crew return decisions. While NASA ostensibly retained ultimate responsibility, internal debates and reputational sensitivities delayed decisive action. It appears the option for the crew to remain on the ISS was considered "real," but had not been rehearsed nor procedurally preauthorized—revealing gaps in the risk-acceptance framework. Likewise, anomalies such as helium leaks and reaction control thruster malfunctions were treated primarily as "engineering findings." The Agency's failure to declare a mishap or a high-visibility close call—despite repeated anomalies and a loss of control in at least one axis in close proximity to ISS—contradicted the intent of NASA Procedural Requirements (NPR) 8621.1D, weakened the institutional learning process, and represents a diffusion of safety accountability (a finding consistent with NASA OIG Top Management and Performance Challenges 2023–2025). Ultimately, the Agency did make the sound decision to return the crew on a Dragon, underscoring both the level of risk that remained unquantifiable and the value of the independent role of the Technical Authorities in the decision process.

When a commercial service contract is used, a commerciality determination ensures that prior use reduces risk to the government, has the "bugs worked out," and that the government is buying a service "off the shelf." In the case of CCtCap, however, NASA ultimately "owns" the risk for the service (crewed flight delivery) and provides the operators of the system that provides the service. This requires NASA to have an appropriate level of oversight of system development, which is inconsistent with the very nature of a commercial service contract. The use of commercial contract structures such as limited data rights constrains NASA's technical and engineering insight into the system, increasing dependence on the vendor and complicating independent validation of contract performance. NASA OIG IG-24-001 and NASA's procurement analyses show that these types of structures effectively locked NASA into continuing Starliner purchases to maintain nominal redundancy, even amid delays and underperformance. As the *2024*

ASAP Report notes, persistent Starliner delays have forced NASA to procure additional SpaceX Dragon flights. Moreover, the negative effects of the contractual countercurrents and cultural pressures we have highlighted here have been exacerbated by significant workforce and industrial base constraints. NASA's aging technical workforce, together with recent hiring freezes and the Deferred Resignation Program, have reduced oversight expertise and capacity at precisely the moment when commercial partnerships require stronger—not weaker—government insight.

In sum, both SpaceX and Boeing had fixed price commercial service-like contracts with the same risk management imperatives and yet the oversight and outcomes were extraordinarily different. Looking forward, NASA needs to better govern its contractors with respect to effective risk and safety management through appropriate contract mechanisms and consistent application of insight and oversight.

Taken together, the pattern of contract misalignment, degraded safety rigor, fragmented oversight, workforce erosion, and budget compression illustrated by the Starliner history constitutes a systemic challenge across NASA's human spaceflight enterprise. The Starliner experience is not an isolated case but a warning signal that the Agency's organizational culture, governance structures, and technical authority frameworks have not kept pace with the Agency's rapid embrace of commercial acquisition models. As the ASAP cautioned in its 2023 report: "Innovation in acquisition must not outpace the Agency's ability to manage risk." The lessons of the Starliner experience thus far confirm that understanding industry business models and constructing appropriate contract types with clear roles and responsibilities for the Agency and the provider that are aligned to achieve safe outcomes is critical. A government contract vehicle need not be limited to a single contract type; in practice, a well-constructed contract can combine multiple pricing and incentive structures to align risk, incentives, and governance with the underlying industry model and the maturity of the work being performed. *(See Annex A for a more detailed explanation.)*

In the end, the Panel urges NASA to make measured and deliberate decisions in building Artemis-related development contracting strategies, as well as other human space programs and projects. In the case of the Artemis campaign, NASA hopefully will avoid the situation that occurred in response to the Constellation Program's cancellation, when the Agency continued open-ended development of the Space Launch System, Orion, and the Kennedy Space Center ground systems as disparate technology programs unmoored from a governing integration function. Although Artemis has recently coalesced under an overarching Moon-to-Mars program office, lingering weaknesses remain, such as the development "partnerships as services" culture, and institutional struggles to manage complex, interdependent risks in an integrated way under existing contractual arrangements.

Recommendation 2025-12-01: NASA should realign its governance of acquisition strategies for human spaceflight-related capabilities Agency-wide, such that contract structures reflect appropriate technical and human spaceflight safety oversight commensurate with NASA's risk management responsibilities. Through its contracts, NASA should establish a cogent framework for government insight and oversight that accounts for program engineering maturity; necessary development timelines; and integrated risk, resilience, and safety factors. To support contract decisions, NASA must understand how each contractor's revenue model and goals differ and how contracts, as portfolios of incentive mechanisms, should be designed to address these differences. Contracts must properly align technical risk, financial exposure, and performance accountability with both the required work and the contractor's operating model. NASA should also design and implement effective and appropriate program management structures to fulfill its own responsibilities and accountability for human spaceflight safety risk management throughout each program's life cycle regardless of contract type.

This reform—aligned with GAO-21-316, NASA OIG IG-21-018, ASAP Annual Reports 2021–2024, and NASA procedural directives NPR 7120.5F and NPR 8621.1D—would directly address the acquisition and procurement concerns across CCP, HLS, and next-generation programs by restoring disciplined contract alignment with appropriate NASA oversight, strengthening technical independence, and reestablishing transparent risk accountability. Maintaining deep awareness of the nuanced influences contract structures have on industry and Agency behavior, including investment choices, verification posture, and transparency, is extremely important as NASA continues to execute critical programs in support of the Nation's Moon to Mars (M2M) and Commercial LEO aspirations.

B. Human Capital

A substantial risk and safety concern to the Panel is the urgent need for adequate human capital embodied in a viable, capable, expert, properly configured workforce. In 2025, NASA offered Voluntary Early Retirement and other separation programs (buyouts) as part of a major workforce downsizing, prompted by proposed budget cuts in its FY26 budget. Throughout 2025, personnel departed NASA at a rate not seen in years. Not only did many leave important programs, depriving them of critical knowledge and experience, but several key leadership positions also turned over. This leaves the Panel very concerned about how NASA will effectively manage imperative programs and whether it has the necessary operational expertise to prepare for and execute the first human Artemis missions.

Figure 2 shows NASA's manpower levels over the past several decades, with a prediction that by the end of 2026, NASA will have approximately 15,000 personnel, its smallest workforce since 1960.

NASA's Workforce in a Historic Context

Civil Service Levels Capped for Much of Modern Era

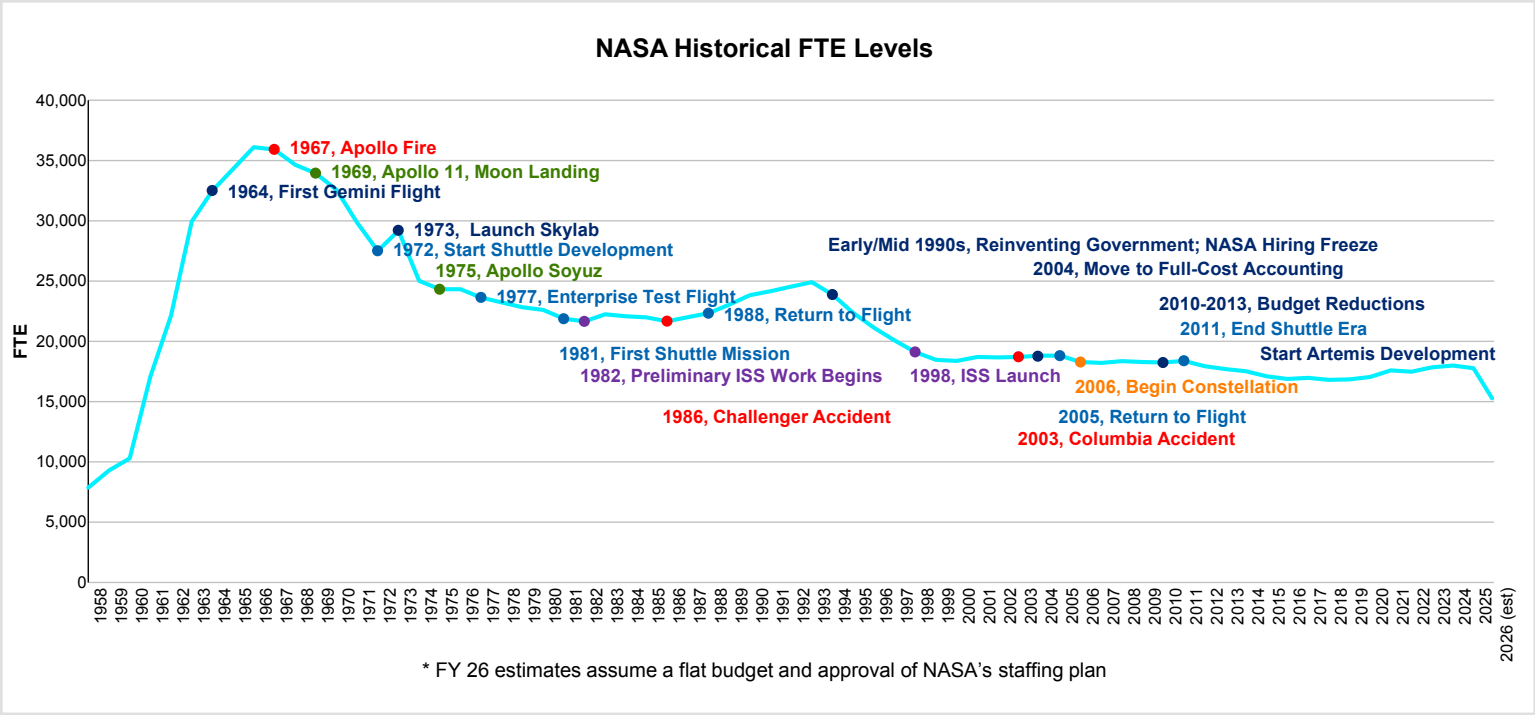


Figure 2. NASA Workforce Trends.

The fundamental questions are apparent:

- Is NASA sustaining an appropriate level of manpower to meet its mission?
- With the retirement of critical and experienced personnel, and the landscape of emerging demands, how well does NASA understand its gaps in workforce experience and capabilities?
- Do the workforce and leadership team have the appropriate knowledge and skills to best serve NASA and its responsibilities and authorities?
- Are the NASA skills and knowledge appropriately distributed to best effect across NASA's portfolio?
- What are NASA's plans to reshape the Agency workforce to meet today's and future needs?
- Is the program management leadership of NASA adequately resourced to execute program responsibilities, in whatever contractual form those programs may take?

- Does the operational, training and evaluation workforce have adequate resources, expertise, and experience to manage complex human spaceflight safety risks?

These and other workforce questions have been a Panel focus area for some time (and are inherent in our formal recommendation 2021-05-01), but the large exodus of personnel in 2025 has heightened concern about the crucial impacts of workforce on NASA risk management capacity.

C. The Role and Effectiveness of Technical Authority

Recent leadership and organizational instabilities at NASA, coupled with budget uncertainties and workforce attrition, raise questions about how NASA will effectively oversee risk and safety over the lifecycle of its programs as they progress through the stages of formulation and implementation. A principal means of assuring safety and mission success is NASA's Technical Authorities (TAs). NASA's Office of the Chief Engineer describes Technical Authority on its website as "an important part of NASA's Governance that employs checks and balances among key organizations to ensure that decisions have the benefit of different points of view and are not made in isolation." In fact, key personnel from NASA TA organizations played a critical role in the leadership decision process during the 2024 Starliner CFT mission.

The ASAP has strongly supported the principles of technical authority and consistently advocated four well-established foundational principles be vigorously operationalized:

1. **Assured independence.** Assured independence means that technical authority operates with clear decision rights and reporting lines that are insulated from cost, schedule, and performance pressures. Technical leaders must be empowered and provided adequate insight to render objective judgments, elevate concerns, and require corrective action without undue influence from program managers whose (often valid) incentives may conflict with technical rigor or whose intimate knowledge may blind them to alternatives. Moreover, without independence, technical authority risks becoming advisory rather than authoritative. When technical judgments are subordinated to programmatic pressures, risks may be accepted implicitly, standards eroded over time, and dissent suppressed. Assured independence is essential to prevent normalization of deviance and to ensure that safety, reliability, and mission success are not compromised. That said, credible and valuable technical authority rests on clear alignment with program managers with respect to mission success and on deep insight into each program's design, margins, risks, history, constraints, and performance born of sustained engagement. Consequently, a central challenge of sound technical authority implementation is how to properly balance the tension between independence and insight.
2. **Consistent application.** Consistent application requires that technical standards, processes, waiver criteria, and escalation pathways be applied systematically across all programs. Comparable technical issues should be evaluated with comparable rigor and criteria, and similar risks should receive similar treatment regardless of program visibility, funding, or leadership. Inconsistent application undermines credibility, creates perceptions of inequity, and incentivizes workarounds. It also prevents organizations from learning across programs

and recognizing systemic risks. Consistency protects institutional discipline, supports knowledge transfer, and reinforces technical standards as organizational commitments rather than negotiable preferences.

3. **Adequate resources.** This goes beyond budget—adequate resources include sufficient availability of qualified personnel, appropriate depth of experience and technical expertise, access to data and analytical tools, and financial support to conduct thorough reviews and independent assessments. Technical authority cannot function effectively as an unfunded mandate. Even well-designed authority structures fail if technical leaders lack the capacity to execute their responsibilities. Resource shortfalls can lead to superficial reviews, delayed decisions, overreliance on internal (rather than independent) analyses, and burnout of key experts. Adequate resourcing enables depth, rigor, and continuity—core requirements for credible technical oversight.
4. **Sustained leadership commitment.** Technical authority ultimately derives its effectiveness from leadership backing. Sustained leadership commitment means that senior leaders consistently reinforce the primacy of technical authority through policies, actions, and messaging—especially when technical conclusions are inconvenient or costly. This support must persist over time and through leadership transitions, not merely during periods of heightened attention, such as in the wake of an incident. When leaders fail to support technical decisions, authority erodes rapidly, and technical staff learn that raising concerns carries personal risk without the reward of a better result for the agency, and engineering talent avoids critical assignments to technical authority roles. Sustained leadership support establishes a culture where technical rigor is valued, dissent is protected, and long-term mission success outweighs short-term pressures.

Robust operationalization of technical authority is an integral element of a healthy safety culture, where these principles are embedded in the decisions and actions of Agency and program leaders and the behaviors of line engineers alike. The principles must also be formalized in the Agency's organizational structure and process. NASA has employed formal technical authority expertise, advice, and oversight for decades. The present structure was implemented in response to recommendations made by the Columbia Accident Investigation Board in 2003, which articulated formal functions and resource arrangements.

Columbia Accident Investigation Board

Recommendation R7.5-1. Establish an independent Technical Engineering Authority that is responsible for technical requirements and all waivers to them, and will build a disciplined, systematic approach to identifying, analyzing, and controlling hazards throughout the life cycle of the Shuttle System. The independent technical authority does the following as a minimum:

- Develop and maintain technical standards for all Space Shuttle Program projects and elements
- Be the sole waiver-granting authority for all technical standards
- Conduct trend and risk analysis at the sub system, system, and enterprise levels
- Own the failure mode, effects analysis and hazard reporting systems
- Conduct integrated hazard analysis
- Decide what is and is not an anomalous event
- Independently verify launch readiness
- Approve the provisions of the recertification program called for in Recommendation R9.1-1.

