

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

February 8, 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 First Quarterly Meeting via teleconference January 25-27, 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  
January 27, 2022  
Conference Call

**2022 First 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  
Dr. George Nield  
Mr. David West  
Dr. Richard Williams

**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 1:30 p.m. EST and welcomed everyone to the ASAP's First Quarterly Meeting of 2022. She indicated that no 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 stating that it seems fitting for the ASAP (or Panel) to be discussing human space flight safety on NASA's annual Day of Remembrance, which honors the members of the NASA family who lost their lives while furthering the cause of exploration and discovery, including the crews of Apollo 1 and space shuttles Challenger and Columbia. This year's NASA Day of Remembrance also marks 55 years since the Apollo 1 tragedy. Dr. Sanders reflected on NASA Administrator Bill Nelson's related words: "Every day we have an opportunity to further uplift the legacies of those who gave their lives in pursuit of discovery by taking the next giant leap, meeting every challenge head-on, as they did. In doing so, we also must never forget the lessons learned from each tragedy and embrace our core value of safety."

As safety advisors, the Panel is naturally charged with focusing on the risks inherent in the highly and increasingly complex exploration efforts of NASA. The Agency should—and must—honor the memory of those who gave their lives and continue to lead the charge on those challenges for which they sacrificed. Dr. Sanders indicated that the Panel collectively believes it is important for NASA to take on and lead the most difficult and inspiring challenges and build on its successes. But they also believe that the Agency should not forget the hard-learned lessons from its failures, and not become complacent as it goes forward. Accordingly, the Panel has advised that NASA relook at both the Rogers Report and the Columbia Accident Investigation Board (CAIB) Report to refresh its awareness of those lessons. Dr. Sanders emphasized that there is a critical balance to be maintained between having the confidence to take on the hard missions and continuing to have a sense of unease with respect to the risks.

Mr. Paul Hill spoke to the Panel's perspective about the importance of maintaining a deliberate level of unease at the Agency. He noted that there is great value in groups, organizations, and individual team members reflecting on mistakes that led to previous failures. This includes considering the management processes that often lead to oversights and failures—to consider these past actions and then make significant change to prevent their recurrence. He added that it is normal human behavior, as time goes by and the Agency racks up new, impressive successes, for the pain that followed each failure to gradually fade. This can and has led back to the bad habits that result in careless avoidable. That normal human tendency is called the paradox of success, Mr. Hill stated. That is, success itself tends to make people believe that we are invulnerable; that our previous successes alone will lead to be further success. That, in turn, leads directly to less rigorous decision-making, avoidable mistakes, and failure. NASA has done that very thing three now, leading up to Apollo 1, Challenger, and then Columbia, Mr. Hill observed. The Panel's point for the Agency today—and every time the Panel engages with NASA—is to keep that awareness in mind in everything they do; keep that paranoia alive and be very deliberate in all decision-making. Every day, NASA management should ask themselves, "Why is this the right choice? Why are we go? Based on what data or rationale?" And then avoid again learning lessons NASA gradually forgot after Apollo 1 and again after Challenger.

Dr. Sanders noted that accordingly, the Panel often asks the NASA personnel with whom they engage to talk about the things that "keep them awake at night" because there surely must be some things that cause them to lose sleep as they take on these new challenges. Over the past year, the Panel focused a great deal of attention to some strategic issues that resulted in three formal recommendations in the ASAP's recently released Annual Report. Dr. Sanders indicated that she would not restate those at this meeting, but she noted the Panel has been assured that the Agency leadership is taking the recommendations seriously and will take steps to address them. These recommendations are not areas that can be entirely dealt with in a short time, Dr. Sanders acknowledged, so the Panel will continue the dialog over the coming year. Meanwhile, the Panel's discussions this week have provided some additional observations consistent with the thrusts of those recommendations.

Dr. Sanders stated that in whatever way the Agency decides to proceed in its vision for the future, communication throughout the entire workforce and with stakeholders is viewed as critical. The Panel proposes one potential tool to facilitate that communication. Lt Gen Susan Helms was asked to illuminate this prospective technique.

### **Leadership Intent**

In times of transition, Lt Gen Helms indicated, it is not uncommon for leaders of an organization to set out in writing a guidance statement of leadership intent that can help clarify and align actions and behaviors across a large workforce. A written leadership intent document, also known as a statement of Commander's intent, is a tool of best practice that helps to align a broad, diverse organization to a common vision, common rationale, and common guiding principles and strategies. Lt Gen Helms emphasized that cogently conveying leadership intent is particularly necessary in times of transition, such as NASA is experiencing now. It is clear to the Panel that NASA has a very full plate with countless technical, managerial, and political challenges.

In the face of these challenges, having clear and unambiguous communication throughout the organization could not be more important, she observed. But in the face of these challenges, the Panel has noted in their multiple engagements that they often hear differing interpretations about leadership priorities from various NASA managers and disciplines, sometimes notably different. There has been a lot of verbal communication, but the Panel would suggest that there is something being lost in translation through solely verbal guidance statements that disseminate through the workforce. The Panel believes that utilizing the tool of a written statement of leadership intent—that conveys the forward vision, the rationale for that vision, and the guiding principles, priorities, and general strategies to execute that vision—would help alleviate the varying interpretations across the NASA enterprise. Lt Gen Helms affirmed that a written leadership intent statement from the top of the Administration, or the top of the Artemis leadership level, or both, would help allay some of the mixed perceptions the Panel has observed regarding the Administration's priorities and guiding principles.

