

**NASA AEROSPACE SAFETY ADVISORY PANEL**  
National Aeronautics and Space Administration  
Washington, DC 20546  
*Dr. Patricia Sanders, Chair*

August 3, 2022

The Honorable Bill Nelson  
Administrator  
National Aeronautics and Space Administration  
Washington, DC 20546

Dear Sen. Nelson:

The Aerospace Safety Advisory Panel (ASAP) held its 2022 Third Quarterly Meeting in-person at the Johnson Space Center, July 19-21, 2022. We greatly appreciate the participation and support that were received from NASA leadership, the subject matter experts, and the support staff.

The Panel submits the enclosed Minutes resulting from the public meeting for your consideration.

Sincerely,

A handwritten signature in cursive script that reads "Patricia Sanders".

Patricia Sanders  
Chair

Enclosure

## **AEROSPACE SAFETY ADVISORY PANEL**

Public Meeting

July 21, 2022

### **2022 Third Quarterly Meeting Report**

#### **Aerospace Safety Advisory Panel (ASAP)**

##### **Attendees:**

Dr. Patricia Sanders, Chair  
Lt Gen (Ret) Susan Helms  
Mr. Paul Sean Hill  
Dr. Sandra Magnus  
Dr. Amy Donahue  
Mr. William Bray  
Mr. David West  
Dr. Richard Williams  
Dr. Mark Sirangelo

##### **Telecon Attendees:**

See Attachment 1

#### **ASAP Staff and Support Personnel**

##### **Attendees:**

Ms. Carol Hamilton, NASA ASAP Executive Director  
Ms. Lisa Hackley, NASA ASAP Administrative Officer  
Ms. Kerry Pettit, Technical Writer/Editor

#### **Opening Remarks**

Ms. Carol Hamilton, ASAP Executive Director, called the meeting to order at 11:30 a.m. CDT and welcomed everyone to the ASAP's Third Quarterly Meeting of 2022. She indicated that the Federal Registry Notice gave the public the opportunity to send safety-related statements or to make opening comments prior to the scheduled meeting. It was noted that no such comments or statements had been submitted prior to the meeting, but time would be allocated at the end for public comments.

Dr. Patricia Sanders, ASAP Chair, opened the meeting by thanking NASA Johnson Space Center (JSC) Director, Ms. Vanessa Wyche, and all of the JSC personnel for hosting the ASAP (Panel) this week. She added that it remains both refreshing and beneficial to be able to meet in person, although the pandemic has clearly not stopped having its impact on the environment. In fact, Dr. Sanders noted, two Panel members participated virtually as they worked their way through COVID-19 recovery. The Panel continues to monitor the effects the virus has on the NASA mission as well. Dr. Sanders stated that NASA has seemed to do a good job taking care of the physical health of its workforce family, and the influence of COVID-19 on the execution has been minimized—although not without insignificant cost and schedule impact. The ASAP is also watching the bearing the pandemic has had on the mental health of the NASA family, which has been a watch item throughout the week.

As the Panel engaged with the various NASA program organizations, the activities were viewed through the lens of the three strategic recommendations made last fall. As a reminder, Dr. Sanders summarized these recommendations: (1) strategic forward-looking at NASA's role with respect to the evolving commercial space environment including the vital communication with the workforce; (2) the associated governance model within NASA to execute the mission as a holistic enterprise; and (3) the management of the overall Artemis or Moon-to-Mars effort as a disciplined and integrated program.

Dr. Sanders then asked Dr. Sandra Magnus and Lt Gen Susan Helms to share their observations on the Commercial Crew Program (CCP).