The Technical Engineering Authority should be funded directly from NASA Headquarters and should have no connection to or responsibility for schedule or program cost.

Recommendation R7.5-2. NASA Headquarters Office of Safety and Mission Assurance should have direct line authority over the entire Space Shuttle Program safety organization and should be independently resourced.

Essentially, NASA's TAs are responsible for technical standards and requirements, waivers to those requirements, and risk analysis. NASA's unique and comprehensive sets of technical standards embody the experience and knowledge gained through decades of spaceflight. These standards and their supporting evidence not only guide NASA programs but also form the basis for knowledge transfer commercially and internationally. Three sets of NASA standards apply to human spaceflight missions: Engineering Standards, Safety and Mission Assurance Standards, and Health and Medical Standards. As codified in NASA Policy Directive 1000.0C, NASA charges three commensurate TAs to steward these standards. The ASAP has long regarded the TAs as a cornerstone of safety from the genesis to the closeout of any technical program.

NASA is actively considering how to align its organization and resources with its missions and strategic goals, grapple with budget constraints, and manage the departure of experienced experts in its senior civil service ranks. In this context, the TAs are working to mitigate negative impacts, provide direct program support, and maintain Agency capabilities currently housed in the NASA Engineering Safety Center and the Independent Verification and Validation Center. Program managers depend on these centers to help them understand, balance, and mitigate risk. The Panel strongly advises Agency leaders to provide clear strategic guidance to the TAs about their role and set expectations about how they function in alignment with programs to solve problems.

The Panel notes that the independence of the three TAs, their direct accountability to the highest levels of NASA leadership, and their unrestrained ability to offer program managers candid observations, perspective, and assessments are what allow them to be effective. The Panel plans to make the functionality of the TAs a salient focus in 2026.

IV. Moon to Mars Management

In recent years, NASA has introduced several key initiatives as part of its Artemis campaign to boost safety, strengthen risk management, and enhance accountability. One of these actions was creating a single office to oversee and carry out the program. This office developed a long-term plan and established top-level requirements for the Artemis missions, while also advancing risk management to assess both individual subsystem risks and the combined risks of each mission. As highlighted in last year's ASAP report, the Panel commended these efforts as essential for ensuring the program's ongoing safety and success.

A. Artemis II

Artemis II, planned as the first crewed test flight of the Space Launch System (SLS) and the Orion spacecraft, is slated for launch in early spring 2026. This flight is a critical next step toward landing on the Moon. The Artemis II flight test follows the November 2022 uncrewed Artemis I test to demonstrate a range of capabilities needed on deep space missions. On this first flight with a full environmental control and life support system, Artemis II will also be the first to carry a crew, sending Reid Wiseman, Victor Glover, Christina Koch, and Canadian astronaut Jeremy Hansen around the Moon as the first NASA people to leave LEO since 1972.

Throughout 2025, the Agency continued progress towards flight readiness. Safety and technical risks have been identified and, as appropriate, effectively addressed. NASA has also moved out on deorbit trajectory constraints designed to control the heatshield heat rate and minimize the spalling that was observed on Artemis I. The year closed with the SLS and Orion stacked, undergoing final tests, and approaching roll out to Launch Pad 39B as this report is written. Program elements have assessed flight readiness and are preparing for an integrated Moon-to-Mars review in January leading to a final Agency-level flight readiness review before launch. In parallel, crew and flight control team training is near completion, and the Artemis Mission Management Team (AMMT) has participated in a series of simulations to exercise executive decision-making during the mission.

Although flight system, crew, and Mission Control readiness receive considerable attention, the ASAP encourages NASA to take similarly deliberate steps to ensure the AMMT is fully prepared to adjudicate the complex technical issues that so often comprise human spaceflight. While important for any mission, AMMT readiness is a notable concern due to a number of factors, including the multi-year delay since the last Artemis mission, the operational complexity of the first crewed lunar mission in decades, and considerable recent turnover in the leadership ranks. The Panel therefore encourages the Agency to include AMMT readiness as a special topic during the flight readiness review.

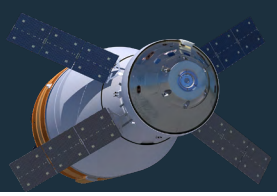
B. Artemis III

Beyond the Artemis II mission, great uncertainty relative to risk, schedule, configuration, and technical architecture remains. In last year's Annual Report, the Panel noted concerns about the ambitious timeline for development of systems critical to Artemis III—the HLS and the Exploration Extravehicular Mobility Unit (xEMU) in particular, which face considerable requirements for concept demonstrations and testing in order to deliver their systems within the Artemis III flight test schedule. Over the past year, programmatic and technical risks with these systems have continued to emerge and affect the overall Artemis III schedule and risk management. This is especially evident with the HLS, given its intricate operational design, complex concept of operations, and challenges during their ongoing flight test program. Taken together, these difficulties cast doubt on the current Artemis III timeline and the feasibility of the Artemis III mission goals.

Artemis III also continues to face several significant risks at the mission level, as the Panel has documented and discussed since its 2023 report, noting that the numerous and unprecedented mission objectives—many being attempted for the first time within a single flight—result in a compounded level of technical and safety risk. Landing at the South Pole remains the most prominent challenge. Figure 3, which we presented in last year's report, highlights other important hurdles, including executing a complex operational concept, confirming vehicle safety for crewed flights, delivering fuel to orbit, managing cryogenic refueling and long-term storage in space, mating the HLS and Orion vehicles, and ensuring the HLS can successfully descend to and ascend from the lunar surface. Each of these individual mission objectives poses significant challenges, and their combined complexity and interdependence introduces substantial technical and safety risks to the mission as a whole. At present, the Panel has not observed a comprehensive plan to address these objectives or to fully mitigate the related risks.

Figure 3. First-time Milestones for the Artemis III Mission.

In addition, early in 2025, the new administration and NASA leaders questioned the future of the SLS rocket, an essential part of the Artemis program. No clear solution or replacement was identified, however. Also in the past year, NASA has stated that significant changes to the architecture and configuration for Artemis IV and missions beyond will be made. Given these ongoing challenges, uncertainties, and unresolved risks, the ASAP strongly advises NASA to restructure the Artemis Program to create a more balanced risk posture for Artemis III and future missions. Formally, given the demanding mission goals for Artemis III and the ongoing issues with several key systems, along with configuration unknowns after Artemis III, the ASAP recommends reassessing the flight test plans and objectives for Artemis III and future missions.



Recommendation 2025-05-02: The Panel recommends that NASA reexamine the mission objectives, and potentially the system architecture, for Artemis III and subsequent missions to establish a more balanced approach to risk, prioritize objectives-driven planning, and maintain a consistent cadence of flight missions. For each test objective, NASA should develop detailed plans for testing and data collection—incorporating both ground-based and flight testing—to ensure that all risks are thoroughly identified and mitigated. This structured approach will provide a more balanced sequence of flight tests, ultimately supporting a successful crewed lunar landing, the creation of a sustainable lunar base, and the progression toward a future crewed mission to Mars.

As planned today, the Panel deems Artemis III a high risk, and rebalancing objectives is thus essential to the safe achievement of the national objective—returning the United States to the moon. The Panel considers it urgent for NASA to act on this recommendation to maintain progress on the M2M Program. As NASA works to revise mission flight plans, objectives, and sequences, the Panel advises the Agency to consider:

1. Developing a sequence of missions and objectives that appropriately balance risk considerations with safety requirements by adopting an integrated approach—similar to the approach NASA took to the Apollo Program—that combines ground-based and flight test objectives into one unified plan. This will provide a thorough understanding of risks throughout the mission flight sequence leading to a successful lunar landing, the creation of a sustainable lunar base, and the progression toward a future crewed mission to Mars.
2. Using a Design Reference Mission accompanied by a System Architecture to drive systematic processes and procedures to enhance architectural integrity and strengthen risk management. These frameworks can serve to define the concept of operations and facilitate the identification of operational and technical risks.
3. Involving an independent Industry Prime Integrator to help lead the Program and ensure a robust, disciplined program management and systems engineering team capable of handling key integration tasks. This need is especially critical now due to recent reductions in NASA's workforce.
4. Develop an integrated acquisition strategy and contract framework for the Artemis Program to align programmatic, technical, integration, safety, and mission risks, ensuring these elements are effectively connected and comprehensively understood.
5. Launch cadence is a critical factor that must be addressed when establishing mission goals and objectives. Maintaining a regular launch schedule fosters the development of a skilled workforce adept at managing complex launch procedures. Furthermore, it enables operational teams to concentrate on preparation, readiness, process optimization, and risk mitigation on a more predictable timeline.

C. Human Landing System Development: Starship

The HLS is the mode of transportation that will take astronauts to the Moon as part of the Artemis program. The program is managed at the Marshall Space Flight Center. In 2021, NASA awarded a contract to SpaceX for its Starship HLS as the initial human lander that will put the first Artemis astronauts on the lunar surface. During August and September of 2025, members of the ASAP had the opportunity to perform insight visits at SpaceX's Starship production and test facility in Boca Chica, Texas, to observe the progress of the Starship program.

The development of Starship struggled during most of 2025, although the last two flights of the year were successful and met the major goals that SpaceX had set for the developmental Starship version 2 (V2), a suborbital prototype of the Starship orbital version 3 (V3). Starship V3 incorporates upgraded Raptor engines to provide Starship the required performance for LEO flight and on-orbit operations. The target performance of the Starship V3 is crucial for propellant transfer testing and will ultimately determine the number of refueling missions required for the HLS mission. The number of HLS refueling missions is currently somewhat ambiguous but often speculated to require at least 12.

A priority goal for SpaceX is to get the cargo configuration of Starship flying so it can place its new, more capable Starlink constellation on orbit. The revenue stream from an upgraded Starlink constellation is significant, and the heavier Starlink design presents an ascent performance challenge for SpaceX's Falcon 9 rocket. The performance of the Starship V3 rocket is expected to provide a dramatic launch advantage by comparison. SpaceX's eagerness to launch and populate an upgraded Starlink satellite constellation benefits NASA, in that numerous Starlink LEO flights on Starship will help enhance the reliability of the Starship rocket.

On the other hand, launching a new Starlink constellation requires neither an HLS (with its critical human safety requirements) nor on-orbit cryogenic fuel transfers (that must happen on a designated timeline using at least a dozen V3s), two of the most complicated and technically challenging Artemis operations. The development and test progress necessary for a version of Starship that has not yet flown in time to support a human lunar landing mission within the next few years appears daunting and, to the Panel, probably not achievable. Beyond this, the physics of landing a six-to-one height-to-width ratio vehicle on the uneven, poorly lit polar lunar surface seems questionable at best. The ASAP had requested a deeper discussion from the senior SpaceX engineering team on HLS design, cryogenic fuel transfer, and other critical aspects of the overall Concept of Operations for the HLS mission, such as boil-off, uncrewed demo, landing stability, and other critical factors that directly relate to resilience in the face of the Artemis III requirements. Delayed by the October 1, 2025, partial U.S. Government shutdown, the discussion will now be rescheduled for early 2026.

In sum, an uncrewed demonstration flight of the HLS is required prior to the Artemis III mission and should provide additional risk reduction. These are major contributing concerns to the Panel's formal recommendation 2025-05-02. That said, at this time it is difficult to imagine another NASA contractor capable of meeting a challenge of this scale and pace as SpaceX.

V. U.S. Presence in Low-Earth Orbit

A. SpaceX

SpaceX's overall scope of achievement is impressive, having launched a record 138 times in 2024 (134 of which were with its Falcon family of rockets) and then a record 165 Falcon 9 orbital missions in 2025 (of which 162 successfully returned the boosters). SpaceX's ingenious multi-faceted, self-perpetuating strategy directly enhances reliability. Its initial manufacturing and flight operations centered on Falcon 9, Dragon, and government contracts, generating revenue that the company contributed to Starlink and Starship development. In turn, Starlink revenue permitted an increasing manufacturing and flight operations tempo, facilitating the constellation's high replenishment rate. This also allowed SpaceX to accrue unprecedented experience in spacecraft and booster manufacturing, launch preparation, and flight operations.

SpaceX has capitalized on this experience and the real-world data it generated to yield higher reliability in manufacturing, operations processes, and hardware and software systems. In some cases, SpaceX has surged ahead in manufacturing which, beyond ensuring no wait-time for those systems, also contributes to preserving the higher production rate for ground and flight systems. Higher reliability and the economies that come from high tempo also directly yield cost reductions. No competitor has marshalled this combination of factors (high manufacturing and flight tempo, real-world data, increased reliability, and cost reduction) so effectively, an important factor for NASA to consider as it evaluates contract types and program risk across companies with varying corporate strategies and cultures. It is clear from its actions that the SpaceX internal business priorities have been historically aligned with NASA's mission. However, the company's priority on delivering an upgraded Starlink constellation using the Starship vehicle could potentially divert attention from its commitment to NASA's priorities and warrants close monitoring in 2026.

In 2025, SpaceX continued to successfully launch Dragon to the ISS from Space Launch Complex 40, a long-held launch site retrofitted for crewed missions to help mitigate future potential schedule risks. Despite SpaceX's strong performance and advantages, the ASAP has remarked on challenges SpaceX also faces. The Panel continues to advise NASA to track issues and commensurate risks fleet wide, including the increased pace of Falcon 9 operations, the addition of west coast-based Dragon crew and cargo spacecraft recovery, the award of the United States Deorbit Vehicle (USDV) contract to SpaceX, and the ongoing large-scale Starship development program.

NASA made excellent progress assessing the associated Falcon 9 and Dragon risks from flights executed in 2025, particularly with respect to the west-coast-based landing adjustments. NASA is also appropriately sensitive to the importance of tracking anomalies and the potential cumulative detrimental impact of numerous small issues. Likewise, in support of the CCP, SpaceX continues to be very thorough and open with NASA on all anomalies that could impact future NASA operations, whether they occurred on NASA or other customer missions, and is to be commended for their openness with NASA and willingness to address each situation.

As the ISS approaches End of Life (EOL), the ASAP cautions NASA and SpaceX to maintain their intense focus on safe Crew Dragon operations and be alert both to complacency and program pressures arising from a host of external factors such as changes to the longer-term transportation plan as a result of Starliner contract adjustments, and necessary deconfliction with the Artemis II mission. NASA and SpaceX must guard against allowing the fast-paced operating environment to undermine sound judgment, deliberate analysis, and careful implementation of corrective actions.

B. Boeing Starliner

In June 2024, the CFT successfully launched astronauts Butch Wilmore and Suni Williams to the ISS for what was intended as an 8- to 14-day mission, but in-flight propulsion system anomalies (helium leaks and thruster malfunctions) compelled NASA to ultimately deem Starliner too risky for their return and to utilize an available return option with less risk. In September 2024, after investigating the anomalies while Starliner was docked to the station, NASA decided to bring the vehicle back uncrewed. The crew were extended aboard the ISS for over nine months to account for Dragon manifest considerations and crew equipment provisioning and training until they safely returned on a Dragon capsule in February 2025. NASA is expected to complete its investigation of the Starliner anomalies in early 2026. Meanwhile, the ASAP has carefully reviewed the CFT flight from technical and management standpoints both pre-launch and in-flight, with a focus on lessons learned that can improve the safety of future operations.