Dr. Sanders added that a statement of leadership intent should not be interpreted as the sole tool for NASA leadership to use to communicate their vision to the workforce. The Panel believes such a written statement is an important adjunct, but NASA leadership will need continual and pervasive engagement with the workforce on their intent.

Dr. Sander's indicated that another area tied-in with the Panel's strategic advice is the impending reorganization of the Human Exploration and Operations Mission Directorate. While the details of the proposed restructure have not been finalized, the execution of the realignment will have implications for safety and risk. In fact, the CAIB Report provided some thoughts in that direction. Dr. Sandra Magnus was invited to discuss some of the Panel's thoughts on potential challenges in restructuring.

### **Human Exploration and Operations Mission Directorate Reorganization**

Dr. Magnus followed up on Mr. Hill's earlier comments regarding lessons in human spaceflight. Such lessons come at great cost, she noted. It is important to look to the past, to the lessons we paid so dearly for, and figure out what lessons can be brought forward and adapted to the new environment. She added that it is important to go back through the CAIB Report and the Rogers Report to glean what one can from those documents and figure out how they apply to organizations. Dr. Magnus then read the following organizational cause statement from Chapter 7, page 177 of the CAIB Report:

The organizational causes of this accident are rooted in the Space Shuttle program's history and culture, including the original compromises that were required to gain approval for the Shuttle Program, subsequent years of resource constraints, fluctuating priorities, schedule pressures, mischaracterizations of the Shuttle as operational rather than developmental, and lack of an agreed national vision. Cultural traits and organizational practices detrimental to safety and reliability were allowed to develop, including: reliance on past success as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements/specifications); organizational barriers which prevented effective communication of critical safety information and stifled professional differences of opinion; lack of integrated management across program elements; and the evolution of an informal chain of command and decision-making processes that operated outside the organization's rules.

There are a lot of parallels that can be drawn from that with respect to the current environment, Dr. Magnus indicated. With respect to the organizational change, NASA has good reasons for trying to manage their ecosystem a bit differently as they continue to evolve and transform the Agency. She read another excerpt from Chapter 8, page 203 of the CAIB Report, which she hopes will help guide the Agency's thinking as they continue to examine the best way to focus.

Changes in organizational structure should be made only with careful consideration of their effects on the system and their possible unintended consequences. Changes that make the organization more complex may create new ways that it can fail. When changes are put in place, the risk of error initially increases, and old ways of doing things compete with the new. Institutional memory is lost as personnel and records are moved and replaced. Changes in the structure of an organization is complicated by external political and budgetary constraints, the inability of leaders to conceive of the full ramifications of their actions, the vested interests of insiders, and the failure to learn from the past.

In summary, Dr. Magnus indicated that it is no small thing to undertake an organizational change. She encourages NASA to seek input from internal and external entities as it contemplates this and consider the lines of communication and accountability that are being established.

Dr. Sanders invited Mr. Hill to add his observations on management structures and maintaining the strong foundational and operational items that have been critical to NASA's success.

### **Spaceflight Operations**

The Panel places great value in NASA's history in preparing and executing real-time human spaceflight operations. Their record of high-performance is a direct result of both their mission management processes *and* their operations team's culture, which have been developed and honed through decades of difficult and complex space operations, Mr. Hill stated. This leads to an important facet of new program formulation: leveraging NASA's existing experience base in future development and operations programs to maximize mission assurance. Mr. Hill indicated that this should be a component of the trade space when deciding on when to procure operations capability as a service versus executing with an in-house team.

The Panel encourages the Agency to keep its experienced operations team engaged in new program formulation, design reviews, and future space operations. This is not intended to suggest that only NASA's operations team should operate all NASA-related missions, Mr. Hill expressed. The Panel recommends that NASA deliberately consider which operational risks can be most confidently met through procured services, and which are best served with the greater insight and control offered by NASA's Flight Operations team.

### **Risk Management**

Dr. Sanders stated that many of the Panel's recommendations relative to NASA's evolving role involved clear accountability for risk management. All NASA programs have a fairly well-defined risk management process, she said. This is key to focusing priorities and efforts. Dr. Sanders emphasized that as NASA enters into acquisition strategies with providers who may have different risk management processes, it will remain imperative that NASA and the provider maintain a shared and consistent view of those risk management priorities. Dr. Sanders indicated that the Panel would discuss some areas where this may be a challenge. But regardless, considering an initiative as complex as Artemis—with a multitude of commercial and international providers—a clear process for a shared understanding of the risks, priorities, and focus will be critical to success.

Dr. Sanders invited Dr. George Nield to discuss some of the ongoing topics of engagement this week with NASA.

### **Exploration Systems Development/Advanced Exploration Systems/Human Landing System/Gateway**

Dr. Nield stated that there is a lot of activity underway right now in the Artemis world, but perhaps the most significant efforts have to do with the upcoming launch of Artemis-1, hopefully sometime this Spring. NASA recently completed a very important series of tests, which included:

- Umbilical Release & Retract Test (URRT)
- Integrated Modal Test (IMT)
- Integrated Vehicle Interface Verification Test (IVT)
- End-to-End Communications Test (E-T-E Comm Test)
- Countdown Sequence Test (CST)

The CST, a simulated launch countdown in the Vehicle Assembly Building prior to integrated vehicle rollout to the launch pad, was performed on December 20, 2021. Dr. Nield stated that the test was mostly successful, but it ended prematurely at T-33 seconds instead of T-29 seconds. Based on that, a second test was completed on January 24.