## **Commercial Crew Program**

### ***SpaceX***

NASA is getting ready to launch Crew-5 in the next few months, continuing the cadence of operations that has been established since Crew-1 launched in late 2020. As both NASA and SpaceX have gained experience with working together, Dr. Magnus stated, and SpaceX has accumulated a flight history on both the Falcon 9 booster and the Dragon capsule, NASA has been thinking carefully about re-use and their certification processes for re-use. As a result, NASA has determined that it is comfortable with up to a five-time re-use for both the Falcon 9 and the crewed Dragon capsule. Dr. Magnus added that NASA has mapped out the certification process for re-use and explained the approach, which consists of tracking the ongoing changes and upgrades to the vehicles and doing delta certifications as needed. As the program matures and continues to expand the operational envelope, and in light of the fact that SpaceX has built up some flight history, the Panel asked the NASA team to spend time reviewing some of the early assumptions that were made and whether those assumptions remain valid. Specifically, the Panel reviewed the use of composite overwrapped pressure vessels (COPVs) in liquid oxygen environments, abort performance, and the rough sea landings, especially with nearly full hypergolic tanks. Dr. Magnus indicated that NASA and SpaceX continue to operate within the margins and the defined operating parameters for the COPVs; have been constantly updating and ingesting their models for abort calculations with flight data; and have robust discussions regarding balancing the risks between protecting propellant for certain contingency situations and management of sea states for safe landings. The Panel suggested that NASA and SpaceX continue to examine other foundational assumptions as the system continues to mature and as the flight history grows.

Dr. Magnus observed that in the next few years—as SpaceX continues to launch at a high cadence, Boeing comes online with its vehicle, the Space Launch System pad sees more activity, and the Vulcan and New Glenn rockets materialize—Kennedy Space Center (KSC) launch operations will become quite busy and launch traffic and pad management will become challenging. She added that NASA will have to examine such things as access to pads for launch prep, clearing pads for launches, juggling launch windows and vehicle availability, and protecting launch capability in the case of contingency situations. The Panel saw a hint of this in the spring when there was conjunction of SpaceX, Boeing, and Artemis launch and pad access requirements that had to be balanced. This traffic congestion problem will continue to grow, and the Panel understands that an activity has been initiated to study these trends and to start thinking about how to manage an ever-increasing amount of launch activity. This is a good problem to have, Dr. Magnus acknowledged, and the Panel looks forward to future discussions on the results of this work as all of these risk and safety balances are managed at a busy launch complex.

Despite the increase in cadence and complexity, it appears that the crew launch cadence appears to be continuing nominally, Dr. Magnus stated, adding that the teams address in-flight anomalies as they occur and disposition them via processes reminiscent of the failure and risk management discussions that have always been core operational strengths in NASA programs.

### ***Boeing***

The Panel had the opportunity to review the status of Boeing's contribution to CCP. Lt Gen Helms noted that the Program Office gave the Panel a summary of Orbital Flight Test 2 (OFT-2), which was executed the 19<sup>th</sup> to the 25<sup>th</sup> of May 2022. Lt Gen Helms indicated that most of the test objectives were successfully met, including docking and hatch opening with the ISS and numerous system checkouts throughout all phases of the operations. Postflight analysis of the vehicle performance is ongoing, she added, and a Joint Anomaly Leadership team has been stood up to work resolution plans as issues are identified.

Lt Gen Helms added that in preparation for Crewed Flight Test (CFT), a comprehensive, although fairly large list of issues is being worked by the team, ranging from completing the necessary abort loads analyses to the finalizing of crew displays. The Panel had the opportunity to walk through the open work with the program office—including crew members, the Chief Engineer, and the Safety Officer—all of whom shared their top program safety issues and concerns regarding the CFT mission. Throughout these discussions there was confidence that forward plans for addressing that open work were expected to be effective, and that the risk management approach of the CFT mission was well understood by all, Lt Gen Helms stated. The Program is also carrying forward a punch list of post-CFT items for the follow-on operational Starliner missions. The Panel's overall sense is that preparation for CFT is going well. The right people are engaged; with the right information, they are communicating effectively and employing appropriate management approaches.

Of note, nearly all of the NASA personnel the Panel spoke to had mentioned a significant improvement in communication and transparency with the Boeing team, perhaps owing in part to recent changes in Boeing's management and increased staffing levels on Boeing's side. These changes have had a notable effect in NASA's confidence in the NASA/Boeing teamwork to manage any forward challenges.