With respect to conditions pre-launch, the Panel has identified as concerns: incomplete verification and validation of the on-orbit command and service module propulsion systems, inadequate hardware-to-avionics integration testing (including the absence of a true "iron bird" ground-based simulator to validate the design, test software/hardware integration, and model flight conditions), and failure to recognize the lack of required two-fault tolerance for deorbit burns, a latent design flaw the program did not identify until just prior to launch. Further, during its fact finding after the crew returned, the Panel learned that, in the years prior to launch, several requests from the Astronaut Office and the Johnson Space Center Flight Operations Directorate to address verification and validation of software and test various failure modes went unanswered. These findings argue for Agency-wide governance realignment of acquisition strategies and contracting approaches to prevent these kinds of pre-launch "misses" in the future and underscore the importance of Recommendation 2025-05-01. Specifically, robust governance must enable two important things: 1) Agency insight and understanding of the design and design trades, and 2) clear articulation of Agency and provider roles and responsibilities relative to safety and technical risk for human spaceflight.

With respect to in-flight conditions, the Panel observed cultural and organizational challenges, particularly with NASA's decision-making about crew return. During rendezvous with the ISS, Starliner experienced a loss of five thrusters that caused a temporary loss of control. This prompted serious concern that without recovery of some control, neither docking nor deorbit would be manageable and could lead to loss of vehicle and crew. On-orbit troubleshooting recovered four of the five jets, enabling docking. Given the severity of this anomaly, NASA appropriately used the ISS as a "safe haven" while testing and engineering analyses of recovery options was conducted. The root cause of these intermittent failures was not definitively determined,

however. The Agency elected to not declare an in-flight mishap or high visibility close call, despite clear guidelines in NPR 8621.1D, the primary NASA directive for reporting, investigating, and documenting mishaps (accidents) and close calls. Instead, technical investigations focused on determining feasibility of a crew return on the Starliner. The crew office, CCP program office, NASA engineers, NASA's senior leaders, and Boeing's engineers and leaders were all deeply engaged for many weeks in activities to resolve the situation.

The deeply committed, all-hands-on-deck approach taken by such a broad set of stakeholders is extremely commendable. Nevertheless, the absence of a mishap or close call declaration created ambiguity and confusion about the goals, priorities, authorities, and responsibilities of the various NASA and contractor stakeholders involved. After the loss of control event and subsequent docking, Boeing and the CCP Office immediately signaled that a crewed return on Starliner was a highly desired outcome. Many employees understood this as the priority effort above all other outcomes. But other NASA stakeholders, including the TA community, noted the Starliner deficiencies that had revealed themselves in flight and focused instead on identifying the safest approach to crew return. In effect, it was unclear which of two philosophical stances would govern decisions: "We will work toward proving the Starliner is safe for crewed return" or "Starliner is no-go for return given the availability of an alternate vehicle, unless and until we are able to ensure the on-orbit failures won't recur on entry." The dissonance between these postures and uncertainty about the basis on which decisions would ultimately be made persisted throughout the summer months, creating significant stress on the workforce while engineers and managers pursued multiple tests of the Starliner propulsion systems.

In short, objectives, risk ownership, and decision-making authority were unclear for a long time. This ambiguity raised questions about whether key NASA personnel recognized the grave safety implications of the docking event. This could have been avoided had NASA declared a mishap, fully consistent with NPR 8621.1D, in a timely fashion. Such a declaration would have clarified and improved communication about decision-making authorities, priorities, success criteria, and the primary path to resolution of the crew return question. The Panel learned that during the CFT mission there had been some discussion that an inflight mishap or high visibility close call declaration should wait until the end of the flight. Such an approach eliminates real-time benefits to safety management, however. Anomaly declarations should be made at the earliest opportunity following the in-flight event to permit the priority setting and clear communication that optimizes outcomes for the flight crew. It should be noted that to date, no mishap or close call declaration has been made regarding the CFT mission. Thus, to forestall similar challenges in the future, the ASAP makes the following recommendation:

Recommendation 2025-05-03: NASA should conduct a thorough assessment of NASA Procedural Requirements (NPR 8621.1D) with respect to the criteria and processes to be used during and after anomalous flight events. Guidance in NPR 8621.1D should be refined as necessary to make it unambiguous that any event on a human spaceflight mission involving NASA personnel that affects crew or spacecraft safety should require timely declaration of a NASA mishap or close call.

Of note, declarations also ensure related investigation reports have official status in NASA records and thus protect documentation of critical lessons learned for future operations. As of this writing, the final report for the independent investigation of the CFT is in draft and expected to be released in early 2026. Because there was no declaration, NASA will need to be very vigilant about tracking the lessons surfaced by its investigation and carefully attending to its findings and recommendations.

C. International Space Station

The Panel continues to be impressed with the excellent management of a complex, dynamic International Space Station in the face of budget and staffing reductions, geopolitical tensions, and an aging facility. The ISS, managed through its more traditional contract structure, has been one of the finest programs in NASA history compared to Apollo, Shuttle, and Mir, all of which had significant setbacks. The lack of significant setbacks, anomalies, and emergencies for the ISS over a 25-year span is remarkable. NASA is targeting 2030 to decommission ISS, and additional extensions would need to carefully consider the growing risks. The Panel is therefore pleased to see the USDV development schedule is tracking to meet a mid-2029 launch date, though the adequacy of planned funding is uncertain. Meanwhile, NASA's ability to sustain reliable operations, properly manage risks, and protect crew safety has grown heavily dependent on the ISS capability over its lifetime. As the ISS EOL approaches, it is important that the Station remain fully functional with crewmembers aboard until near the very end.

As a consequence of aging, ISS faces growing technical risks, the single most significant of which is the microcracking in the Russian Service Module vestibule (PrK) hull that has resulted in long-standing air leaks. A sealant has been applied to the interior PrK hull, which has stopped the air leaks, but the underlying risk—microcracking—has increased over the past six years and will likely continue to worsen. NASA and Russia have reached a more common understanding of the cracking mechanism, and both partners are investigating Environmental Assisted Cracking as a likely contributor to crack growth in addition to fatigue. The ISS program has operational protocols in place to isolate the PrK vestibule at lower pressures when access is not required. The lower pressure reduces crack growth and risk of hull integrity failure. In addition, PrK hatch openings are minimized, and NASA has precautions in place to close the hatch between the Russian and U.S. segments to minimize the risk to crewmembers in the U.S. segment. The ASAP applauds NASA and its international partners for their efforts to properly protect crewmembers.

The aging, 40-year-old Extravehicular Mobility Unit (EMU) is also a significant risk and ongoing area of concern for the Panel. In 2019, the ASAP recommended that NASA begin an immediate transition to a next-generation Extravehicular Activity (EVA) suit system. Unfortunately, NASA's contracting attempts with available industry providers for follow-on ISS EMU improvements have been unsuccessful and the program must now manage an obsolete space suit system. In some cases, replacement parts are no longer available, and old parts must be returned to vendors to be refurbished. Design weaknesses with the EMU result in a system susceptible to water crossover failures into the crew's breathing atmosphere, requiring that it be closely monitored. EVA sustainability with the current suits is thus a significant safety risk that must be rigorously managed through the ISS EOL.

Coincident with operational demands and these risk management challenges, temptation to reduce the ISS budget looms as some may anticipate lower costs over the next four years until EOL. As budgets decline, it is increasingly difficult for NASA to ensure the ISS risks remain manageable for day-to-day operations with enough contingency margin. The budget reductions to the ISS Program over the past two years have resulted in fewer resupply vehicles, fewer spare Environmental Control and Life Support regeneration system Orbital Replacement Units, and a plan to buy fewer crew rotation vehicles. (NASA is extending some of the standard U.S. Dragon crew rotations from six months to eight to enable this.) The availability of ISS to test and validate critical capabilities—such as life support systems and EVA suit systems—and conduct human health research for Moon and long-duration Mars programs could be substantially compromised. Budget cuts have also resulted in significant reductions in the contracted workforce that supports ISS across the entire program, including many reductions for science and research, ISS Software testing and validation, and medical operations. Compounding this, the 2025 workforce streamlining program resulted in unplanned talent loss to the ISS Program with effects that are not yet clear.

As a result of these resource reductions, the margin is now so thin that contingencies easily addressed in the past—such as hardware component failures, cargo vehicle delays, and the need to accommodate additional crewmembers—could now result in significant ISS degradation or the need to return U.S. crewmembers early. The ultimate worst-case scenario is that the ISS becomes uncontrolled, and a tumbling re-entry cannot be prevented, leading to safety risks to humans on Earth.

The ASAP's assessment is that the ISS program has been pushed to the brink of safe operations by significant budget cuts. As long as the ISS continues to support astronaut activity, funding must be sustained and may need to increase both to mitigate degradation due to aging and to support EOL activities like developing, testing, and deploying the USDV to support safe termination. Resource sufficiency and microcracking are therefore the Panel's most immediate and important safety concerns for ISS.

D. Transition to Commercial Low-Earth Orbit Destinations

The Panel greatly appreciates the ISS Program's efforts to make the best possible use of the ISS until EOL. As we have previously noted, however, it is increasingly clear that the remaining station life is insufficient to meet all critical test and research objectives necessary to support development and reduce risk for the Artemis campaign and beyond. Importantly, NASA's ability to sustain a human presence in LEO depends on a successful transition strategy from the ISS to commercial LEO destinations (CLDs). Accordingly, the Panel made the following recommendation in 2023:

Recommendation 2023-04-01: NASA should develop a comprehensive understanding of the resources and timelines of the ISS-to-CLD transition plan to a much higher level of fidelity, to provide confidence that the Nation will be able to sustain a continuous human presence in LEO. The plan should be grounded in explicit, defensible assumptions and should include quantifiable metrics and progress deadlines for ensuring that the market for commercial LEO activities exists and is sufficient to support the development, production, and operation of one or more commercial platforms to replace the ISS.

The Panel's view is that NASA's transition strategy remains aspirational, as it lacks a clearly defined and executable path to transition to a CLD before or immediately after the ISS EOL. As we said in 2023, NASA needs to fully articulate detailed objectives for sustained human presence in LEO, outline a practicable transition of objectives to alternative LEO platforms, identify NASA's roles, responsibilities and authorities for operations on CLD platforms it neither owns nor maintains, and develop a feasible supporting budget. In 2025, NASA apparently intended to revise its 2024 transition planning objectives, but the effect on forward work remains unclear.

The Panel has also observed that the transition to a commercially owned and operated destination raises many fundamental strategic, technical, and operational questions, several of which are not answerable by NASA alone. For example, NASA must be convinced a potential provider has the technical and financial wherewithal to manufacture a CLD and operate it successfully long-term. They must be able to construct it, acquire and fly the number of missions needed to assemble it in space, and create a livable science-ready interior bay. They must also have realistic access to a non-NASA client base that will contribute significantly to covering the cost of operations and eventually provide a viable commercial return.

For emphasis, the ASAP reminds NASA of questions previously raised in our 2023 and 2024 Annual Reports, the answers to which are necessary to ensure NASA can successfully transition LEO research and technology efforts from ISS to a CLD (see sidebar).

Because NASA expects to contract for "services" with a CLD provider, the design, build, deployment, and operational costs will be the responsibility of the provider, the Panel's Recommendation 2025-05-01 is germane as NASA must use a more mature acquisition strategy as contract formulation for CLD services continues. It is highly conceivable that companies who vie for a CLD services contract could resemble any of the three models presented in Annex A, or some variation or hybrid thereof. To protect the safety of NASA personnel, NASA must note the lessons of the CCP and carefully determine:

- The engineering maturity of CLD platform designs,
- The business models and incentives of potential CLD providers,
- How to maintain proper oversight for and gain technical insight into key interfaces with NASA operations,
- How to ensure clarity about authorities and responsibilities, especially with respect to managing anomalies, and
- What role NASA will assume and communicate relative to long-term risk and safety management in support of their personnel.

Moreover, as the Panel has said before, it will be important for NASA to clearly define human certification requirements and provide these in the contract award. Finally, the Agency must carefully consider what risks arise because of very limited insight, involvement, and participation in the development and operation of a CLD and determine how to mitigate those risks, especially as NASA's own knowledge base and direct experience degrade over time post ISS EOL.

Critical Considerations for the ISS to CLD Transition

- How will NASA determine which CLD options are viable for ISS transition, both technically and financially?
- How much is the U.S. Government willing to invest in the CLD market to ensure an orderly LEO transition?
- Will there be a consistent U.S. Government position on NASA's role in LEO operations?
- Without U.S. Government investment, is there a viable CLD market within NASA's necessary timelines for ISS retirement?
- What will be the future regulatory paradigm for CLDs, and will Congress designate a U.S. regulator?
- With numerous elements as part of the broader system of systems, many of which will be industry owned and managed, who has the authority and responsibility to support safe and effective operations and how will NASA have a role in that authority?
- What are the acquisition or investment approaches (near-term and long-term) that will allow the Agency to understand the risks to NASA personnel and resources, and how will integrated risks be addressed?
- As a risk-reducing platform for the M2M program, to what extent will risks for the Artemis campaign be retired by the time ISS reaches its planned EOL 2030?
- How will new and emerging risks be addressed in a timely and cost-effective manner without the ISS?
- What role will CLDs play in astronaut training for the M2M program, and how will CLD crew training be accomplished in a way that translates to Artemis risk reduction?
- How will NASA be assured that CLDs can support the infrastructure to conduct mission-essential research?
- How does NASA envision using the CLD operations to support and sustain workforce expertise required for overall human spaceflight experience?

VI. Health and Medical Risks in Human Space Exploration

Health and medical risks in human spaceflight are integral to the overall mission risk and safety profile. With intent to accelerate Mars Missions, the Office of the Chief Health and Medical Officer (OCHMO) and the Human Research Program (HRP) are pursuing understanding and mitigation of health and medical risks with greater focus. Figure 4 below appeared in the 2024 ASAP report and remains a useful visual tool for depicting the overall health and medical risk hierarchy. OCHMO and HRP are applying available resources to the highest risks for exploration class missions, depicted in red.