Key milestones remaining prior to launch include rolling the vehicle out to the pad and performing the Wet Dress Rehearsal. Once those activities have been successfully completed, NASA should be in a good position to settle on a target launch date, Dr. Nield stated. One issue that was encountered along the way was a failure of the Engine 4 Controller on the Space Launch System (SLS). Originally, it was thought this problem might require removal of the entire

engine; however, the team was able to remove and replace the unit while still attached to the stack.

Dr. Nield indicated that a couple of the other Panel members had some observations on launch processing. Lt Gen Helms provided her insights on that topic.

Mike Bolger and his team updated the Panel on the current status of launch processing in prep for Artemis 1. Lt Gen Helms specified that several dynamics relating to risk were noted, including the impact of COVID on the workforce, as well as a local manifestation of the “Great Resignation,” with higher than historical rates of attrition. But the area that the Panel found most of interest is the progress toward the very first flight of Artemis. As with any first flight, Lt Gen Helms stated, the workforce is experiencing a notable learning curve on this first-ever processing flow of NASA’s first exploration-capable rocket in decades. As Dr. Nield indicated, several critical tests are imminent or recently completed, including the Countdown Sequence Test, which will verify appropriate operation of the Ground Launch Sequencer software, and the important Wet Dress Rehearsal, which will execute a flight-like countdown of the fully tanked flight vehicle down to within the T-10 second point. She noted that these tests are especially critical, as the mission hardware and software have not been fully tested together end-to-end until this point of the processing. February 15 is the estimated date for the rollout of Artemis 1 to the pad for the Wet Dress Rehearsal.

There are a lot of risk management complexities to manage, as Artemis 1 advances to liftoff, Lt Gen Helms stated. However, with all of the risks being managed at this point, including the workforce learning curve, a significant contributor to mitigating those risks was last year’s Green Run, the hot fire of the SLS core, conducted at Stennis. The Panel was always an advocate of completing a successful Green Run as a critical milestone to risk management, and NASA is now reaping the significant benefits of having completed a full test fire of the SLS core, Lt Gen Helms said. Without that test, NASA’s risk posture for Artemis 1 would have been considerably more uncertain at this point. NASA is to again be commended for their commitment to fulfilling that strategic test milestone, and their prioritization of critical risk reduction over cost and schedule.

Lt Gen Helms turned the discussion back to Dr. Nield.

Dr. Nield mentioned that looking at some of the downstream Artemis missions, NASA had concluded that having a second Mobile Launcher would be extremely important to more easily accommodate the Exploration Upper Stage. However, Mobile Launcher 2 (ML-2) has encountered some challenges. First, the selected contractor, Bechtel, has experienced performance issues associated with under-estimating the complexity of the project, supplier-related issues, and COVID. NASA is evaluating changes in contract structure and program management to address these issues.

Dr. Nield then turned to the status of the Human Landing System (HLS), which will be used to land astronauts on the Moon. Appendix H, Option A (Initial HLS) execution was awarded to SpaceX. Dr. Nield stated that there was a protest, which has been resolved. SpaceX milestones were updated and were received by NASA in December 2021. An Integrated Master Schedule was delivered to NASA in January 2022. Five of those provider milestones have been completed and are being assessed. NASA also conducted site visits to Boca Chica and Hawthorne, California that indicated there has been significant progress in the overall production of Starship and HLS.

Dr. Nield indicated that these visits also provided NASA with a strong understanding of some of the challenges SpaceX is experiencing with Raptor engine production.

Dr. Nield spoke to the Appendix N effort, which is attempting to keep potential suppliers for follow-on sustainable human landings. He stated that interim reviews were conducted in January 2022 of five providers with the HLS insight team, which were augmented with representatives from the Agency Office of the Chief Engineer personnel as independent assessors. Dr. Nield stated the Lunar Exploration Transportation Services (LETS), which is the name of the follow-on effort that will hopefully provide NASA with sustainable landings on the Moon, is making progress. However, the Procurement Strategy Meeting has been postponed as the Agency looks at different options to support competition while aligning with the overall Artemis plan. So, Dr. Nield emphasized, the issue of how the Agency will cope with long-term strategic vision is certainly a key component there, as well as the budgets that are received from Congress and are requested from the Administration to make all of this work.

In discussing the risks associated with this more commercial approach that is being used for HLS, the Panel asked NASA how risk was being handled. Dr. Nield stated that the response was that NASA does not own the design, but it does own the requirements, the data deliverables, and the flight certification.

Among the top risks for the HLS program—which the Panel has been very interested in but has not been able to discuss with NASA until recently—is the cryofluid transfer and management of refueling. As part of SpaceX’s proposed mitigations. SpaceX will thoroughly test Starship variants for Starlink prior to HLS Starship. They also have performance-based milestones on propellant storage and transfer in 2023.