Dr. Sanders noted that one of the lessons learned, which evolved out of the CCP, has been the critical interaction between the commercial providers and the expertise of NASA personnel with an eye to knowing when to allow the industry to go its own way in meeting NASA's requirements and when to assist with solving technical issues that arise. She added that this balance on the insight/oversight continuum can be both subtle and key to successful outcomes, and also means that it is vital for NASA to retain the necessary talent and expertise to perform this function—for all its programmatic engagements. The Panel also heard this week from an amazing young NASA engineer about the intricacies of heat shields—a real tutorial on epoxy fills, temperature control, “lumpy spam,” and “wrinkly pica”—all of which demonstrated the kind of in-depth knowledge that NASA has been able to bring to the table.

Dr. Sanders emphasized that going forward it will be so very important for NASA to identify what skills it needs to retain and take the steps to sustain that expertise. One recurring theme the Panel noted throughout this quarterly meeting has been the challenge to workforce retention within the environment of a commercial space industry competing for that same talent with less restrictions on their hiring practices and resources.

Turning to the International Space Station (ISS), Dr. Sanders called on Dr. Mark Sirangelo to lead off with the Panel's observations following interchange with that program.

### **International Space Station**

The Panel wants to start this section by recognizing the dedication, talent, and abilities of the entire ISS team, being led by Joel Montalbano. Dr. Sirangelo noted that few people truly understand the complexity and difficulty of managing this facility at this stage of its life. He added that it has been fortunate that—over the course of its life and from the very first day that Bill Shepherd entered the facility over 20 years ago—NASA has been able to bring an unbroken line of ISS Program Manager and team members who work tirelessly 24-7/365 to enable this facility to be the nation's scientific outpost in space.

That said, the ISS is now in its third decade and is feeling its age, Dr. Sirangelo stated. It is a facility that is not running autonomously, but rather, needs to be actively managed every day and each week it faces new challenges. He went on to discuss the new challenges assessed as being critical and presented updates on the previous items the Panel has brought to the attention of NASA.

The Panel asked the program leadership to identify their top concerns/issues. The reported issues fall into the categories of: 1) physical structure issues and implications to the ISS life extension; 2) the failing status of the Extravehicular Mobility Unit (EMU) suits and the implications on the emergency needs of the station; 3) the need for a reliable second U.S. crew transportation provider to begin operations; and 4) the ongoing geo-political challenges and potential impact on the ISS partners and being able to continue to provide continuity for operations by executing agreements like the recently signed Soyuz/U.S. Crew Vehicle (USCV) crew swap agreement.

As reported by NASA, it appears that ISS partner relations continue to run smoothly. Communication between the control centers in Moscow and Houston, as well as with the other partners has been maintained at the level needed for operations. The U.S. team in Russia has been able to operate nominally. Dr. Sirangelo indicated that NASA continues to maintain the necessary staffing in Russia, of 30 people, and travel between Houston and Moscow for operational and coordination purposes has not been impeded.

Dr. Sirangelo stated that NASA and Roscosmos recently completed and approved an agreement on July 14 for cosmonauts to fly on USCV and for U.S. astronauts to fly on Soyuz to ensure U.S. and Russian crew members can maintain a presence onboard at all times, including in the event either country experiences an interruption in launch capability. Currently, the agreement includes one crew rotation on each other's vehicles per year with the first expected in the fall of 2022.

According to the Panel, three of the most significant issues facing the ISS are:

1. The threat of external debris impacting the station.
2. The current inability for the U.S. and its partners to do any critical contingency repair extravehicular activities (EVAs) due to the ongoing challenges with EVA suits, which are currently out of service until the root cause of the latest problem with water leaks in the helmet are understood.
3. Cracks in the pressure shell and resulting cabin atmosphere leaks.