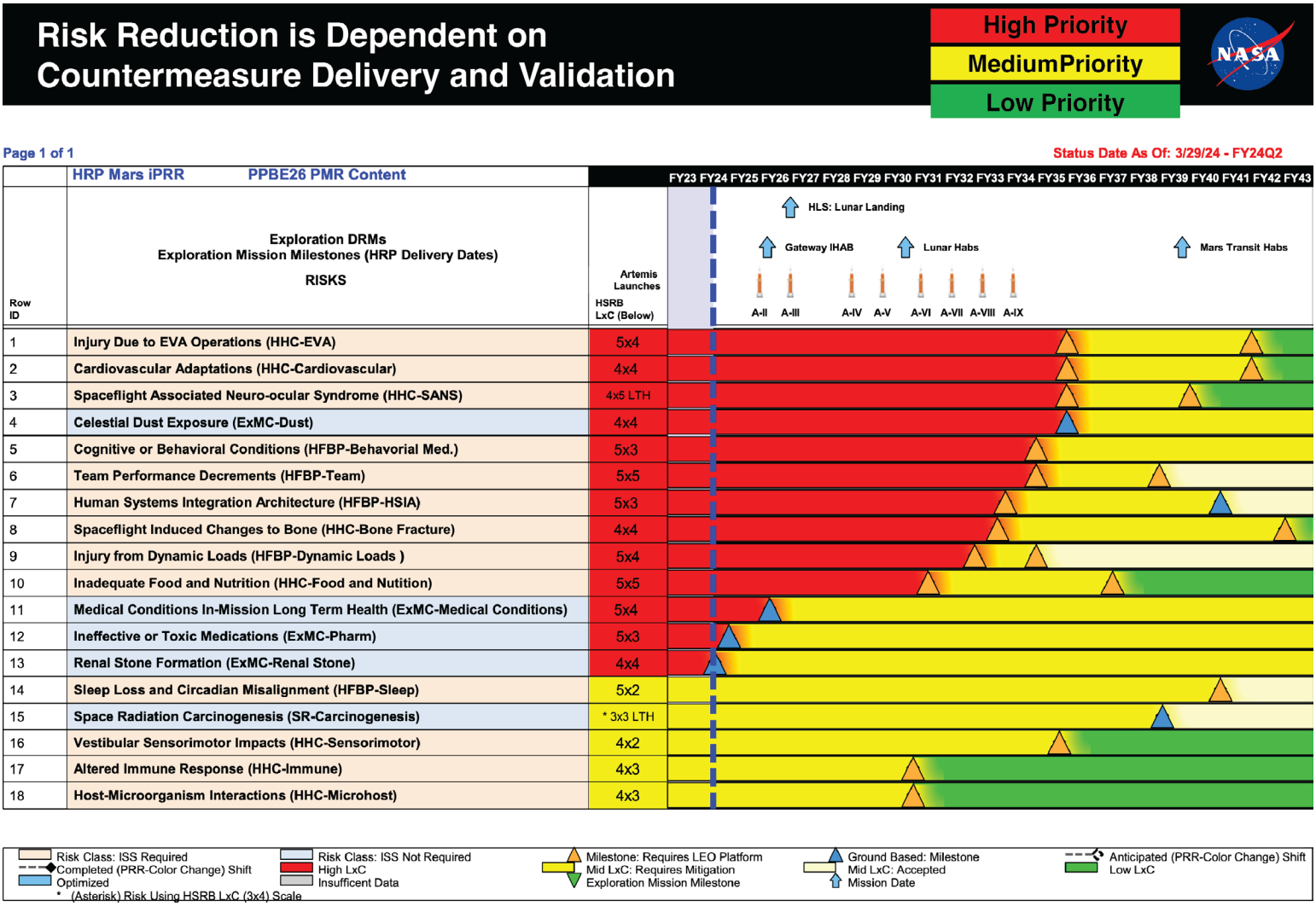


Figure 4. Human Research Program Risk Rweduction.

OCHMO and HRP have been very active in 2025. Of particular note, they made significant progress in understanding Spaceflight Associated Neuro-ocular Syndrome (SANS) and working towards potential countermeasures. They are pursuing Artificial Intelligence models that can help predict which crewmembers will get SANS to help tailor countermeasures for them. Leveraging international collaboration, in 2026 they plan demonstration of a pharmaceutical countermeasure for SANS in a validated head-down tilt bedrest model. In addition, OCHMO held a workshop with subject matter experts to review research and clinical activities relevant to the risk of venous thromboembolism during spaceflight. The working group produced a comprehensive report that identified risk factors and included a proposed algorithm for spaceflight venous thrombosis management. The HRP plans to initiate a research study on the ISS to characterize and test countermeasures for the venous thromboembolism risk.

HRP has also engaged in several important projects, including: examining behavioral health, team and remote operations risks, demonstrating sensorimotor countermeasures designed to promote crewmember recovery, validating pre-breath protocols for early Artemis missions, and delivering a validated CO_2 standard for contingency EVAs.

As the Panel has said before, human research in LEO is key to the health and safety of astronauts on long-duration missions. Very few increments remain for human research through the remaining planned life of the ISS. OCHMO and the HRP are working hard to focus their efforts and maximize clinical research return over these increments, but NASA needs to think carefully about how to ensure continued access to LEO for vital health research in order to manage long-term exploration risks.

VII. Special Topic: X-59 Low-Boom Flight Demonstrator Project

The X-59 is a quiet supersonic experimental aircraft under development by Lockheed Martin (LM) Skunk Works for NASA's Low-Boom Flight Demonstrator (LBFD) project, a project that aims to develop the ability to fly faster than the speed of sound without generating loud sonic booms. In 2024, NASA senior leadership requested that the ASAP assess the X-59 LBFD program which had experienced several timeline delays and hardware handling incidents during the previous several years of development.

Figure 5. The X-59 Low-Boom Flight Demonstrator Aircraft During Flight Operations.

Two Panelists, both experienced test pilots and astronauts with unique aviation test and safety experience, were detailed to accomplish this task. Through a series of briefings and on-site visits to the NASA Armstrong Flight Research Center (AFRC) and Lockheed Martin Palmdale facilities, they were given an overview of the Quiet SuperSonic Technology (QueSST) mission, the LBFD project, the LM X-59 Software-in-the-Loop simulator and the X-59 aircraft, including flying the X-59 simulator with guidance from the lead NASA X-59 test pilot. The NASA briefings were thorough and covered LBFD top risks, the LBFD hazard matrix, top technical issues and challenges encountered that included close calls, incidents and mishaps during X-59 development.

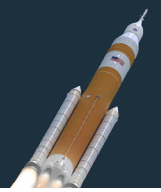
NASA briefings also covered the program timeline and history of delays. The program timeline was initially scheduled for three years, but eventually more than doubled. The original First-Flight date of March 2021 was re-baselined in December 2023 with further slips into 2024 and 2025. The March 2021 date was significantly impacted by the COVID pandemic, as it rendered key workforce groups unavailable and created major

supply chain delays. The way the X-59 development project was managed also contributed to timeline delays. Specifically, it appears LM used the unclassified LBFD program as a place to "hold" workers while their clearances were being approved, after which they were reassigned to "higher priority programs." This created a revolving door of inexperienced employees. Many additional delays caused by issues in software testing, lack of performance in production, aircraft incidents and impounds, and flight instrumentation challenges might have been reduced with a more consistent and experienced workforce. By early 2025 LM recognized the challenges with their staffing approach and modified it to assign a more experienced, stable workforce. After multiple Flight Test Project Leads, it appeared that as of early 2025 LM had the right leadership in place to manage the difficult challenges of X-plane development. This experience offers important lessons about contract management as it relates to program safety. Specifically, the contract terms did not incentivize the contractor to keep an experienced, stable workforce assigned to the program, resulting in degraded program performance. ASAP Recommendation 2025-05-01 is intended to support better consideration of the effects of contract structures in the future.

In addition to program delays, the Panel's review also surfaced a lack of diligence and consistency by NASA in its application of waiver procedures required by its Aviation Medical Certification Standards (OCHMO-STD-1880.1). NASA has a pilot age requirement of less than 65, after which age waivers are required for any pilot in any NASA aviation program. As the LM lead test pilot continued to support the program after age 64, it appears NASA's approval processes were inconsistently applied and, in one case, mischaracterized at a NASA decisional meeting. From the perspective of the Panel, such process deviations lead to the lack of an appropriate "risk vs. risk" evaluation that age waivers are intended to prompt. Given the medical sensitivities involved, the details of the Panel's observations on this matter have been shared with NASA leadership through other avenues.

Beyond these findings, the Panelists judged the X-59 Phase One Flight Testing plan to be very thorough and believe it will build up in a logical and safe manner. The Panelists also observed that good safety protocols are in place and are being properly enforced. Initially, they suspected that flying an airplane without a forward window by relying on a vision system would be risky, but after they flew the simulator and had detailed conversations with the lead NASA X-59 test pilot, they deemed the risks manageable.

In sum, the Quiet SuperSonic Technology under development with the X-59 LBFD appears promising to the Panel, exemplifying cutting-edge aerospace innovation in the realm of noise reduction. The LBFD project has encountered numerous technical challenges, but these have been or are being addressed with no known significant issues remaining. The Panel applauds NASA and Lockheed Martin for the successful first flight of the X-59 in October 2025. The X-59 project represents a continuation of the historic X-plane program tradition and has the potential to significantly enhance future commercial supersonic land overflight by dramatically reducing sonic boom disturbances.



VIII. Focus for Congress

The Administration and Congress have issued clear guidance that providing global leadership in space exploration and expanding human reach in space is a national priority. Moreover, international space competition is serious now and growing rapidly. Addressing these challenges depends on sufficient financial and human resources.

In this light, the Panel acknowledges the ongoing dialogue regarding NASA's budget, with respect to both size and programmatic focus and remains concerned about the implications of potential reductions. As the Administration and Congress work to reach a final determination, we reemphasize our previous caution that resource allocation decisions have very significant risk and safety implications that demand serious attention. This is particularly important for critical mission elements such as sustainment of the ISS through EOL, development of the USDV, the follow-on CLDs, and the Artemis technologies necessary to support human flight to and activity on the Moon. Absent a robust budget, fiscal realities will require NASA's leaders to significantly adjust program content and schedules to meet constraints. Moreover, NASA's missions require years—or even decades—to fulfill, making programs vulnerable to annual debates and uncertainties, and thwarting thoughtful program planning, management, and contracting. Thus, the Panel has repeatedly expressed the urgent need for executive leadership in contracting and strong acquisition expertise at the Agency. The Chief Acquisition Officer role is crucial to focused management of NASA's industry providers.

As we said last year:

> ***"As NASA increasingly engages the commercial sector for its missions, the complexity and diversity of its acquisition strategies grows. The Panel believes that strong acquisition experience is essential at all levels of NASA leadership. While NASA has made commendable strides in strengthening program management and acquisition skills within its workforce, the Panel still advocates for the creation of a Chief Acquisition Officer (CAO) role akin to other government agencies that manage complex acquisitions."***
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> *2024 ASAP Annual Report*

Finally, to meet national aims, it is far safer, more cost efficient, and ultimately more effective to provide balanced, systemic, and predictable programmatic funding rather than inconsistent or insufficient initial allocations on an annual basis.

Similarly, the widespread use of workforce streamlining mechanisms in 2025, while fiscally expedient in the near term, can carry substantial and often underappreciated risks for a highly specialized technical workforce such as NASA's. These strategies tend to disproportionately incentivize the departure of senior engineers, scientists, and program managers whose value lies not only in their deep technical expertise but in their

accumulated program experience and engineering judgment which takes years to develop and reconstitute. Rapid attrition can erode technical authority, dilute mentorship pipelines, and increase reliance on contractors, thereby weakening the government's intellectual capacity to lead programs effectively and ensure safety and mission assurance. While reshaping the workforce to align with current missions and programs is vitally important, Congress and the Administration should remain cognizant of the importance of retaining mission-critical knowledge and skills in the NASA workforce, lest the Agency fall prey to erosion of discipline-level technical depth, degradation of independent verification and validation capability, and greater programmatic instability. NASA must maintain the long-term technical competence and safety culture required for the United States to maintain credible global leadership in space.

As the resource picture coheres, the Panel believes it is critical that NASA be completely transparent in communicating the most accurate, current information about these financial and human capital realities to its stakeholders. Resource leaders in the Administration and Congress must understand realistic expectations and schedules, not aspirational ones, to make fundamentally sound choices. An unvarnished assessment of where NASA stands with respect to our national space interests and against the status of our global competitors is a vital element of strategic resource decisions. Consistent with this task, ASAP Recommendation 2021-05-01 was intended for the Agency to broadly review its national priorities across the entire Agency, with a directed focus to make Artemis a priority and successful program. Absent an honest assessment, we face the real possibility of introducing unacceptable safety risks and failing to achieve our imperatives in space.

IX. Conclusions and Looking Ahead to 2026

In 2025, the ASAP maintained sustained attention on a set of interrelated safety, organizational, and programmatic risks that it views as consequential to NASA's near- and long-term mission success. Across the year, the Panel's work reflects a consistent assessment that NASA's most significant safety challenges increasingly arise from systemic interactions among workforce dynamics, acquisition strategies, technical authority, budgetary pressures, and the growing complexity of human spaceflight programs rather than from isolated technical failures.

A recurring area of attention throughout 2025 was human spaceflight risk in the Artemis and CCP. The Panel closely monitored Artemis II readiness and expressed confidence in NASA's disciplined handling of known technical risks, while repeatedly raising concern that Artemis III and subsequent missions combine too many first-time systems and operations into a single flight. The ASAP found that this "stacking of firsts" materially elevates mission risk and reduces margin. The Panel recommended redistributing objectives across missions, adopting a more deliberate test-flight cadence modeled on Apollo-era practices, and ensuring that schedule pressure does not override prudent risk reduction—particularly for the HLS development, spacesuit readiness, and cryogenic propellant transfer capabilities.

The Panel also devoted extensive attention to the CCP, with particular focus on Boeing's Starliner. Across the year, the ASAP reviewed propulsion and thruster anomalies encountered during the CFT and emphasized the critical role of crew training and manual flying skills during that mission. The Panel supported NASA's use of independent review teams and endorsed the likelihood of an uncrewed follow-on flight before returning

Starliner to crewed operations. More broadly, the ASAP cautioned against cultural drift arising from treating contractors as "partners" rather than vendors, noting that this mindset can delay problem recognition and weaken objective oversight.

A major cross-cutting theme in 2025 was contracting, procurement, and acquisition sophistication. The ASAP identified acquisition strategy as an emerging determinant of safety outcomes, particularly as NASA increasingly relies on fixed-price contracts and commercial business models. The Panel found proficiency in allocation, management, and oversight of risk to be uneven across programs and contractors, and cautions that milestone-based progress "on paper" does not necessarily equate to reduced technical risk.

Technical authority remained a central concern throughout the year. The Panel reaffirmed the post–Columbia accident framework of independent technical authorities as essential to NASA's safety posture and expressed concern that workforce attrition, proposed budget reductions, and organizational pressures could erode their effectiveness. The ASAP has consistently emphasized that with appropriate access to insight, technical authorities must retain independence, provide consistent application across programs, and adequate resourcing.

The Panel also gave significant attention to workforce health, safety culture, and organizational stressors. The ASAP reviewed results from NASA's safety culture survey, finding overall positive trends but identifying opportunities to strengthen behavior-based indicators that encourage open communication and early risk reporting.

Finally, the Panel consistently characterized the ISS as entering the riskiest period of its operational life. The ASAP tracked aging-related structural issues, growing life-support and resupply challenges, and the increasing complexity of sustaining safe operations through 2030. The Panel stressed that safe ISS operations and safe deorbit planning are inseparable from the broader transition to CLDs.