Dr. Nield indicated that another identified risk that was discussed with NASA is landing technology accuracy, stability of the vehicle during landing, and hazard avoidance, including manual, blended, and autonomous piloting, all of which are important for a vehicle as large as Starship. Dr. Nield added that some of the mitigations in place include an uncrewed test landing, which will occur prior to the human landing, extensive use of simulators and emulators, as well as performance-based milestones for landing software and sensors in 2022.

Other risks discussed according to Dr. Nield include software and hardware integration, flight rate, hardware turnaround times, and reuse. NASA is working on all of those identified risks and is trying to make sure it is comfortable with the approach being proposed by SpaceX. An additional risk discussed was the Environmental Control and Life Support System (ECLSS) development for such an expansive cabin. Dr. Nield stated that all those risks are being looked at between NASA and SpaceX.

Dr. Sanders added that HLS provides a good illustration of both advantages and challenges in embracing a commercial provider. NASA can take advantage of the fact that SpaceX is developing the major components for the basis of the HLS. There will be cost reductions and tests and flights and other demonstrations of capability that do not have to be part of a NASA program, but NASA will get important insight into the risk and the mitigation of the risk and performance of the system. The flip side, Dr. Sanders pointed out, is that because the HLS is being built with other needs and requirements in mind, outside of NASA’s, there is a potential to add risk to the overall development because it must meet other requirements. It will be



interesting to follow this, and it is important for NASA to manage from that perspective. Dr. Sanders stated that she believes NASA is aware of the implications here.

Dr. Nield noted that Dr. Sanders made an excellent point. He said that in addition to the Lander itself, another key component of a lunar landing is having a good space suit to use. The Panel has been talking to NASA for some time about having usable space suits for the Space Station and for the lunar missions themselves. The Panel is pleased to hear that the ESDMD and the AES are in the process of establishing a new program called the Extravehicular Activity (EVA) and Human Surface Mobility (HSM) program, which will be responsible for the ISS EVAs, for the exploration EVAs, including on the Moon, for the lunar terrain vehicle, for the pressurized rover, and for EVA and human surface technology development. Dr. Nield stated that the implementation of such a program is a great step. He added that the benefit of having a separate program office is that it can provide clear program-level authority and accountability with the ability to elevate issues to the program level, which the Panel feels is commensurate with the criticality of EVA capability.

Dr. Nield shared that the program formulation authorization document for the new EVA HSM organization has been approved by the NASA Associate Administrator, and NASA has just received Congressional concurrence. The Panel looks forward to working with that organization. Industry proposals for Exploration Extravehicular Activity (xEVA) services to provide suits for the ISS, Gateway, and the lunar surface proposals were received on December 14, 2021, and NASA is targeting contract award as early as April 2022.

In terms of HSM status, Dr. Nield continued, NASA put out a second request for information in September 2021 and it received 21 responses containing feedback on approaches to surviving the extended lunar night, supporting 10 years of operation, delivery service preference, and interest in providing a Lunar Terrain Vehicle (LTV) as a commercial service. These responses are feeding updates to the Survive the Night assessment and informing the LTV procurement strategy.

Dr. Nield discussed a few concerns the Panel has in the EVA and HSM arena, which include the potential for delayed starts of the xEVA contract. There is very little margin to get to some of the Agency's desired landing dates. Also, there are a few architectural-level requirements for the LTV that are not yet fully defined; they need to be worked in terms of interfaces with the other elements.

One other key component in terms of long-term Artemis activity is Gateway, Dr. Nield stated. The Gateway Program Office was established at Johnson Space Center in February 2019. In December 2020, NASA signed agreements with the European Space Agency (ESA), the Canadian Space Agency (CSA), and the Japan Aerospace Exploration Agency (JAXA), which define various agency roles, contributions, and benefits. The program office has now established its business rhythm and governance, including control boards, monthly element reviews, program quarterly reviews, and risk boards. Dr. Nield added that the relationships with stakeholders have been defined, and all the early element contracts are in place, with the exception of the airlock.

Dr. Nield added that the Gateway Program Office has completed several milestones in 2021. In February, the Power and Propulsion Element (PPE) and Habitation and Logistics Outpost (HALO) Launch Vehicle contract was awarded. Also, the HALO primary structure assembly was initiated

in Italy. In April, the Gateway Program Key Decision Point 0 was developed. In July, Northrop Grumman was awarded the fixed-price HALO contract. In November, an International Habitat (I-HAB) preliminary design review (PDR) part 2 close-out took place, and Maxar completed part 2 of their PDR for the Gateway PPE in December.

Dr. Nield summarized that a lot of exciting activity is taking place for the Artemis campaign, and a lot of challenges remain ahead.

The meeting was then turned back over to Dr. Sanders who agreed there is a lot of activity, and because of such levels of activity, the Panel recognizes that Artemis needs structure. Dr. Sanders added that the Panel engaged some with the folks doing the architecture work that needs to be done to bring the campaign together, at least at the top level for the requirements. She then asked Mr. Bill Bray to comment on this topic.

### **Mission Operations Directorate**

Mr. Bray stated that the Mission Operations Directorate team spoke with the Panel about their efforts on mission engineering and architecture development. The team is continuing to make good progress, Mr. Bray observed, having updated a number of mission engineering documents dealing with top-level requirements and standards. The team also completed their FY21 strategic analysis cycle, and they conducted a number of trade studies, which inform these documents as well as inform the top-level requirements and architecture going forward. Mr. Bray added that the team also laid out their FY22 analysis, which they've already embarked on. From that perspective, the Panel encourages the Mission Operations Directorate team to focus on the lunar missions as part of the Artemis campaign in the context of the mission to Mars. The Panel believes it is important for the team to stay focused on those areas moving forward.