### ***External Debris***

Dr. Sirangelo indicated that the U.S. has benefited from increased ability to track space debris both in the quality and consistency of the imaging as well as the ability to track even smaller debris pieces. This means, he explained, the baseline of resident space objects has increased due to better detection systems. That said, data indicates that the number of conjunctions with the ISS has increased substantially and by multiples over the past two years. Thus far in 2022, through June 1, the ISS has had a total of 681 conjunction notifications with 505 of these, or 74%, tracing to the Russian Anti-Satellite Test, known as Cosmos 1408 debris. The increase in conjunction notifications resulted in avoidance maneuvers. This produces an increased risk of roughly two times in the short term (100 forward day view), Dr. Sirangelo noted. The risk of a conjunction due to the Cosmos 1408 debris field diminishes to a single digit over the remaining expected life of the Station due to the Cosmos 1408 debris decaying out of orbit.

### ***EVA Challenges***

At this point, as previously noted, the U.S. and its ISS partners are unable to conduct EVAs on the ISS due to EVA suit concerns. Dr. Sirangelo emphasized that the failure is part of the ongoing challenges that have developed due to the age and degradation of the existing EVA suits, exacerbated by the inability to transport the EMU suits back for repair/refurbishment, and the lack of replacement suits to replace those that age out. He added that serious life-threatening problems, such as the water in the helmet incident, have occurred frequently. The engineering and operational teams have continually created workarounds with the result that it is nominal to have short-term fixes on top of the fixes incorporated into hardware and procedures.

The Panel has observed that the slow but steady compilation of workarounds has complicated maintenance and operations, slowly increasing the risk posture of operating the suits. Importantly, with the EMUs not available for use, NASA currently does not have a U.S. response capability for responding to external contingency emergencies, without increased risk due to the known EMU problems. Dr. Sirangelo stated that this is especially concerning in the event if one of the critical 13 known primary system failure situations, which require immediate EVA response, occurs.

There will be an EMU returned on SpaceX Commercial Resupply Service-25 (SpX-25) for an expedited test, teardown, and evaluation, which might help identify additional short-term fixes. Dr. Sirangelo explained that given the continuing degradation of the EMUs—and the increase in risk posture by operating with accumulating “fixes,” along with the extension of the ISS to 2030—it is critical that NASA expedite the acquisition and replacement of the EMU on the ISS. He asserted that there needs to be proper funding and urgency for EMU transition efforts.

### ***Pressure Shell Cracks and Resulting Cabin Atmosphere Leaks***

Dr. Sirangelo reiterated that the ISS is showing its age and has been developing system and structural challenges. Among the most important challenges, he added, is the development of leaks in the primary structure of the aft-most pressurized module. Over the last several years, three such cracks of have been identified; each have been addressed and patched with mutual efforts between the U.S. and Russian crews and their respective scientific teams. Dr. Sirangelo stated that these patches have largely held, although some residual leaking has been detected at a reduced level. Further, the U.S. has begun to procure and deliver non-destructive testing equipment. NASA intends to—and the Panel supports—the

expansion of proactive structural testing as being necessary to understand the failure cause and ongoing risk. There has been good international collaboration identified in this area, which will need to continue if a substantial life extension is to be obtained.

Dr. Sirangelo indicated that there have been some encouraging developments, like the reduced leak rate, on-orbit tests that appear to confirm the expected loads environment, and some estimates that suggest these cracks are much smaller than critical crack length. However, the Panel encourages NASA to retain their engineering skepticism about this risk, since the structural and material failure mechanism at play here is still not understood. Therefore, Dr. Sirangelo stated, in the absence of that understanding, any conclusions are preliminary at best.

He mentioned several other notable ISS points for consideration:

- There are at least 14 launches to the ISS planned over the next 12 months from at least 4 and possibly 5 or 6 different providers.
- New solar arrays are expected to fly on SpX-26. These have to be deployed in 60 days.
- Some supply chain issues are hitting the U.S. commercial cargo program, which may cause potential future mission delays.
- With the expansion of launch activity on pad 39A becoming overloaded, restoration and modernization of pad 40 is in its beginning processes.
- NASA is still facing the ongoing issue of the U.S. being unable to re-boost the Station unilaterally at this point. It is not expected to be fully addressed with the current slate of visiting vehicles over the next few years.
- The Private Astronaut Missions (PAMs) will be discussed elsewhere, but one positive ISS effect is that EMU hardware was brought home on an Axiom return mission.