In 2026, the ASAP intends to give particular attention to four areas: 1) Strategic human capital management and mission alignment, 2) Acquisition, contracting, and procurement strategies, 3) Technical authority, and 4) The transition to CLDs, ISS EOL, and USDV development.

The Panel's planned focus on workforce shaping reflects the growing imperative that NASA maintain a technical workforce capable of executing increasingly complex future missions. This emphasis goes beyond near-term staffing levels to address the long-term alignment of skills, experience, and institutional knowledge with exploration architectures, advanced space systems, and evolving operational models. Anticipated retirements, continued competition with the private sector, and changing acquisition strategies heighten the risk of gaps in systems engineering, safety and mission assurance, and technical assessment. Proactive workforce shaping in 2026 will be essential to preserving technical rigor, sustaining a strong safety culture, and ensuring the government retains the internal expertise necessary to act as an informed, independent mission owner.

The Panel will continue its attention on "make, manage, buy" decision-making in 2026 recognizing that NASA's future success will depend on its ability to function as a highly capable and discerning customer in an increasingly commercialized space enterprise. As the Agency relies more heavily on a variety of commercial

entities, acquisition decisions will have profound implications for safety, resilience, and mission assurance. Sophisticated procurement practices—supported by a technically fluent workforce—are critical to defining clear requirements, understanding contractor risk postures, and maintaining appropriate government insight and oversight. Without this capability, NASA risks ceding too much control over cost, schedule, and safety outcomes to external vendors.

Continued emphasis on technical authority in 2026 reflects the Panel's concern that the foundations of independent technical decision-making must be sustained in a changing organizational environment. Strong technical authority ensures that discipline experts have the independence, resources, and leadership backing to raise concerns, challenge assumptions, and influence risk-informed decisions. As workforce transitions, schedule pressure, and contractor reliance intensify, the potential for subtle erosion of technical authority increases. Maintaining its strength is essential to preventing tacit acceptance of unreasonable risks, ensuring that dissenting views are addressed rather than overridden, and preserving NASA's credibility as a safety-driven organization.

Finally, the Panel's forward-looking focus on the transition of the ISS to commercial destinations and its safe deorbit in 2030 reflects the scale and complexity of decisions that must be made well in advance of execution. In 2026, NASA will need to mature technical, programmatic, and governance frameworks that ensure the ISS can be safely operated through EOL while preparing for a controlled deorbit in coordination with international partners. At the same time, the agency must ensure that CLDs develop the technical maturity and operational reliability necessary to assume ISS functions without a gap in capability. Early, disciplined attention to these issues will be critical to protecting crew safety, honoring international commitments, and sustaining U.S. leadership in human spaceflight during a pivotal transition period.

NASA's work is exceptionally ambitious and complex, carried out in a taxing environment that demands constant vigilance to ensure safety and effectiveness. NASA's long-term mission success depends less on any single technical solution than on maintaining a resilient ecosystem of people, processes, and authorities. The Panel's recommendations repeatedly call for foresight, institutional discipline, and sustained investment to ensure that near-term pressures do not erode the foundations of safe and effective space exploration. The Panel commends NASA for its impressive efforts in 2025 to strategically enhance the Agency's risk management posture despite turbulence in the Agency's organizational environment. We once again and very sincerely thank NASA's leaders and workforce for their passionate dedication to space exploration and their unwavering commitment to the safe pursuit of the Nation's lofty aims to the great benefit of the future of humankind.

Annex A

Understanding Industry

Industry models that support NASA

There are several industry "models" that support NASA. For purposes of this report, they will be called "Private Vertical Integrator Model (SpaceX is an example), Legacy Public Aerospace Model (Boeing is an example), and Venture Capital (VC)-Backed Commercial Model (Axiom is an example). This is not an exhaustive list but is used for purposes of demonstration of thought needed to ensure the right incentives are utilized.

Tables 1 and *2* provide a comparison of key attributes of these three Industry models that support commercial contracting and the associated impacts. Depending on NASA's need and state of the maturity of the product or service required, any of these industry models can provide an effective solution. However, when developing and executing the contract for the product or service, it is essential for NASA to know, understand, and consider the potential implications of these attributes. They will drive behavior and risk acceptance between the Agency and the industry provider.

Table 1. Proposed Comparison of the Attributes of Archetype Industry Models.

Risk-Related Attribute	Private Vertical Integrator Model	Legacy Public Aerospace Model	VC-Backed Startup / Commercial Model
Vertical Integration	Approximately 80–90% in-house fabrication and design	Heavy reliance on multi-tier supplier networks	Low to moderate integration; primes and partners provide major subsystems
Engineering Culture	Rapid iteration; test–fly–fail–fix philosophy	Design to perfection before test	Incremental innovation layered on proven heritage systems
Manufacturing Approach	Agile, modular, high-volume production	Batch production with specialized tooling	Low-rate production; mix of custom and heritage components
Reusability	Core element of the business model	Mostly expendable systems	Selective reuse via host platforms (ISS, future stations)

Risk-Related Attribute	Private Vertical Integrator Model	Legacy Public Aerospace Model	VC-Backed Startup / Commercial Model
Decision-Making	Flat hierarchy; rapid delegation of authority	Multiple review gates; multi-level approvals	Lean leadership teams; investor and partner influence
Financial Structure	Significant internal reinvestment; diversified revenue streams	Reliant on government revenue; limited internal Research & Development investment	VC funding with anchor government contracts; milestone-based financing
Mission Planning Cadence	High cadence enabling rapid learning	Low cadence resulting in slower learning curves	Dependent on partner flight rates and host platform availability
Supplier Management	Competitive pressure with rapid vendor turnover	Long-term, protected supplier relationships	Strategic partnerships; limited leverage during early phases
Contract Mindset	Fixed-price contracts used as an anchor, not sole revenue source	Preference for cost-plus stability	Fixed-price contracts with milestone payments essential for survival
Innovation Strategy	Integrated roadmap across multiple commercial and government markets	Product silos; slow cross-domain integration	Focused innovation tied to near-term revenue milestones
Capital Risk Exposure	Company absorbs technical and schedule risk	Government absorbs most technical and schedule risk	Investors absorb early development risk; government absorbs operational risk
Primary Value Proposition	Cost reduction, increased cadence, and performance	Assurance, compliance, and political stability	Speed to market for new commercial services

Table 2. Impact on Commercial Contracts According to Business Model.

Industry Model	Commercial Contract Impact
Private Vertical Integrator	Enables aggressive fixed-price bids, rapid schedule recovery, and performance-based accountability when incentives and priorities between NASA and the contractor are aligned.
Legacy Public Aerospace	Favors cost-plus, low-risk contracting; exhibits challenges with fixed-price structures and schedule accountability; closely follows customer-directed priorities.
VC-Backed Startup / Commercial Model	Requires milestone-based, hybrid contract structures with the government serving as an anchor tenant to unlock private capital; investment priorities strongly influence execution.

Given the insights gained from execution of contract types in NASA, *Table 3* chart provides for some "pros and cons" that should be taken into consideration in future acquisition strategy.

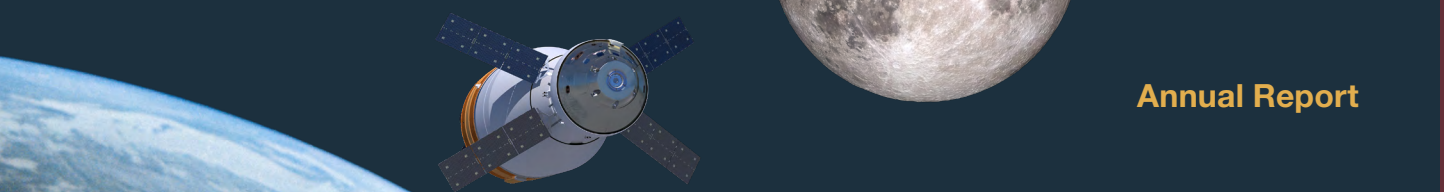
Table 3. Pros and Cons by Industry Model.

Model	Pros	Cons
Private Vertical Integrator Model	▪ Lowest unit cost over time due to reuse and scale ▪ High tolerance for technical risk and rapid recovery ▪ Strong alignment with fixed-price, performance-based contracts ▪ Fast learning cycles improve reliability and schedule predictability	▪ High internal capital exposure ▪ Cultural friction with traditional government oversight and priorities ▪ Single-company failure can have systemic impact ▪ Not easily replicable without scale and sustained revenue
Legacy Public Aerospace Model	▪ Deep experience with safety-critical, national-priority systems ▪ Politically durable and geographically distributed workforce ▪ Strong compliance and documentation discipline ▪ Well-suited for unique, low-volume missions	▪ Poor fit for fixed-price or commercial-style contracts ▪ Slow innovation and limited cost discipline ▪ Incentivizes risk avoidance rather than performance ▪ Learning curves reset between programs
VC-Backed Startup / Commercial Model	▪ Brings private capital into government-adjacent missions ▪ Focused, mission-driven teams with startup agility ▪ Uses heritage systems to reduce technical risk ▪ Enables new markets (LEO destinations, in-space services)	▪ Dependent on government as anchor customer ▪ Limited leverage over suppliers and launch providers ▪ Vulnerable to funding gaps and investor sentiment ▪ Cannot absorb major overruns without contract relief

Once there is an understanding of these industry business models and potential providers in the Space Sector marketplace, insights can be gained about potential NASA governance, contracting structure and clauses, industry incentives, and risk acceptance between the Agency and industry provider. *Table 4* provides the risk considerations and implications across the program's acquisition tied to contract implementation and the various industry models.

Table 4. Internal Validation and Governance Risk/Control Attributes Across Industry Models.

Risk / Control Attribute	Private Vertical Integrator Model	Legacy Public Aerospace Model	VC-Backed Startup / Commercial Model
Internal Validation Philosophy	Fly and test operational hardware; validate through flight data	Validate through analysis, documentation, and formal reviews	Validate through heritage inheritance supplemented by targeted testing
Design Authority	Centralized internal technical authority	Distributed across integrated product teams (IPTs), boards, and customer	Mixed: startup retains concept authority; partners retain subsystem authority
Governance Structure	Executive-led and engineering-driven	Process-led and compliance-driven	Driven by investors, boards, and customer requirements
Decision Rights	Clear and rapid decision ownership	Consensus-driven, committee-based decision-making	Conditional decision rights tied to funding and milestone achievement
Independent Technical Authority (ITA)	Internal, informal, and empowered	Formal, external, and mandatory	Partial: external reviews conducted to establish credibility
Change Control	Agile; changes encouraged early in development	Highly controlled; changes discouraged	Controlled through investor and customer milestone gates
Risk Acceptance Threshold	High levels of technical risk tolerated	Low technical risk tolerated	Moderate risk tolerated, bounded by company survivability
Failure Response	Immediate corrective action followed by rapid return to flight	Stand-down, root cause analysis, and recertification	Pause, re-baseline, and revalidate with partners



Risk / Control Attribute	Private Vertical Integrator Model	Legacy Public Aerospace Model	VC-Backed Startup / Commercial Model
Schedule Governance	Engineering reality drives schedule	Contractual milestones drive schedule	Funding and investment milestones drive schedule
Cost Governance	Internal cost discipline	Costs recoverable through contract mechanisms	Burn-rate and financial runway discipline
Safety Governance	Embedded within engineering culture	Externalized to boards and customer oversight	Shared with partners and certifying bodies
Customer Oversight Role	Insight-based	Oversight-based	Hybrid approach combining insight and milestone verification

Contract Structures

A government contract need not be limited to a single contract type; in practice, a well-constructed contract can intentionally combine multiple pricing and incentive structures to align risk, incentives, and governance with the underlying industry model and the maturity of the work being performed. Within one overarching contract vehicle, different contract line items (CLINs), phases, or work packages can be structured as FFP, time-and-materials (T&M), cost-plus-fixed-fee (CPFF), or cost-plus-award-fee, depending on technical uncertainty, the contractor's ability to control cost and schedule, and the government's desired behavior. Early-stage activities with high technical risk or incomplete requirements (e.g., concept refinement, integration planning, anomaly resolution) may appropriately use cost-type or T&M structures, while mature, repeatable, or operational tasks can transition to FFP once scope and performance are well understood.

When deliberately designed, this mixed-type approach allows the government to tailor incentives to each portion of the work rather than forcing a single contract model to absorb all risk. For vertically integrated commercial providers, fixed-price CLINs can be used where internal governance, reuse, and high cadence enable cost control, while cost-type elements may be reserved for novel capabilities or one-time integration with government systems. For legacy public aerospace firms, cost-plus structures can be limited to genuinely non-recurring engineering, with production or services moved to fixed-price to counteract cost growth incentives. For VC-backed startups, milestone-based fixed-price elements can anchor private investment, while targeted cost-type CLINs can mitigate survivability risk during first-of-a-kind efforts. In this way, a single contract becomes a portfolio of incentive mechanisms, aligning technical risk, financial exposure, and performance accountability with both the work content and the contractor's operating model, rather than treating "contract type" as a one-size-fits-all decision.

Commerciality

Among the challenges NASA faced as it shifted from traditional government-directed development to commercially oriented partnerships are instances where substantiated commerciality determinations required under Federal Acquisition Regulation (FAR) Part 12 and Acquisition.gov 46.202-1 were absent. The NASA OIG and GAO both found that NASA adopted commercial-item practices before true commercial markets or revenue models existed for crewed services, and, in fact, before systems had performed in any model, commercial or otherwise (NASA OIG IG-14-001 and GAO-12-282).

"Commerciality" refers to the quality of being suitable for commerce, generally meaning something is profitable, marketable, or intended to generate income. If something is deemed commercial, then the government may be able to buy it more easily and affordably (as any other customer would). The FAR requires commerciality determinations in order to use streamlined acquisition. A simple case example illustrates how a defensible commerciality determination is constructed:

Commerciality Determination for a Ruggedized External Hard Drive

Item: Ruggedized 2TB External Hard Drive for Field Use

Issue: Determine whether a ruggedized external hard drive with enhanced shock and vibration tolerance qualifies as a commercial product under FAR 2.101, despite the exact model being unique to the offeror.

Analysis: The contracting officer determined the item to be commercial because it is *"of a type" customarily used by the general public and non-governmental entities.* Market research identified multiple commercially available ruggedized hard drives with comparable storage capacity, performance, and durability characteristics used in demanding environments such as medical, construction, and oil and gas industries. A side-by-side comparison with a commercially sold hard drive used in the oil industry showed only minor, non-essential differences. Prior commercial sales were validated through redacted invoices demonstrating sales to non-government customers at market prices. Agency technical personnel confirmed that the proposed customizations did not alter the item's essential characteristics or core functionality.

Outcome: The commerciality determination was assessed as well supported and defensible. It aligned with FAR 2.101 by focusing on functional equivalence rather than identical part numbers, incorporated technical concurrence to validate "of a type" status, and relied on comparable commercial sales and pricing to support price reasonableness under FAR 15.404-1(b). The documentation provided a clear, evidence-based rationale that would withstand audit or protest scrutiny.