As NASA rolls out the new organizational structure, the Panel will be very interested in understanding the missions' organization within that structure and how it relates to the risk acceptance as well as accountability, and of course its relationship to the rest of the organization within NASA. Mr. Bray noted that the Panel looks forward to hearing about updates from the Mission Operations Directorate team at the next ASAP quarterly meeting.

Dr. Sanders added that this architecture work is very important, as it lays the foundation, it provides top-level requirements, but it does not substitute for the detailed systems engineering and integration that this complex initiative is going to need. The Panel will continue to look for more on that as well.

Dr. Sanders turned the discussion to a little closer to Earth when she invited Dr. Amy Donahue to reflect on the status of the ISS.

### **International Space Station**

The Panel has been watching a variety of risks and risk-related concerns with respect to the ISS program. Dr. Donahue indicated that at the Panel's quarterly meeting that took place earlier in the week, members had the opportunity to meet with Joel Montalbano and his team. She noted that Joel and his team are extremely knowledgeable and professional, and the Panel appreciated what was a very informative conversation.

At the top of mind for the ISS program, Dr. Donahue stated, is the recent life extension, as the Biden Administration has affirmed that the ISS will operate through 2030. The U.S.'s international partners are proceeding to align with this timeline. This extension is vital to NASA's ability to close capability gaps and, more importantly, to demonstrate the reliability and robustness of technologies on which future performance relies. Had the ISS operations not been extended, NASA would not have been able to accomplish nearly as much of this work and would not be able to posture itself for the Moon as effectively. In particular, this life extension permits longer test campaigns (on the order of three years) that can better establish reliability. This also permits transition of low earth orbit capabilities to commercially owned and operated destinations later this decade. To be ready for that, NASA recognizes it needs to assemble the list of requirements and assess the extent to which ISS will meet them, which will let NASA characterize what commercial destinations need to be able to do.

That said, the ISS lifetime depends on the continued ability to operate and maintain all systems onboard. Dr. Donahue mentioned that NASA must continue its ongoing assessment of risks that threaten the 2030 time-horizon and be prepared to develop and fly solutions to the highest risk failures. One ongoing concern the Panel has noted previously relates to the cracks discovered in the hull of the ISS service module transfer tunnel. These cracks manifested as an increased leak rate in 2019. In early 2021, two cracks in the pressure shell were repaired, which reduced the leak rate but did not fully mitigate it. To this day, the investigation of the root cause or causes continues, Dr. Donahue said. This will support mitigation strategies, which could include various forms of patching, altering load conditions, or adding doublers, just as examples of options. Ultimately, it appears likely that cracks will continue to be discovered, making this investigation very important. NASA considers this the top risk about which it is concerned, and the Panel concurs. Dr. Donahue stated that the Panel continues to be interested in the procedures that will be used to manage this risk and will keep following this closely.

Alongside the concerns about the operability and maintainability of the ISS over its life is also the concern about assuring U.S. access and a continuous presence of U.S. crewmembers, which is critical, Dr. Donahue emphasized. NASA and Roscosmos are working on an agreement for cosmonauts to fly on U.S. vehicles and astronauts to fly on Soyuz to meet this need. Crew training has already begun to support this "seat barter" starting in Fall of this year. The uncertainty around this, though, makes a reliable second U.S. crew transportation provider a risk about which NASA is also very concerned.

Beyond this, in the ASAP Annual Report for 2021, the Panel emphasized their continuing concern about the risks posed by orbital debris. These risks were underscored and severely exacerbated this past November when a Russian anti-satellite test destroyed the Russian Kosmos 1408 satellite and dramatically enlarged the debris field near the altitude of the ISS. There are now 1,500 to 1,700 trackable pieces of debris, which have effectively doubled the background debris environment. This is a concern that will be with the Panel for the duration of the ISS lifetime.

Relatedly, the Panel noted that small satellites are being launched ever more frequently, and private companies are seeking to put many thousands of satellites in orbit. Currently, for example, there are over 1,800 Starlink satellites from 35 launches, mostly above ISS. SpaceX is planning an expansion of this constellation and is approved for 12,000 satellites but has

requested up to 30,000. NASA noted that SpaceX has been a very responsive partner in the Space Act Agreement related to their constellation—but there are other groups out there with similar ambitions and no agreement, Dr. Donahue stated. This problem is only getting worse and lends further urgency to the Panel’s persistent contention that the risks to all who use the space environment must be actively managed on a continuous basis. Over a year ago, the Panel recommended that Congress designate a Lead Federal Agency for Civil Space Traffic Management. As the Panel has said, the sustainability of space as a peaceful domain for science, exploration, innovation, and commerce depends on it.

According to Dr. Donahue, there are two other contextual factors that contribute to the risk environment worth noting. One factor is obviously the context of tensions in Ukraine and Kazakhstan. NASA reports that they are working well with their Russian colleagues, but the geopolitical instabilities threaten to undercut the relationship. And the other persistent factor, Dr. Donahue said, is the ongoing constraints and challenges of coronavirus pandemic. This makes it difficult to work on-site in person, which is especially a problem as NASA works to onboard new people and build teams. Dr. Donahue noted that new people need to learn from experienced people first-hand, which is very hard to do remotely.