Dr. Sanders turned the discussion to a closely related topic to the ISS: Commercial Low-Earth Orbit (LEO) efforts. The Panel has long supported a continuing NASA presence in LEO as a place for learning and risk reduction for future exploration in longer range and deeper space exploration. To the extent that need endures—as well as the science that can be beneficially conducted in the LEO environment, the Panel believes that the Agency is on a highly risky path to avoiding a gap in maintaining LEO presence.

On one hand, Dr. Sanders stated, the ISS needs to come to an end state as NASA plans to move on to a position where the Agency is one of several customers of a commercial LEO destination. But the ISS also needs to endure until the next destination is available. She noted that in order to do so, the integrity and safety of the Station has to be maintained, yet the decreasing viability of the current EMU puts some of that maintenance at risk. Dr. Sanders indicated that on the other hand, as Dr. Amy Donahue will discuss, the efforts toward the establishment of a commercial LEO destination, despite competent management, are on a precarious trajectory to realization on a schedule and within the projected resources needed to maintain a NASA LEO presence.

### **Commercial Low-Earth Orbit**

Ahead of the week's Third Quarterly meeting at JSC, the Panel had an opportunity to make an insight visit to meet with the leadership team from Axiom Space, and to observe some of the development work they have ongoing. Dr. Donahue explained that it was a very interesting and informative engagement that gave the Panel a sense of the commercial LEO agenda from Axiom's vantage point. In particular, the Panel heard about and saw some of the design and development activities Axiom has

underway for Commercial Destination on the ISS (CDISS). As the Panel noted previously, their first element is Hab-1, a combination of crew quarters and some payload capabilities. Launch of that first element is still planned for late 2024 and begins a program that culminates when the Axiom vehicle ultimately detaches from ISS and becomes a free-flying station.

Then, during the quarterly meeting, the Panel had a discussion with Ms. Angela Hart, NASA's program manager for the Commercial LEO Development Program, with whom the Panel met at both the First and Second Quarterly meetings this year. By way of update to prior discussions, the main focus of the CLDP is currently the development and refinement of NASA's requirements for commercial LEO destinations. Dr. Donahue added that this involves work to clarify what science and research is envisioned and what will be needed to support these activities post-ISS. NASA has also had considerable engagement with industry via various requests for information, workshops, and forums to share data with providers and to solicit their feedback on requirements.

This aligns with what the Panel heard during their visit to Axiom, where they noted important conceptual consistency between Axiom and NASA. Axiom sees its mission as building a platform that helps humanity by carrying forward the agenda begun with the ISS. One of the most important elements Axiom is undertaking, Dr. Donahue indicated, is helping grow the customer base for LEO activities, which is also NASA's interest. And, as we know, she added, all of the potential LEO space station commercial providers, including Axiom, have aggressive schedules targeted at placing a capability on orbit prior to the 2030 retirement of the ISS. In light of this, the Panel has a couple of important observations that can implicate safety and performance risk.

The first of these observations concerns schedule risk. Dr. Donahue emphasized that given NASA's intention to issue commercial space station requirements in late 2024, with an expectation that the first commercial LEO destination would be available in 2029, there is very little margin for ensuring a continuous U.S. presence in LEO is maintained given that the ISS is scheduled for retirement in 2030. Historically, she explained, NASA has not engaged in development and certification of a human-rated vehicle on such a timeline since Project Mercury in 1961, which raises some question about what NASA might do to mitigate the risk of failing to meet this schedule. This is an important consideration NASA is tracking and thinking about.

The second, and related observation is budgetary. As the Panel understands it, NASA is currently resourced for the certification of providers, but lacks a forecast and guarantee to providers on the extent of NASA business once a commercial laboratory is available. In addition, Dr. Donahue observed, it is likely NASA will have to provide bridge funding during the transfer of operations from a fully funded government space station to a fully commercial space station for the duration to time required to develop a robust commercial market. In short, NASA needs to acknowledge and plan for the underlying reality that maintaining a continuous human presence on orbit now and into the future will require significant government investment.