Appendix A

Summary and Status of Aerospace Safety Advisory Panel Open Recommendations

Each previous year's recommendation has an associated action color. **RED** highlights what ASAP considers to be a long-standing concern or an issue that has not yet been adequately addressed, or for which there is no identified resolution. **YELLOW** highlights an important ASAP concern that the Panel is not confident is being addressed adequately, or where a resolution has been identified but does not yet have a defined implementation plan. **GREEN** indicates a positive aspect or concern that is being adequately addressed but continues to be followed by the Panel. No color indicates that the ASAP has not received a response.

2025 Recommendations

2025-05-01: Agency-Wide Realignment of Acquisition Governance for Human Spaceflight Capabilities

Finding: The 2024 ASAP Annual Report identified NASA's evolving use of commercial contracts as an emerging area of safety concern; consequentially, throughout 2025 the Panel conducted extensive fact-finding on this topic.

The Panel determined that while commercial partnerships can foster innovation and efficiency, safety risks increase when fixed-price or commercially structured contracts are applied before technologies and program baselines are sufficiently mature. Reviews of Commercial Crew, HLS, and Starliner programs revealed that uneven technical oversight and over-reliance on contractor assurance can weaken safety accountability, engineering rigor, and schedule stability.

Recommendation: NASA should realign its governance of acquisition strategies for human spaceflight-related capabilities agency-wide, such that contract structures reflect appropriate technical and human spaceflight safety oversight commensurate with NASA's risk management responsibilities. Through its contracts, NASA should establish a cogent framework for government insight and oversight that accounts for program engineering maturity, necessary development timelines, and integrated risk, resilience and safety factors. To support contract decisions, NASA must understand how each contractor's revenue model and goals differ and how contracts, as portfolios of incentive mechanisms, should be designed to address these differences. Contracts must properly align technical risk, financial exposure, and performance accountability with both the required work and the contractor's operating model. NASA should also design and implement effective and appropriate program management structures to fulfill its own responsibilities and accountability for human spaceflight safety risk management throughout each program's life cycle regardless of contract type.

Rationale: This recommendation highlights the importance of applying lessons learned not only to future procurements but also to existing contracts, modifications, and extensions. It emphasizes the need to consider integration across multiple contractors and subcontractors; recognizing that NASA delivers integrated systems

rather than isolated components. The Panel notes that incentive structures and integration responsibilities are critical as commercial ecosystems grow more complex.

2025-05-02: Reexamine Artemis III Mission Objectives and Architecture to Establish a More Balanced Approach to Risk

Finding: The Panel's concerns for Artemis III and beyond stem from the cumulative technical, operational, and schedule risks associated with multiple first-of-a-kind objectives planned for a single mission, including the Human Landing System (HLS), extravehicular activity (EVA) systems, complex rendezvous and docking operations, and operations at the lunar South Pole.

The Panel's 2023 Annual Report identified that the number and interdependence of first-time mission objectives significantly elevate the overall safety risk posture of Artemis III. The ongoing uncertainty regarding mission architectures for Artemis IV and subsequent flights further complicates the risk landscape and introduces additional unmitigated or unidentified risks.

Recommendation: The Panel recommends that NASA re-examine the mission objectives, and potentially the system architecture, for Artemis III and subsequent missions to establish a more balanced approach to risk, prioritize objectives-driven planning, and maintain a consistent cadence of flight missions. For each test objective, NASA should develop detailed plans for testing and data collection—incorporating both ground-based and flight testing—to ensure that all risks are thoroughly identified and mitigated. This structured approach will provide a more balanced sequence of flight tests, ultimately supporting a successful crewed lunar landing, the creation of a sustainable lunar base, and the progression toward a future crewed mission to Mars.

Rationale: The Panel has not observed a comprehensive integrated plan to fully mitigate the risks associated with the combined Artemis III objectives. Several enabling systems, including HLS, cryogenic refueling, and EVA systems, require substantial demonstration and testing to meet mission timelines. The potential architecture changes for Artemis IV and beyond further support the need to reassess flight test plans using an integrated approach similar to that employed during the Apollo program.

This recommendation applies not only to hardware but also to mission profiles, operational concepts, duration, precursor missions, and overall integration. NASA has successfully employed stepwise testing approaches in the past and is encouraged to leverage that experience. The Artemis risk accumulation has been a long-standing concern of the Panel. This recommendation provides timely guidance as NASA moves forward under new leadership.

2025-05-03: Timely Declaration of Mishap or High-Visibility Close Call

Finding: During the Starliner crewed flight test, multiple in-flight propulsion anomalies occurred, including the loss of five thrusters during rendezvous with the ISS, resulting in a temporary loss of control. Although on-orbit troubleshooting recovered sufficient capability to dock, the mission was

extended significantly while teams evaluated return options. Ultimately, the crew returned on an alternate vehicle.

The Panel's key finding was that NASA did not formally declare an in-flight mishap or high-visibility close call under NPR 8621.1. As a result, there was confusion regarding decision-making authority, priorities, and ownership of risk during an extended period of operations. While stakeholder engagement was extensive and well-intentioned, the absence of a formal declaration contributed to ambiguity regarding the primary objective of the response effort.

Recommendation: NASA should conduct a thorough assessment of NASA Procedural Requirements (NPR 8621.1D) with respect to the criteria and processes to be used during and after anomalous flight events. Guidance in NPR 8621.1D should be refined as necessary to make it unambiguous that any event on a human spaceflight mission involving NASA personnel that affects crew or spacecraft safety should require timely declaration of a NASA mishap or close call.

Rationale: Early declaration of a mishap or close call enables the prompt formation of independent investigative teams and supports best practices in safety management.

Open Recommendations from Prior Years

2023-04-01: Establishment of a Comprehensive International Space Station (ISS) to Commercial Lower Earth Orbit (LEO) Destination (CLD) Transition Plan

Finding: Perhaps the most far-reaching concern about planning for the end of the ISS Program is the need for timely and assured transition of the capability for living and working in LEO to the CLD. NASA's current plan for transitioning from ISS to one or more commercial destinations features a high-level framework and a timeline that is very tight. The Panel, being watchful of this extremely tight schedule, remains concerned that there is not a clear, robust business case for commercial LEO, nor clear evidence of the financial viability of the commercial destination for ISS and free-flyer destinations, creating programmatic and safety risk with the entire plan for NASA LEO. If these new commercial platforms are not complete and operational before the ISS is deorbited, the U.S. will face the loss of its ability to perform vital scientific research in weightless conditions, research essential for minimizing safety risks posed by future space exploration activities and specifically the Artemis Program.

Recommendation: NASA should develop a comprehensive understanding of the resources and timelines of the ISS-to-CLD transition plan to a much higher level of fidelity, to provide confidence that the Nation will be able to sustain a continuous human presence in LEO. The plan should be grounded in explicit, defensible assumptions and should include quantifiable metrics and progress deadlines for ensuring that the market for commercial LEO activities exists and is sufficient to support the development, production, and operation of one or more commercial platforms to replace the ISS.

Rationale: Managing and understanding integrated risk across the complex transition from ISS to CLD is challenging and requires a clear rationale, a strong business case, and a viable, executable plan. In the 2022

Annual Report, the ASAP noted that the transition to a commercially owned and operated destination raises many fundamental strategic, technical, and operational questions. Specifically, NASA should ask and answer the following questions: What are the U.S. Government's desired goals and objectives in LEO? Are NASA's goals and objectives dependent on the development of a non-government-driven LEO market? If so, how big is this market, how much is the U.S. willing to invest to get it, and who is responsible for developing that market? Who is responsible for defining and certifying that commercially owned and operated orbiting facilities are safe? What is the acquisition or investment approach that will allow the Agency to understand the risk they are accepting? How will the Agency address shared risks between the government and industry? And what will be the role of NASA's workforce in LEO operations in the future and what skill sets are needed?

As stated in 2022, "the Panel believes that NASA's activities in LEO can benefit from a similar approach in strategically outlining architecture, requirements, systems engineering and integration, and integrated schedule and program management as is being applied to the Artemis campaign."

If this program fails, NASA would be facing two very undesirable options: either extending ISS further or abandoning LEO. Abandoning LEO has significant implications for NASA's ability to manage risk in the M2M Program, which is perhaps the most compelling reason a viable CLD is vital. Specifically, the LEO environment allows the M2M Program to train crew, test equipment, investigate the operational and environmental implications of decisions, and engage in other testing and training to mitigate risk.

NASA Response: In June 2024, NASA published a transition plan that includes several of the elements highlighted by the ASAP, "International Space Station Transition Plan," including strategies to maximize the use of ISS, maintain continuity of research through the transition, and delineate future desired on-orbit services. NASA agrees with the need to develop the details of the transition to a higher level of fidelity and continues to work with the ASAP to develop and communicate the additional elements requested by the Panel in the recommendation. More detailed transition planning for facilities and workforce from ISS to Commercial LEO Destinations (CLDs) is underway. In December 2024, NASA published the Low Earth Orbit Microgravity Strategy (LMS), which defines the goals and objectives that NASA intends to achieve in LEO in the future. This strategy was used to inform initial requirements definition for CLDs. As part of NASA's annual budget planning cycle, we are refining the fly-out plan for ISS and the initial flight plan for CLDs, as well as the budget phasing required to support a healthy transition for transportation and utilization to ensure ongoing access to and use of LEO. This work is ongoing with NASA's stakeholders in Congress and the Executive Branch.

Additionally, NASA is actively working with its Phase 1 providers to better understand the size and scope of the future Commercial LEO market and recognizes that NASA will be integral to catalyzing the LEO economy. NASA has commissioned several studies to better understand market demand for LEO services, and many providers regularly provide NASA with updates on financial investments into their company, business demand outlook data, as well as revenue and cost projections to develop their CLDs sustainably.

This recommendation is **OPEN**.

2021-05-01: Development of Agency Strategic Vision for the Future of Space Explorations and Operations

Finding: 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.

Recommendation: NASA should develop a strategic vision for the future of space exploration and operations that encompasses at least the next twenty years, including potential alternative scenarios, that is driven by how the Agency is going to understand and manage risk in the more complex environment in which it will be operating.

- The vision should describe the role that NASA intends to play during that period and how it plans to engage with both commercial and international partners.
- NASA should assess the workforce, including the number, types, skills, experience, and responsibilities that will be required, and the infrastructure facility requirements, with a plan for managing changes needed to meet those requirements.
- NASA should also propose general criteria for evaluating "make, manage, or buy" decisions on future programs or projects.
- All aspects of the strategic vision and its implementation should be clearly and unambiguously communicated throughout the Agency.

Rationale: NASA is no longer the sole driver or customer for human spaceflight capabilities and related technology, nor is it the sole organization creating demand. NASA, however, still has a critical role and responsibility in the space sector, and the Agency's decisions, opinions, and direction have weight and merit in the industry and across the globe. Consequently, it is imperative for NASA leaders to establish a clear vision of the future and an understanding of the Agency's purpose to anchor its decisions today and tomorrow. A strategic vision, and a set of guiding principles—well communicated to NASA's workforce and stakeholders—will help the Agency navigate the new environments within which it must operate to execute government missions. In addition, such a top-down, strategically driven approach can expose and enable the organization to anticipate risks that otherwise might go unknown or unforeseen through an organic bottoms-up approach.

NASA's Response: NASA appreciates ASAP's communication of its concerns regarding the need for an Agency Strategic Vision, as outlined in the recommendation submitted to the Agency in December 2021. Since that time, significant progress has been achieved through the NASA Strategic Plan 2022, implementation of the Moon to Mars objectives, development of the Agency Master Plan, and other key milestones. While the NASA 2040 program discussed in last year's report as NASA's tool for implementation of the Strategic Vision, was formally sunsetted this year, and no longer exists as a standing initiative, many recommendations and foundational analysis have transitioned into implementation activities and progress has continued selectively, subject to budget authority and leadership priorities.

NASA reports continued progress in areas originally addressed under NASA 2040, including the advancement of the Agency Master Plan; improved collaboration between major mission directorates, particularly Science and Human Exploration; and increased coordination across centers relative to previous years.

With new Agency leadership in place at the end of 2025, and per the meeting between the Administrator and the ASAP, the NASA Strategic Plan 2026 will clearly articulate a long-term strategic vision for space exploration and operations over the next twenty years and beyond, reflecting the increasingly complex environment in which the Agency operates.

This recommendation is **OPEN**.

2021-05-02: Establishment of an Agency "Board of Directors"

Finding: Over the decades, at various times with varying amounts of success, NASA leadership has sought to create an Agency-wide identity to foster greater coordination. There remains, however, a very strong and separate culture at each NASA Center, which drives the Centers to prioritize their own goals rather than those of the overall Agency. In turn, this creates pressure against the implementation of a strategic approach that aligns the whole organization to a common set of goals. Importantly, moreover, the resource flow remains Center-focused rather than optimized around integrated outcomes.

Recommendation: As a part of an overall risk management approach and in order to develop and execute its strategic vision for the future of space exploration, NASA should establish and provide leadership through a "board of directors" that includes the Center Directors and other key officials, with the emphasis on providing benefit to the Agency's mission as a cohesive whole, and not to the individual components of the Agency. The Board should act to identify the strategic risks and obstacles that NASA may encounter in executing its mission, evaluate Agency-level mitigation approaches, and align the efforts of all Centers to ensure desired outcomes.

Rationale: Although NASA has well-established executive management forums through which it deliberates various Agency decisions, it does not convene senior leaders as a strategic team with a holistic perspective on the Agency. Thus, the Panel recommends the Agency adopt a "Board of Directors"-like governance approach for its executives. Under this construct, the Administrator's most senior staff at Headquarters and the Center Directors would comprise an Agency steering committee with a deliberate Agency-level focus, rather than as representatives from and advocates for their areas of responsibility or field centers.

NASA could convene this team in various ways, but it need not be a new or separate forum. Rather, NASA should set different engagement expectations for these leaders when they meet, in that they should "leave their individual program and/or Center hats at the door," and focus on corporate-level challenges, opportunities, and decisions driven by the best interests of the Agency and its ongoing missions. This imperative to focus on the entirety of the enterprise can help support the tough resource decisions necessary to contend effectively with the challenges of stakeholder demands, inevitable schedule pressures, and budget constraints. With NASA's critical resources, workforce, and infrastructure largely managed at field centers incentivized to protect them, the Agency has struggled for many years to shift the workforce out of less critical work, or

to divest obsolete facilities and infrastructure. This has added cost and manpower pressures to field centers that need margin for higher priority work, innovative solutions, and new opportunities. To escape the status quo—for example, protecting budget, preserving the workforce configuration, maintaining every building and piece of major equipment—an explicit shift to an Agency-level focus is an essential start to reducing fixed costs and freeing more resources for new work in space exploration.

NASA's Response: After discussion with the ASAP, NASA understands that the intent of this recommendation is not to stand up or establish a new body. As such, NASA appreciates the intent of the recommendation to ensure that the Agency's most senior leaders are aligned and accountable for a holistic strategic vision. NASA further agrees that this vision should be executed as a cohesive whole, rather than through isolated components of the Agency, noting that some top-down decisions have been executed successfully and additional work is needed to build trust across centers and reduce competitive behaviors driven by budget uncertainty. With new Agency leadership in place, priorities include acknowledging and addressing shortcomings, strengthening accountability and transparency, improving decision velocity, and reinforcing the Agency's prestige—all of which are fully consistent with the spirit of this recommendation.