Overall, the Panel’s assessment is that the ISS team is proceeding appropriately. The Panel would like to make particular mention of a new effort at risk analysis the ISS team is beginning. Dr. Donahue stated that the team has started to look at how their top program risks have changed over time. Some risks have evidently been mitigated or managed effectively. The ISS team has also discovered where some risk has been added. The good news, Dr. Donahue indicated, is the team’s assessment process captured it and allowed them to determine if they are mitigating risk appropriately. And, through this process, they are growing attuned to areas where they may not have made progress on risks that persist, which allows them to ask why. The Panel commends the ISS team on this work. Dr. Donahue added that such work is likely to yield valuable insights and might well be a model other parts of the Agency should adopt.

Dr. Sanders stated that another area of interest for the Panel is Commercial LEO. A presence in LEO is a continuing need for NASA and other customers, so the transition from the ISS to some commercial location in LEO space is of great importance for not only NASA but for the entire space community. She then called on Mr. David West to speak on that topic.

### **Commercial Low Earth Orbit Development Program**

Mr. West noted that NASA is working toward the development of commercial destinations in LEO. Earlier in the week, the Panel had a discussion with Angela Hart, Manager, Commercial LEO Program Office. The planned commercial LEO destinations are in two different categories—Commercial Destinations Free Flyers, and the Commercial Destination on the ISS (CDISS). The Commercial LEO Development Program is poised to benefit from NASA’s several years of recent experience managing programs such as Commercial Resupply Services and the Commercial Crew Program (CCP).

As part of Phase 1 of Free Flyer activities, Space Act Agreements were awarded on December 2, 2021, to three partners: Nanoracks, Blue Origin, and Northrop Grumman. NASA will be holding kickoff meetings with all three of these partners during the next couple of months. Drafts of Crew and Service Requirements are under development with a planned completion date of

March 2022. Mr. West indicated that all three providers have ambitious schedules for key design review milestones over the next two to three years, and initial operational capabilities as early as 2027.

Mr. West added that design, development, and early construction activities for CDISS are already underway by Axiom Space. PDR has been completed and the critical design review is targeted for this summer. The first element launch is planned for late 2024. Plans are for the Axiom CDISS to ultimately detach from ISS and become, itself, a free-flying station.

The aggressive schedules that the Free Flyers and CDISS are working to will be a subject of particular interest for the Panel over the coming years. On one hand, it will become more and more vital that the schedules are met so that, when the ISS reaches the end of its life and needs to be deorbited, there is uninterrupted U.S. access to an LEO platform for continued scientific research and experience overcoming the challenges of living and working in space, Mr. West stated. However, as the Panel repeatedly points out, schedule pressures must not lead to unwise risk management decisions.

Another top concern to the Panel that was discussed was the uncertainty of funding. Currently, with NASA and all of government under a continuing resolution, the Free Flyers are funded only through the completion of PDR activities. As the Panel has pointed out many times, funding uncertainties present a major source of risk. In this case, funding shortfalls would not only jeopardize the success of commercial LEO destinations, but they could also interrupt U.S. access to living and working in LEO.

During discussions with the Commercial LEO Development Program, especially the discussions around the Axiom CDISS, the Panel noted that there will be some challenging new situations that NASA will need to work through, with respect to how a commercially owned and operated platform will attach to the U.S. Operating Segment of the ISS. Lt Gen Helms pointed out that there are several models for setting up commercial facilities on government property that the Commercial LEO program may want to consider. Mr. West asked Lt Gen Helms to explain more about these models and how they help protect the government's interests in such arrangements.

Lt Gen Helms noted that it was enlightening for the Panel to listen to how the Commercial LEO Development Program is looking forward to goals such as integrating purely commercial activity with government activity such as the ISS. It was interesting to hear, she added, how their journey was progressing from the standpoint of how you set up contracts and agreements and other supporting types of documentation for something like this to happen. Clearly, this is a situation where there is mutual benefit for the government and for the commercial enterprises to move forward on this. One thing the Panel suggests is that there is a lot of precedent of how to integrate a commercial activity on government-operated property and still maintain what is in the government's interest to protect within that process. Lt Gen Helms added that the Commercial LEO Development Program Office should look into existing related documentation, an example of that being the Enhanced Use Lease, which is something broadly used in government. There is other documentation directly related to the Space Code, such as when the commercial enterprise of SpaceX ended up leasing the use of one of the launch pads at Cape Canaveral, and the Cape Canaveral enterprise, run by the Air Force, ensured that its interests were protected along with supporting the SpaceX enterprise. Lt Gen Helms indicated that there

is a lot out there that can be looked at as models of how to successfully do this kind of integration. Lt Gen Helms stated that it is just a suggestion but based on what the Panel heard over the course of the week's discussions, it may be worth the effort for the Commercial LEO Development Office to look into such supporting documentation going forward.