Dr. Donahue indicated that it is worth considering this schedule and resource context is likely affecting the workforce, which is certainly aware of these constraints, and may wonder how they will be resolved. In particular, if the workforce perceives a possible gap between the ISS and viable commercial LEO destinations and does not understand how that gap will be filled, their commitment to the Agency may be weakened. Dr. Donahue stated that this, in combination with the extreme competition for talent in the industry writ large and the many opportunities offered by providers, means that NASA must give close attention to how it communicates with its employees and manages its talent. In short, it is



important for NASA to articulate a coherent plan for the transition from a fully funded government-owned and operated Space Station to a fully funded and commercially operated LEO laboratory. Dr. Donahue noted that acknowledging the challenges and articulating a practical implementation plan will motivate and provide focus for the NASA workforce and other stakeholders.

Beyond the challenges of transitioning from the ISS to a purely commercial LEO space station paradigm, the Panel also discussed PAMs and their role in this process. In particular, discussions with Ms. Angela Hart from the NASA Program Office, the Axiom team, and the NASA Flight Operations Division, centered on the lessons learned from the Axiom-1 mission. As a reminder, Axiom-1 launched on April 8, 2022 from KSC onboard a SpaceX Crew Dragon. The crew was commanded by a former NASA astronaut. That mission splashed down shortly before the ASAP's last quarterly meeting, so it wasn't until this week that Panel members were able to hear what was learned. Dr. Donahue stated that NASA—both from the program and operations viewpoint—and Axiom both view Axiom-1 as an important learning point, with many important lessons about what private astronauts want to achieve and are able to achieve on orbit, what the impacts are to the NASA crew, and what it takes for these missions to be successful. The lessons from Axiom-1 are being translated into requirements for subsequent missions. In general, the Panel's impression is that NASA and Axiom are communicating well and working very productively together.

Dr. Sanders indicated that equally, or arguably more challenging yet, is the overall Artemis mission set with many complex components. She asked Mr. Bill Bray to lead off on this topic.

### **Artemis**

As noted, the Panel once again had good and robust discussions with Mr. Mark Kirasich, Deputy Associate Administrator for the Artemis Campaign Development Division, and his team on the progress of the Artemis program, its key system elements, and the ongoing systems engineering and integration challenges and efforts across the campaign. Mr. Bray stated that the Artemis campaign has a complex set of challenges, and they are handling them well.

Starting with Artemis I, the Wet Dress Rehearsal (WDR)-4 was executed and, although it terminated early due to a hydrogen leak at a quick disconnect in the tail service mast umbilical, NASA was able to complete the desired objectives during this WDR and through other testing. The hydrogen leak was root caused and corrected, and the data from the event continues to be reviewed. The Panel appreciates the Artemis I team's diligence and completeness in its efforts to root cause and correct the specific hydrogen issue as well as other issues discovered during WDR-4 to ensure confidence in the execution of the Artemis I flight. Flight Readiness Reviews are scheduled for August as the team proceeds to a final launch decision. Mr. Bray explained that this event is critically important to the overall Artemis campaign and particularly to the Artemis II mission since Artemis I hardware will be reused. The Panel is looking forward to the successful completion of this crucial event for the Agency.

As far as the broader Artemis campaign mission and systems engineering efforts, the Panel is pleased to see the continued maturity of a top-down systems engineering approach anchored on a single end-to-end mission architecture that encompasses the holistic Artemis campaign—today, that architecture is defined through Artemis VI. Although still maturing, as the Panel has noted in the past, this effort forms an important basis for the flow-down of requirements, management of risk and safety, and ensures a thorough definition of critical interfaces to include areas for commonality across the entire Artemis

program. Continued documentation of this approach and supporting processes in the Systems Engineering Management Plan (SEMP) is important, Mr. Bray asserted.