This recommendation is **OPEN**.

2019-02-01: Required Transition to Next Generation Extravehicular Mobility Units (EMUs)

Finding: The ASAP has become increasingly concerned with the risk posture that NASA has adapted regarding the current EMUs used in International Space Station (ISS) operations and has concluded that the current EMUs are now outside their design life.

Recommendation: NASA should begin an immediate transition to a new-generation Extravehicular Activity (EVA) suit system EMU, before the risk to EVA becomes unmanageable.

Rationale: It is an undeniable fact that the 40-year-old EMUs used in ISS operations are reaching the end of their useful life. The Panel reviewed the increasing challenges of difficult upgrade efforts, loss of component vendors over time, lack of critical refurbishment parts, and life extension analyses that will grow in uncertainty as the suit hardware continues to age. Over the years, the Panel has commented on the highly innovative and often heroic approach that NASA has taken to devise EMU component upgrades and suit life extensions. The Panel has also noted the small but productive steps accomplished by the development program for the next generation xEMU prototype. The current plan is to extend today's EMU use to 2028; however, it is increasingly apparent that the usable life of the current EVA suits is limited. The Panel encourages NASA to step back from day-to-day management issues to view this urgent issue from a broader, more holistic outlook. The problem does not lie simply in the fact that the suits are old; but the fact that manufacturers of several critical suit components, including the very fabric of the suits, have now gone out of business, creates real urgency for transitioning to new EVA suit systems. New suits are needed not only for future space exploration, but also for its current space activities. NASA cannot maintain the necessary, ongoing low-Earth orbit operations without fully functional EVA suits.

NASA's Response: NASA continues to develop Lunar Surface and Microgravity next generation EVA service capability and is assessing an ISS demonstration of the Microgravity capability. The EMU continues to go through rigorous life evaluation of all components and proactively refurbishing or replacing all components as needed for life. With this continuous replacement of components, NASA is able to certify the EMU to its original performance and safety requirements, ensuring no additional risk to the crew. No trend in age related failures has been identified with the EMU, however inventory and obsolescence challenges must be continually managed. Supply chain and obsolescence issues affect the EMU the same way they affect other NASA systems, given the niche market and very low demand of custom parts and specific materials (this is not isolated to an aging EMU). The existing EMU inventory is sufficient to support ISS through 2030, but a significant ISS extension would require unplanned financial investment and lead time to increase inventory and replace critical components. While continuing to manage these challenges, the EMU does have design deficiencies including the crossover between the vent loop and water loops that allows some failure modes to result with water in the helmet. NASA continues to implement many mitigations to this risk.

This recommendation is **OPEN**.

2015-05-02: Human Space Flight Mishap

Finding: The CCP is now developing a formal plan for how it will respond in the event of a major malfunction or mishap. In addition to optimizing what can be learned by proper investigation of malfunctions or mishaps, this plan must comply with the specific language in the NASA Authorization Act of 2005 concerning Human Spaceflight Independent Investigations. NASA has tentatively identified the entities that would investigate various types of mishaps during the five mission phases. Under the current Authorization language, a Presidential Commission would be required in all cases involving loss of the flight crew as well as in all cases involving loss of the vehicle, even if the flight crew is not injured. Use of a Presidential Commission in the latter cases appears excessive.

Recommendation: The Authorization language should be reviewed with today's systems in mind. Also, more details appear appropriate for the NASA implementation document. These details would include the level of vehicle damage requiring investigation, the temporal issues of when mission phases begin and end, and NASA's oversight role in mishap investigations conducted by its providers, as well as when the need for outside oversight is required. The mishap response procedures should be thought through, documented, and in place well before any actual flights.

Rationale: The requirement for a Presidential Commission was logical for the International Space Station (ISS) or Space Shuttle missions because they were reusable national assets. It would, however, appear excessive in some cases for commercially provided vehicles or other vehicles not planned for reuse. One example would be the sinking of a non-reusable vehicle after the flight crew had been safely recovered and were on their way home.

NASA's Response: NASA originally responded on April 30, 2016, concurring with the recommendation. The response stated that NASA was reaching out to the Federal Aviation Administration (FAA) and the

National Transportation Safety Board to jointly develop viable options to revise the Authorization language with today's systems in mind. NASA provided a follow-up response on March 20, 2017, in which they provided the results of NASA's assessment of strategy option in the event of a major malfunction or mishap in the Commercial Crew Program (CCP). The ASAP provided a written response on September 8, 2017, followed by subsequent discussions during which the ASAP provided alternate solutions to which NASA provided a third response on March 15, 2018. NASA and the Congress are still working to establish a satisfactory process to address the concerns previously articulated. The ASAP believes action is increasingly essential and urgent as NASA has already begun launching astronauts on commercially provided vehicles, and the future Artemis missions will be even more complex in their involvement of commercial providers and international partners.

On July 11, 2025, a legislative proposal for the 119th Congress entitled "Amendment of Human Space Flight Accident Investigation Committee" was submitted to the Senate Commerce, Science and Transportation Committee, the congressional authorizing committee of jurisdiction.

Since the enactment of Chapter 707 in 2005, NASA's human spaceflight mission has evolved significantly. The proposed amendment recognizes that the requirement for the Presidential Commission is not optimized for NASA's human spaceflight efforts; and modifies the requirement to better align with the need for a rapidly responsive, transparent investigation of human spaceflight mishaps across a variety of flight regimes.

Proposed changes to Sections 70701-70704 of chapter 707 of Title 51, include:

- Adding the definition of a Mishap Interagency Investigation Board (MIIB) and a
- Change in the language requiring the Establishment of a Commission to state that "The President may make a determination whether to establish an independent, nonpartisan Commission within the executive branch or authorize the NASA Administrator to activate the independent MIIB to investigate incidents that result in the loss of the International Space Station or its operational viability; or (2) any other orbital space vehicle carrying humans that is owned by the Federal Government; or (3) a U.S. crew member or U.S. passenger physically located on the International Space Station or on a U.S. space vehicle owned by the Federal Government or space system owned by the Federal Government. (4) any other space vehicle or space systems occupied by humans under contract with the Federal Government, or U.S. crew member on the vehicle or system, that is not covered under 2 or 3 (above) and not covered by an existing mishap investigation authority."

At the time of the writing of this Annual Report, the proposal had not been introduced as bill language.

This recommendation is **OPEN**.

Appendix B

Aerospace Safety Advisory Panel Members

Lieutenant General Susan J. Helms, USAF (Ret.)

- Chair, Aerospace Safety Advisory Panel
- Former Commander, Joint Functional Component Command for Space, U.S. Strategic Command, and 14th Air Force, Air Force Space Command
- Former Commander, 45th Space Wing, Cape Canaveral, FL
- Former NASA Astronaut
- Former Air Force Flight Test Engineer

Lieutenant General Susan J. Helms, USAF (Ret.), is currently an independent consultant and the Principal of Orbital Visions, LLC. She has served on several boards, including the Board of Trustees for The Aerospace Corporation, and is a member of the National Academy of Engineering.

General Helms has almost 36 years of military service in the USAF. In her last assignment, she was Commander of the 14th Air Force, Air Force Space Command and Commander of the Joint Functional Component Command for Space, U.S. Strategic Command at Vandenberg Air Force Base in California. As the leader of the USAF's operational space component, General Helms led more than 20,500 personnel responsible for providing missile warning, space superiority, space situational awareness, satellite operations, space launch, and range operations. As Commander of the Joint Functional Component Command for Space she directed all assigned and attached space forces providing tailored, responsive, local, and global space effects in support of national and combatant commander objectives.

General Helms was commissioned from the USAF Academy in 1980 and is a distinguished graduate of the USAF Test Pilot School (Flight Test Engineer Course). She has served as an F-15 and F-16 weapons separation engineer and as a flight test engineer for the CF-18. She has also commanded the 45th Space Wing of Patrick Air Force Base at Cape Canaveral, Florida and served as the J5 of the U.S. Strategic Command.

Selected by NASA in January 1990, General Helms became an astronaut in July 1991. On January 13, 1993, then an Air Force Major and a member of the Space Shuttle Endeavour crew, she became the first U.S. military woman in space. She flew on STS-54 (1993), STS-64 (1994), STS-78 (1996), and STS-101 (2000), and

she served aboard the ISS as a member of the Expedition-2 crew (2001). A veteran of five spaceflights, General Helms has logged 211 days in space, including a spacewalk of 8 hours and 56 minutes, a world record. She was inducted into the Astronaut Hall of Fame in 2011.

Mr. William P. Bray

- Former Vice President, Strategic Business Operations, Frontier Technology Incorporated
- Former Deputy Assistant Secretary of the Navy for Research, Development, Test and Evaluation (DASN RDT&E)
- Former Executive Director, Navy Program Executive Office (PEO) for Integrated Warfare Systems (IWS)
- Former Director for Integrated Nuclear Weapons Safety and Security at Navy Strategic Systems Program, Direct Reporting Program Management

William P. Bray is currently the Principal Consultant and owner at W.P. Bray Consulting, providing independent consultant services to the defense and aerospace acquisition and engineering community. From Feb 2021 to Aug 2022, he served as the Vice President for Strategy and Business Operations at a defense data analytics company.

Prior to that, Bray retired in October 2020 after 36 years of government service, the last 14 years serving in the Senior Executive Service (SES). His last assignment was as the Deputy Assistant Secretary of the Navy (DASN) for Research, Development, Test and Evaluation (RDT&E) under the Assistant Secretary of the Navy (ASN) for Research Development and Acquisition (RD&A). In that role, Bray was responsible for executive oversight of all matters related to Naval RDT&E Budget Activities, Science and Technology, advanced Research and Development, Prototyping and Experimentation, Systems Engineering, and Test and Evaluation. In addition, he was responsible for oversight and stewardship of the Department of Navy Research and Development Establishment which included all Naval Laboratories, Warfare Centers, and Navy University Affiliated Research Centers.

Prior to the DASN RDT&E position, Bray was the Executive Director for PEO Integrated Warfare Systems (IWS), where he directed the acquisition and Fleet support of the Surface Navy's combat systems, weapons, radars, and related international and foreign military sales programs. Other leadership roles within the Navy included the Director, Integrated Nuclear Weapons Safety and Security at the Navy Strategic Systems Programs Office, and Major Program Manager (MPM)

for Surface Navy Combat Systems. Mr. Bray started his career at the Naval Surface Warfare Center, Corona Division, Corona, California in December 1984.

Bray graduated from The Pennsylvania State University in 1984 with a B.S. degree in Petroleum and Natural Gas Engineering and earned a Master of Science in Systems Management from the University of Southern California. He was a member of the defense acquisition workforce and certified at Defense Acquisition Workforce Improvement Act (DAWIA) Level III in Program Management, Systems Engineering, and Test and Evaluation. During his government career, he received a Meritorious Executive Presidential Rank Award in 2018, the Navy Distinguished Civilian Service Award in 2017 and 2020, and the Navy Superior Civilian Service Award in 2013.

Dr. Amy K. Donahue

- Provost and Chief Academic Officer, United States Coast Guard Academy
- Professor emeritus of Public Policy, University of Connecticut (UConn)
- Former Senior Advisor to the Administrator for Homeland Security at NASA

Dr. Amy Donahue is Provost and Chief Academic Officer at the United States Coast Guard Academy. She is responsible for the quality and effectiveness of the Academy's academic enterprise in support of its core mission to educate leaders of character who serve as officers in the Coast Guard. Dr. Donahue is also professor emeritus of public policy at the University of Connecticut (UConn). As a social scientist, her research has focused on executive leadership, homeland security, and disaster preparedness.

From 2011 to 2018, Dr. Donahue served as the UConn's Vice Provost for Academic Operations and Chief of Staff to the Provost. As part of a small team of executive leaders, she was a key partner in developing the $1.7 billion Next Generation Connecticut program, crafting the University's academic vision, guiding program development to support excellence in teaching and learning, preparing the University for reaccreditation, and building a new regional campus.

Previously, Dr. Donahue headed UConn's Department of Public Policy. She also advised the Chancellor of Louisiana State University (LSU) immediately following Hurricane Katrina. She was principal investigator on research funded by the Department of Homeland Security as part of the Center of Excellence for the Study of Natural Disasters, Coastal Infrastructure and Emergency Management. From 2002 to 2004, Dr. Donahue was Senior Advisor to the Administrator for Homeland Security at NASA. In 2003, she had a major leadership role in the field response

to the crash of space shuttle Columbia. From 2004 to 2007, Dr. Donahue served on the Aerospace Safety Advisory Panel. She was reinstated to the Panel in 2021.

As the Distinguished Military Graduate of Princeton's Reserve Officer Training Corps in 1989, she began her career serving in the U.S. Army on active duty in the 6th Infantry Division at Fort Wainwright, Alaska. Her military assignments included serving as Officer in Charge of a Forward Surgical Team, as the Training and Operations Officer (S3) for the 706th Main Support Battalion, and as Chief of Mobilization, Education, Training, and Security for Bassett Army Hospital.

Dr. Donahue holds her Ph.D. in Public Administration and her Master of Public Administration (MPA) from the Maxwell School of Citizenship and Public Affairs at Syracuse University. She graduated magna cum laude with a B.A. in Geological and Geophysical Sciences from Princeton University. She was elected a fellow of the National Academy of Public Administration in 2011.

Mr. Paul Sean Hill

- Author, Speaker, and Principal of Atlas Executive Consultant, LLC
- Former Director of Mission Operations, NASA Johnson Space Center
- Former Shuttle and ISS Flight Director

Paul Sean Hill is a speaker and consultant focused on creating and leading high-performing teams in any industry. He also is a Director of the Manned Spaceflight Operations Association, chaired NASA's Orion Thermal Protection System Independent Review Team, and is the author of *Leadership from the Mission Control Room to the Boardroom* and *The Last Butterfly*.

During his 25 years at NASA, he first developed Space Station construction techniques and then led flights from Mission Control as a Space Shuttle and ISS Flight Director. He supported 24 missions as a Flight Director from 1996 through 2005, culminating as the Lead Shuttle Flight Director for the return to flight on STS-114 after the Columbia accident. After a series of senior leadership positions, Hill served as the Director of Mission Operations for human spaceflight from 2007 through 2014, responsible for all aspects of mission planning, flight controller and astronaut training, and Mission Control. He is credited with revolutionizing the leadership culture, dramatically reducing costs, and increasing capability, all while still conducting missions in space.

Before his work with NASA, Hill served in the USAF in military satellite operations. He earned his Bachelor and Master of Science degrees in aerospace engineering

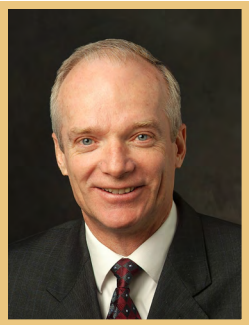
from Texas A&M University in 1984 and 1985, respectively, and was a member of the Corps of Cadets.