One more thing the Panel discussed with the Commercial LEO Development Program earlier in the week was the status of Private Astronaut Missions (PAMs). The 10-day Axiom-1 PAM is scheduled to launch on a SpaceX Falcon 9 and Crew Dragon on March 31, 2022. Final preparations, including the training of the primary and backup crew, are nearly complete, Mr. West stated. He added that all open risks have been accepted. Axiom was also selected for PAM-2; however, NASA will evaluate lessons learned from the Axiom-1 PAM before awarding any additional PAMs beyond PAM-2. The program is concerned about the execution of many first-time processes associated with PAMs, and the Panel will be monitoring this concern closely during the first two PAMs.

Dr. Sanders indicated that the Panel would also like to discuss the status of the Commercial Crew Office. Although the capability with SpaceX—one of the providers—has matured, it is still in the phase where every flight is considered a test flight. Plus, she added, the second provider is still coming online. Next, Dr. Sanders asked Dr. Magnus to discuss the Panel's recent discussion with that program office.

### **Commercial Crew Program**

Dr. Magnus stated that the Panel would first like to correct a factual error in the ASAP Annual Report for 2021. The following statement made on page 25 is incorrect: "The Panel's concern is that during the OFT-2 Flight Readiness Review (FRR), NASA and Boeing differed in how they characterized the risk that was brought to light by the stuck propulsion valves." The subject technical issue was not the stuck propulsion valves, which were discovered post-FRR, but rather a difference in risk characterization regarding the parachutes, Dr. Magnus clarified. However, the point the Panel was making remains the same—different methods and approaches to identifying and tracking risk can result in a disconnect in priorities about where resources should be applied in addition to reaching a clear, broad understanding of the actual risk posture.

Dr. Magnus advised that as NASA continues to refine its acquisition processes—which place industry front-and-center for vehicle design and development, along with the myriad of decisions that define the risk of operating those same vehicles—the Agency should ensure that there is constant two-way communication between itself and the provider to ensure that a common understanding and agreement of risk drivers and concerns are reached. The CCP has used their identification of risk to drive changes for both providers informed by NASA risk assessments. However, the level of insight that NASA has on day-to-day decisions that influence risk is, by intent, limited; constant communication is imperative, Dr. Magnus emphasized. The Agency has the final accountability for mission success and crew safety, regardless of the acquisition methodology, and must ensure that the appropriate priorities and risk-related issues are worked and resolved, certainly well before an FRR. The FRR is the important final step before launch to ensure that there are no disagreements on the nature of the mission risks and risk acceptance criteria, but the actual risk management is a continual process that happens throughout the mission development life cycle. Ensuring clear and unambiguous communication throughout that life cycle, particularly when it comes to perceived and documented hazards and

risks, is the necessity, not just risk adjudication at the FRR event, Dr. Magnus stated. It is a delicate balance but extremely important that the CCP and the lessons learned from the program are propagated to other NASA programs that allow NASA to maintain appropriate awareness of risk-related decisions that impact the ability to manage its accountability for crew safety and mission success.

However, Dr. Magnus added, in general, the CCP appears to be proceeding along according to plans, and it is impressive to see how much activity is ongoing. NASA has several crew rotation flights on SpaceX in the pipeline during 2022, plus a private mission to the ISS. Boeing also continues to work towards a spring Orbital Flight Test (OFT)-2 launch date. If anything, Dr. Magnus stated, NASA and SpaceX will must be watchful during 2022 that they are not victims of their success. SpaceX has an ambitious 52 launches planned over the course of the year, an incredible pace, and both NASA and SpaceX will have to ensure the appropriate attention and priority are focused on NASA missions. Boeing continues to tackle the issues in front of them—resources, software, mitigating the valve issue discovered on the launch pad late last year—to prepare and complete a successful OFT-2 mission and move to the first crewed flight. The long-sought national goal of two crewed transportation systems to LEO is near to realization.

Again, Dr. Magnus emphasized, at the end of the day, the Agency has the final accountability for the mission's success and for crew safety, and that should be the driver for how these lessons are applied elsewhere.

Dr. Sanders moved the discussion along from individual NASA operational program status and future efforts to the latest reports from the Office of the Chief Health and Medical Officer (OCHMO). She asked the Panel's Dr. Rich Williams to provide his insight on this subject.

#### **Office of the Chief Health and Medical Officer**

The Panel had the pleasure of meeting with Dr. J.D. Polk, Chief Health and Medical Officer, to discuss current NASA health concerns as well as health and medical technical authority issues. NASA is withstanding the Omicron surge as well as can be expected, Dr. Williams stated. NASA cannot currently enforce vaccine mandates for employees due an injunction; at this time approximately 93 percent of the NASA workforce is vaccinated. He added that the Omicron variant has increased caseloads and containment demands for the Agency, but illnesses have generally resolved more quickly and there have been no employee deaths attributable to Omicron thus far. NASA is conservative with regard to return-to-work criteria following COVID-19 disease or high-risk exposure; employees can return at 7 days masked if they test negative for COVID-19, as opposed to 5 days masked per Centers for Disease Control (CDC) recommendations. NASA is following CDC recommendations concerning the use of masks in the workplace. KN 95 and N 95 masks are supplied for higher-risk and critical operations. The COVID-19 pandemic has interrupted, to a great extent, data collection supporting the Lifetime Surveillance of Astronaut Health (LSAH) due to travel restrictions; Dr. Polk is hoping to resume more normal operations for this important study as soon as possible.