He added that this mission architecture framework, and this holistic program view, will facilitate the development of an integrated master schedule for all systems within the program that identifies critical paths, key integration points, and system-to-system dependencies that should lead to the delivery of a complete and integrated program with fully informed budget requirements and a solid understanding of program safety and performance risks upfront. This is particularly important for integral elements such as the Human Landing Systems (HLS), the EMU suits, and Gateway. Each of these systems, Mr. Bray stated, is individually critical to the Artemis architecture with programmatic dependencies, conjunctive technical requirements, and key interfaces, which in the end must be delivered in an integrated and distinct sequenced order for the Artemis program and campaign to be successful.

For HLS and EMU, the Panel continues to encourage NASA to implement acquisition approaches that create a competitive landscape that will help provide options and manage risk for each of these systems and the Program as a whole. The Panel also recognizes that to pursue this approach and achieve the benefits, the plan must be properly resourced and supported by realistic schedules. Today, the Panel is concerned that these programs are executing at a high level of programmatic risk.

The Gateway program continues to progress. As noted at the last ASAP Quarterly, the Agency had just completed 33 subsystems preliminary design reviews (PDRs) and was preparing for a system-level PDR-informed sync review. That sync review was conducted in May 2022, and the completion of actions is progressing with anticipated close-out in October 2022. The Panel views Gateway and the completion of this technical milestone as important not only for the success of the Artemis campaign but also for NASA, the global coalition, and the future of deep space exploration and science.

In closing, Mr. Bray stated, NASA has been working the organizational construct to manage risk and safety across the Artemis program and is making progress against it, and that is evident in the Panel's discussions this past year. The Panel is anxious to better understand the Agency's final organizational construct and, specifically, to understand the flow of responsibility, accountability, and authority for all Artemis campaign elements and missions, from development through mission operations, and across the various organizational touchpoints of program and project managers, technical authorities, development leaders, operational leaders, and center directors. Mr. Bray indicated that the construct should be seamless and well understood across the Agency and its workforce. In the coming months, the Panel looks forward to a detailed discussion utilizing use cases to demonstrate how the organization will operate under clear lines of authority, accountability, and responsibility for Artemis program leadership, risk, and safety management going forward.

Dr. Sanders added that clearly, as with CCP, ISS, and Commercial LEO, competent and capable management seems to be working diligently on Artemis. But here again, the Panel sees a high-risk environment that will need careful planning and attention. Even beyond the intrinsically hazardous nature of space exploration, the Panel views as troublesome the ambitious and aggressive schedule, which is likely unrealistic given the resources available for execution. The ASAP repeatedly cautions that the program needs to be planned and managed with a careful eye to risk management and not allow unrealistic schedules and constrained budgets to dictate decisions that jeopardize safety and successful mission performance.

One aspect of NASA safety with which the Panel has not been able to fully engage over the past two years is Enterprise Protection. The Panel attempted to catch up with this effort over the course of the week's engagements. Dr. Sanders then asked Lt Gen Helms to cover the Panel's observations on that topic.

### **Enterprise Protection**

Lt Gen Helms read through Panel notes from five years ago and shared the takeaways publicly noted in 2017:

1. The Panel thought the Enterprise Protection (EP) Office was understaffed and under-resourced.
2. The Panel applauded the intent of the Office to document and codify best practices, along with the intent to help NASA leadership draft and disseminate guidance and direction across the Agency to address protection risks throughout Agency programs.
3. The Panel noted that while intent was an important first step, the more important outcome was to have a NASA culture that would actively work to mitigate risks associated with the protection of NASA's space systems. This would include deliberate implementation of programmatic action plans to stay on top of an agile threat and to build resilience in the face of those threats.

First of all, Lt Gen Helms indicated, the Panel remains resolute that the EP Office is still understaffed and under-resourced. Having said that, she added that some excellent collaboration has been observed—the NASA EP community is hard at work networking together with non-NASA entities who are knowledgeable about threats to space systems and strategies for mitigation of vulnerabilities. So relative to relationships with other pockets of government who deal with this risk, a lot of goodness has occurred since 2017, in spite of being understaffed.