His professional awards include the Presidential Rank Award of Meritorious Executive, three NASA Outstanding Leadership Medals, the NASA Distinguished Service Medal, the NASA Exceptional Service Medal, the Rotary National Award for Space Achievement Stellar Award, and selection as one of the Marshall Goldsmith 100 Coaches.

Ms. Katharina McFarland

- Former Vice Chair of the Army Science Board
- Director of SAIC Board of Directors
- Director of Transphorm Board of Directors
- Former Chairman and current member of the Board of Army Research and Development at the National Academies of Science

Katharina McFarland, with over 30 years of government service, is widely recognized as a leading subject-matter expert on government procurement. From 2012 to 2017, she was the Assistant Secretary of Defense for Acquisition, as well as acting Assistant Secretary of the Army for acquisition, logistics, and technology from 2016 to 2017. She was President of the Defense Acquisition University from 2010 to 2012. From 2006 to 2010, McFarland was the Director of Acquisition for the Missile Defense Agency. She is an accredited materials, mechanical, civil, and electronics engineer. She has received an Honorary Doctoral of Engineering from the University of Cranfield, United Kingdom; the Presidential Meritorious Executive Rank Award; the Secretary of Defense Medal for Meritorious Civilian Service Award; the Department of the Navy Civilian Tester of the Year Award; and the Navy and United States Marine Corps Commendation Medal for Meritorious Civilian Service. McFarland has substantial experience with the US Department of Defense, Department of Army, and intelligence community procurement with focuses on space applications, artificial intelligence, cyber, and informational technologies in defense acquisition, program management, logistics, and technology.



Mr. Charlie Precourt

- Former Vice President and General Manager, Northrop Grumman
- Former NASA Astronaut
- Retired USAF Colonel, Fighter Pilot and Test Pilot

Charlie Precourt currently serves as a director on several boards, and consults in a variety of aerospace activities, including director with the National Business Aviation Association, the Experimental Aircraft Association, World View, Inc., Avio, USA, the American Center for Manufacturing and Innovation and the Astronaut Scholarship Foundation. He was appointed to NASA's Aerospace Safety Advisory Panel in 2023.

Precourt led the solid rocket motor propulsion business at Northrop Grumman, having joined the company in 2005 and retiring in 2021. In that capacity he oversaw a workforce of 3,500 employees in engineering, manufacturing, and program management with a portfolio including NASA's Space Launch System, the US Navy Trident D5, the USAF Sentinel and Minuteman Nuclear Missile systems, propulsion for DoD's satellite launch vehicles, and two new hypersonic missile programs that are a national priority.

Precourt joined Northrop Grumman following a 15-year career with the NASA, where he was an Astronaut and a program manager in the Senior Executive Service. He was qualified as an astronaut in 1991, and is a veteran of four Space Shuttle missions, serving as pilot and commander. After piloting Atlantis for the first docking with the Russian Mir Space Station in 1995, he gained extensive experience working with the Russian Space Agency and was appointed Director of Operations for NASA at the Gagarin Cosmonaut Training Center in Star City, Russia. From 1998 through 2002, he was Chief of NASA's Astronaut Corps, responsible for the selection, training, and mission certification of all Space Shuttle and ISS crews. Mr. Precourt was later appointed Deputy Program Manager for the International Space Station, responsible for the day-to-day management of ISS operations, on-orbit assembly, and the interfaces with NASA contractors and the ISS International Partners in Europe, Canada, Russia, and Japan. He was inducted into the Astronaut Hall of Fame in 2012.

Precourt entered USAF active duty upon commissioning from the US Air Force Academy in 1977 and completed Pilot Training in 1978. From 1981 to 1984 he was an F-15 pilot and flight commander at Bitburg Air Base in Germany. He then attended the USAF Test Pilot School at Edwards AFB and served as a test pilot on the F-15E developmental test program and later as an instructor at the USAF Test Pilot School. He served twenty-three years in the US Air Force, retiring as a Colonel.

A native of Hudson, Massachusetts, Precourt received a Bachelor of Science degree in aeronautical engineering from the United States Air Force Academy in 1977 having also attended the French Air Force Academy in 1976 as part of an exchange program. He earned a Master of Science degree in engineering management from Golden Gate University in 1988, and a Master of Arts degree in national security affairs and strategic studies from the United States Naval War College in 1990.

Mr. Kent V. Rominger

- Former Vice President of Strategic Programs at Northrop Grumman Propulsion Systems
- Former NASA Astronaut
- Former Navy Fighter and Test Pilot

Kent Rominger held numerous positions at Northrop Grumman, Orbital ATK, and ATK over a 15-year period from 2006 to 2022. These positions included the director of Missile Programs, the vice president and capture lead for the OmegA launch system, the vice president of Strategic Programs with responsibility for the Navy's Fleet Ballistic Missile Program, the USAF's Ground Based Strategic Deterrent pursuit and Minuteman II Sustainment. He also served as vice president of Strategy and Business Development for Propulsion Systems and as vice president of Propulsion Systems' Test and Research Operations. Mr. Rominger joined Northrop Grumman (ATK) in October 2006 as vice president of Advanced Programs following distinguished careers with NASA and the U.S. Navy.

Rominger was selected as a NASA astronaut in 1992. A veteran of five space shuttle flights, including two as the mission commander, has logged over 1,600 hours and traveled almost 27 million miles in space. He culminated his NASA career as the Chief of the Astronaut Office and was selected into the Astronaut Hall of Fame in 2015.

Rominger was commissioned as a naval officer in 1979. During his 26-year career, he served as an F-14 Tomcat pilot with fighter squadrons VF-2 and VF-211 and as a Navy test pilot. While with VF-211, he completed a deployment to the Arabian Gulf during Operation Desert Storm. He is a graduate of the Navy Fighter Weapons School (Top Gun) and the Naval Test Pilot School at Patuxent River, Maryland. He has logged more than 8,500 flying hours in 35 different types of aircraft and has completed 685 carrier landings.

A native of Del Norte, Colorado, Rominger received a bachelor's degree in civil engineering from Colorado State University and a master's degree in aeronautical engineering from the U.S. Naval Postgraduate School.

Dr. Mark N. Sirangelo

- Scholar in Residence at the University of Colorado
- Founding executive and former Head of Sierra Nevada Space Systems
- Founding member and past Chairman of the Commercial Spaceflight Federation
- Most recent past Chairman of the DoD Defense Innovation Board

Dr. Mark N. Sirangelo currently is the Scholar in Residence at the University of Colorado. He is also on the Tuskegee University Aerospace Advisory Board and is a visiting professor of government at Syracuse's Maxwell College. In addition, he provides industry advisory services through his company QS Advisors, LLC. Dr. Sirangelo has over a two-decade industry executive aerospace and space career having led teams which have successfully managed billions of dollars of programs for over 300 programs and missions.

In the space industry, he was the founding executive and head of Sierra Nevada Space Systems for over 10 years until 2018. Previously, Dr. Sirangelo was the Chairman and Chief Executive Officer (CEO) of SpaceDev, a publicly traded commercial space company that he grew from an early stage. He was a past two-term Chairman of the Commercial Spaceflight Federation, has been inducted as a Fellow of the American Institute of Aeronautics and Astronautics and has served on the executive board of the Aerospace Industries Association.

Dr. Sirangelo served as the Chief Innovation Officer of the State of Colorado. He is the most recent past Chairman of the U.S. Department of Defense's Defense Innovation Board and the founding past Chair of the DoD's Space Advisory Committee. Previously, he completed an assignment as Special Assistant to the NASA Administrator helping to develop NASA's Moon to Mars program.

Dr. Sirangelo and his organizations have been recognized with induction into the Space Foundation's Technology Hall of Fame, the World's Top 10 Innovative Space Companies by Fast Company, Inc. Magazine's top 200 companies, Defense Industry's Fast Track 50, and in Ernst & Young's Entrepreneur of the Year amongst other awards.

One of the ways Dr. Sirangelo gives back to the space industry is as the founder and Chairman of eSpace, a nonprofit that supports the start-up and growth of space technology companies. As a personal passion, he has worked to make the world a safer place for children as a founding and two-decade Board member of the National Center for Missing and Exploited Children (NCMEC) which resolved over 100,000 missing children's cases to date. He holds Bachelor of Science, Master's in Business Administration, and Doctorate level degrees and has served his country proudly as a U.S. Army officer.

Dr. Richard S. Williams, MD, MPH, FACS

- Medical Consultant, Virginia Department of Health
- Former Senior Aviation Medical Examiner, Federal Aviation Administration
- Former NASA Chief Health and Medical Officer

Dr. Richard S. Williams is a general surgeon and aerospace medicine physician who currently serves as a Medical Consultant in the Virginia Department of Health. His duties include providing medical consultation services to Virginia public health districts without a physician on staff and serving as a consultant for the Medical Director, Community Health Services, Virginia Department of Health. Dr. Williams is also a former FAA Senior Aviation Medical Examiner and still provides aeromedical consultation services for all classes of airmen on request. Previously, he served as NASA's Chief Health and Medical Officer. He spent 27 years in the USAF as a general surgeon, flight surgeon, and medical manager and leader, domestically and in contingency operations abroad.

Dr. Williams was assigned to NASA Headquarters as an Air Force Colonel in 1998. He served as Director of the Office of Health Affairs and entered the Senior Executive Service as NASA's Chief Health and Medical Officer in 2002. He led NASA's health care team through the construction and initial operation of the ISS and the final years of the Space Shuttle Program. His responsibilities included leadership, policy, oversight and advocacy for astronaut health care, NASA employee health care, protection of research subjects, and bioethics. During his 15-year-tenure, Dr. Williams led efforts to secure legislative authority for beyond-career astronaut health care, implemented Health and Medical Technical Authority, produced policies on ethics-based risk assessment for astronaut health and medical exposures during spaceflight missions, and fostered cooperative efforts between NASA's Human Research Program and health care system to better understand spaceflight related health risks and mitigations.

Dr. Williams received a B.S. degree from the College of William and Mary in 1975, as well as an MD degree in 1979 and a Master of Public Health (MPH) degree in 1996, both from Virginia Commonwealth University. He completed general surgery residency at Wright State University in 1984 and aerospace medicine/occupational health residency at the USAF School of Aerospace Medicine in 1998. He is a Fellow of the American College of Surgeons and maintains certification by the American Board of Preventive Medicine in Aerospace Medicine. His awards and decorations include the Bronze Star medal, the Meritorious Service Medal, the John R. Tamisea Memorial Award, NASA's Space Flight Awareness Award for Safety, the Melbourne C. Boynton Award, the Seniors Executive Service Presidential Rank Award, the W. Randolph Lovelace Award, the Forrest M. and Pamela Bird Award, the NASA Exceptional Leadership Medal, and the NASA Distinguished Service Medal. He has contributed to and published numerous articles and book chapters relevant to aerospace medicine.

Aerospace Safety Advisory Panel Members

Ms. Carol Hamilton

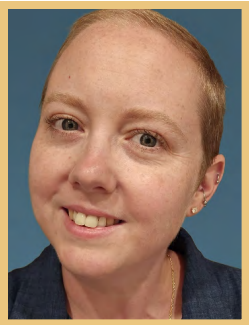
- Aerospace Safety Advisory Panel Executive Director

Carol Hamilton, Executive Director of the ASAP since 2015, has specialized in system safety engineering for more than 25 years. Her career also includes experience in systems engineering, systems verification, and system test engineering for both NASA space systems and the Department of Defense systems. During her time at Goddard Space Flight Center from 1991 to 2015, Hamilton contributed to more than 20 spaceflight missions, serving as a Senior System Safety Engineer for Hernandez Engineering for 8 crewed Space Shuttle missions and later as the Project Safety Manager for 14 uncrewed space missions. During her NASA career, Hamilton has been an instructor for the NASA Safety Training Center and has served on several NASA mishap investigation boards.

Ms. Lisa Hackley

- Aerospace Safety Advisory Panel Administrative Officer

Lisa Hackley has worked at NASA Headquarters for more than 29 years, providing administrative support for numerous mission directorates and divisions, including the Office of Space Flight (now Human Operations and Exploration), the Office of Life and Microgravity Science and Applications (now Space Life and Physical Sciences), the Office of Biological and Physical Research, and the Office of International and Interagency Relations (OIIR). Prior to joining the Advisory Committee Management Division as the ASAP Administrative Officer in May 2019, Ms. Hackley worked in OIIR's Export Control and Interagency Liaison division for 15 years, including a voluntary secondment to the Federal Emergency Management Agency in late 2017 to assist with hurricane relief efforts.

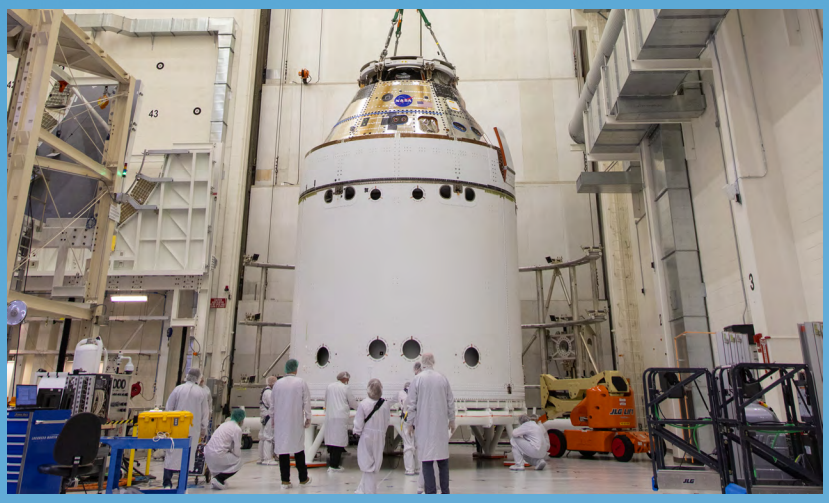


Ms. Ashley Mae, RN

- Aerospace Safety Advisory Panel Technical Writer

Ashley Mae is an accomplished technical writer with more than a decade of experience specializing in medical, scientific, and educational content. She holds a Bachelor of Science in Nursing from Georgia Southern University and a Master of Science in Nursing Education from Western Governors University, combining a strong academic foundation with extensive clinical and instructional experience. In April 2020, Mae deployed as an emergency mobilization response nurse to New York City, where she worked in a Queens hospital providing care to COVID-19 patients during the height of the pandemic. This experience, along with her broader clinical background, has informed her understanding of healthcare systems, patient care, and operational risk in high-consequence environments.

Mae has more than five years of experience in nursing education and currently serves as an Environmental Health Technician at Robins Air Force Base, where she supports occupational health, hazard assessment, and regulatory compliance in complex operational settings. This role further informs her perspective on risk identification, safety culture, and compliance-driven documentation. She is currently entering her fourth year serving as the Aerospace Safety Advisory Panel (ASAP) technical writer and editor for Tom & Jerry, Inc., where she supports the development of high-quality reports for diverse technical and leadership audiences. Through her interdisciplinary background, Mae brings a unique blend of clinical expertise, safety and compliance experience, educational insight, and technical writing proficiency to safety-critical documentation.



Aerospace Safety Advisory Panel

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Mr. William P. Bray
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Ms. Katharina McFarland
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Dr. Richard S. Williams

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