Dr. Williams indicated that financing for the Health and Medical Technical Authority (HMTA) has markedly improved. Contractor and civil service personnel with specific technical expertise have been hired for programmatic technical authority support; there is no longer a need for a single person to cover multiple areas. The OCHMO has been able to update many policies and

standards, such as the radiation exposure standard and NASA-STD-3001, NASA Spaceflight Human-System Standard, which is now maintained in the public sector and open for vendor review.

NASA Institutional Review Board (IRB) activities have quadrupled due to the demands of ISS-related research, pursued by universities and the private sector, Dr. Williams informed. All NASA IRB members are certified IRB professionals, following guidelines set forth by the Department of Health and Human Services to optimize human research-related safety and risk mitigation. Reciprocal agreements are in place with some university IRBs to reduce redundancy and unnecessary duplication of review.

Another policy in development at the NASA Headquarters-level concerns crewmember or spaceflight participant death during the in-flight phase of a human spaceflight mission, stated Dr. Williams. NASA is working with the Federal Bureau of Investigation, the Agency Planetary Protection Officer, the Armed Forces Medical Examiner, and other partners to produce a policy and procedure to address death on-orbit, in deep space, or on another planetary body to be issued at the NASA Administrator-level.

Another change in NASA policy, Dr. Williams observed, will be to publish crew medical selection standards for the Artemis missions in the public domain, allowing a better specific understanding of crew medical requirements for potential applicants as well as programmatic personnel and vendors outside the Agency. Dr. Williams added that NASA is committed to sharing lessons learned in space medicine over decades of human space flight support. NASA is meeting with the Federal Aviation Administration and the U.S. Space Force to transmit relevant spaceflight human health-related information on a regular basis as the commercial human spaceflight industry matures.

The ESA Para-astronaut program is also of interest to the Panel. ESA has down-selected to a pool of about 60 applicants for further review. The ISS International Partners agree in principal that the most important qualification from a health and medical perspective is to ensure successful candidates can meet all functional requirements imperative to safety. NASA is conducting analyses on multiple levels to evaluate hatch opening/closing dynamics, limb prosthetic interface with space suits, ingress/egress considerations, exercise countermeasures, and other matters from a safety perspective for such potential crewmembers. The Panel will look forward to further reports on progress in this area.

The Panel also discussed the Genetic Information Nondiscrimination Act and its implications for NASA. Many of NASA's crew medical selection and flight qualification standards can be interpreted as having some basis in genetic information. NASA is carefully evaluating the implications of this legislation in the high-risk environment of human spaceflight and will keep the Panel informed going forward.

Dr. Sanders's thanked the Panel for their shared observations. She then recognized that Dr. George Nield would be leaving the ASAP after the First Quarterly Meeting of 2022. She thanked him for his exemplary contributions to the Panel over 12 years.

Dr. Sanders asked that the lines be opened for a few minutes for public comments. No comments were received. She then concluded the meeting and reiterated how exceptionally



busy NASA is and how it is continuing to do impressive work. One only needs to look at the number of launches and other activities planned for the next few months to appreciate the challenge, she noted. As NASA tackles the near term and the future, the Panel will continue to encourage the Agency to remain true to the fundamentals that have been the foundation of its successes, to embrace the emerging capabilities that are available to it in innovative fashion, and to retain the unease that there could be something forgotten or neglected that could defeat the successful achievement of its missions.

Dr. Sanders adjourned the meeting at 2:42 p.m. EST.

**ATTACHMENT 1**

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

**PARTICIPANTS**

Angela Hall	Boeing
Ann Zulkosky	Lockheed Martin
Ashley Wilkins	Health Science Committee
Ben Jurewicz	St Mary's University
Bill Harwood	CBS News
Caitlin Smith	SpaceX
Chris Davenport	Washington Post
Christine Joseph	US Congress
David Kerley	FullThrottleBulletin.com & Discovery Channel
David Melman	Not Affiliated
Deborah Circelli	Boeing
Dee Russell	The Boeing Company
Diana Oglesby	NASA
Diane Rausch	NASA HQ
Dillon McInnis	SpaceX
Etienne Dauverane	ESA
Gene Mikulka	Talking Space Podcast
Jeannette Plante	NASA
Jeff Sous	Space News
Joey Roulette	The New York Times
Josh Barrett	Boeing
Joy Kim	GAO
Juan Castilleja	Boeing
Julie Arnold	United Launch Alliance
Kelly Kabiri	NASA Office of Safety and Mission Assurance
Kimberly Benoit	NASA Office of Inspector General
Kristy French	NASA
Kristy Joseph	U.S. Congress
Kronmiller	Law Office
Kyle Nowlin	Boeing
Lauren Seabrook	Boeing
Lewis Groswald	Lockheed Martin
Linda Karanian	Aerospace Consulting
Loren Grush	The Verge
Marcia Smith	SpacePolicyOnline.com
Mary Hovater	NASA
Michael Lapidus	SpaceX
Michael Sheetz	CNBC

Michael Smith	NASA
Michelle Green	NASA
Micah Maidenberg	Wall Street Journal
Mike Wall	Space.com
Miles Doran	CBS News
Nicholas Cummings	SpaceX
Paul Brinkmann	United Press International
Rebecca	Boeing
Richard McKinney	Consultant
Robert Schwank	NASA
Rosa Banuelos	Boeing
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