Lt Gen Helms stated that within NASA itself, there has been some movement toward definitive protection direction, most recent being the new NASA Standard 1006, which defines some foundational space system protection requirements that program managers must manage to improve mission resilience. The Panel notes that this is one recent example of important protection improvements in enterprise-wide program direction that should make a difference. However, based on NASA's own 2021 Zero Base Review on EP, there is still a great deal of work to be done regarding NASA-wide direction and guidance, including addressing gaps in supply chain security and incident prevention and recovery.

And finally, the Panel's comment from 5 years ago regarding the necessity to see measurable improvements in space system protection postures still stands. Lt Gen Helms said the intent of the EP community to make progress is obviously there, and the overall awareness of the need for protection has clearly grown, but whether definitive action has been taken to broadly improve NASA's spacecraft threat resilience is still, in the Panel's view, a work in progress. Of note, in future meetings, the Panel will have a pointed interest in how NASA's intent, guidance, and direction promulgates to reducing risks to the Artemis campaign, including actions taken to build in threat resilience early in development life cycles.

Dr. Sanders thanked all Panel members for their contributions to the day's discussions. In summary, she reemphasized that NASA has embarked on an ambitious and aggressive portfolio of space exploration endeavors. The Agency has a talented and capable management and technical workforce to meet the challenges, but it will still take very careful and deliberate planning and integration at all levels, accompanied by realistic schedules and adequate resources to achieve the desired goals safely and

successfully. She noted that the comments that Dr. Donahue made earlier about workforce satisfaction and retention hold true across the enterprise; NASA's space exploration efforts will be mission impossible without that workforce's total dedication and engagement.

Going forward, the Panel intends to continue the emphasis on three strategic-level recommendations, and they plan to better define how they would characterize successful achievement of the intended results.

Dr. Sanders then opened the meeting up to comments from the public. No comments were received. She thanked all who joined and adjourned the ASAP Third Quarterly Meeting of 2022 at 12:20 p.m. CDT.

## ATTACHMENT 1

**Note: The names and affiliations are as given by the attendees, and/or as recorded by the telecon operator.**

### **PARTICIPANTS**

Amanda Miller	Air Force Magazine
Andy Hoskins	Aerojet Rocketdyne
Garrett Schwartz	House Science Committee
Bill Harwood	CBS News
Christina Koch	JSC
Christine Joseph	House of Representatives
Darlene Pokora	NASA Langley
Dave Huntsman	NASA Retired Board Member
David Sullivan	Public
David Willman	Public
Debra Ferselli	Boeing
Dillon Macinnis	SpaceX
Donald Wood	NASA
Donna Shafer	NASA JSC
Erin Kennedy	GAO
Gene Mikulka	Talking Space
Heielle Eauvergae	European Space Agency
Jackie Wattles	CNN
Jacob Lewebinos	NASA OIG
Jay Misener	U.S. House of Representatives Science Committee
Jeff Foust	SpaceX
Jessica	NASA
Joey Roulette	Reuters
Johnny Neuidn	NASA
Juan Castilleja	Boeing
Kate Maliga	Aerojet Rocketdyne
Kelsey Evecith	Information not provided
Kevin Ford	ISS Advisory Committee
Kianna Mitchell	Boeing
Lee Steinke	CisLunar Industries
Linda Karanian	AFB
Loren Grush	The Verge
Marcia Smith	Spacepolicy.com
Margaret LeVeon	Information not provided
Micah Maidenberg	Wall Street Journal
Michael Massey	NASA JSC
Michelle Green	NASA

Moriah Lee	NASA OIG
Pat Forrester	NASA
Richard Brandt	NASA
Russ DeLoach	NASA
Saka Hariama	NASA
Stephen Clark	Space Flight Now
Susan Sawyer	Marshall Crew Program
Taylor Desco	NASA
Tim Proctor	FL Senate
Tonya Woodbury	Committee on Space and Technology
Tremayne Days	JSC
Troy Kim	DAA
William Readdy	NASA ISS Advisory Committee
Information not provided	Space Agency
Information not provided	NASA OIG
Information not provided	Boeing