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

June 13, 2019

Mr. James Bridenstine
Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Mr. Bridenstine:

The Aerospace Safety Advisory Panel (ASAP) held its 2019 Third Quarterly Meeting at NASA Headquarters, Washington, D.C. on June 4–6, 2019. We greatly appreciate the participation and support that was received from the 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,

Patricia Sanders

Patricia Sanders
Chair

Enclosure

AEROSPACE SAFETY ADVISORY PANEL
Public Meeting
June 6, 2019
NASA Headquarters
Washington, D.C.
2019 Third Quarterly Meeting Report

Aerospace Safety Advisory Panel (ASAP) Attendees
Dr. Patricia Sanders, Chair
Lt Gen (Ret.) Susan Helms
Dr. Sandra Magnus
Dr. Don McErlean
Dr. George Nield
CAPT (Ret.) Christopher Saindon
Mr. David West
Dr. Richard Williams

ASAP Staff and Support Personnel Attendees
Ms. Carol Hamilton, NASA ASAP Executive Director
Ms. Lisa Hackley, NASA ASAP Administrative Officer
Dr. Mary Beth Saffo, Writer/Editor

Other Attendees
Joan E. Higginbotham (Collins Aerospace)
Griffin Reinecke (Subcommittee on Space and Aeronautics/ Committee on Science, Space and Technology, U.S. House of Representatives)

Telecon Attendees (36) – see Attachment 1

Opening Remarks: Ms. Carol Hamilton and Dr. Patricia Sanders
Ms. Carol Hamilton, ASAP Executive Director, called the meeting to order at 9:30 a.m. EDT and welcomed attendees to the ASAP's third quarterly meeting of 2019. Ms. Hamilton informed attendees that they were welcome to make comments at the end of the meeting. She also noted that the public has an opportunity to submit formal verbal or written reports to the Panel; none, however, were received for this meeting. Ms. Hamilton then turned the meeting over to the ASAP Chair, Dr. Patricia Sanders.

Dr. Sanders observed that this an exciting time for NASA — although perhaps it always is an exciting time for this Agency. Accordingly, it has been an intense several days of exchange for the Panel in its engagement with the Agency personnel at NASA headquarters. Dr. Sanders offered the Panel's appreciation for the time that personnel have spent with ASAP over the past few days and in the two months since the 2nd quarterly meeting. The recent direction NASA has received for a human presence on the Moon by 2024 has created a sense of schedule urgency and energized the workforce. But for that goal to be realized, focus on safety and mission assurance remain integral to success. It is also important to note that planning for the lunar campaign is not the only critical area of work on NASA's agenda. In addition to the activities reported at this meeting, NASA is also deeply involved in X-plane development, final testing and readying of the James Webb Space Telescope for launch, and a host of critical science and technology programs that were not discussed during this ASAP visit.

One of the extremely important current enterprises at NASA, which the Panel has been assessing for some time, is the Commercial Crew Program (CCP). Since the last Quarterly meeting, the Panel has conducted in-depth Insight meetings with both of the providers of Commercial Crew vehicles, in addition

to extensive discussions with CCP staff at this meeting. After years of hard work, this program is poised to launch NASA astronauts into Low Earth Orbit (LEO) from U.S. soil. Reminding attendees that the excitement about the moon should not distract NASA from its focus on achieving mission assurance in this arena, Dr. Sanders introduced Dr. Don McErlean and Lt Gen Susan Helms to lead discussion on the status of this endeavor.

Commercial Crew Program (CCP)

CCP continues to make significant progress towards its goal of providing transportation of U.S. astronauts to the International Space Station (ISS). The two primary CCP contractors, Boeing and SpaceX, have both scheduled major test flights in 2019. In early March, SpaceX successfully flew an uncrewed flight (Demo-1) to the Station, and Boeing is in final preparations for its first uncrewed demonstration flight (OFT-1) later this year.

Dr. McErlean noted that technical challenges remain for both contractors, principally involving parachute system testing and qualification. In addition to parachutes, each contractor continues to work on resolution of specific issues for their respective systems. Boeing is in final preparation for the Pad Abort Test, which is scheduled for late summer 2019, and its success is required for certification of this critical safety system. Boeing hopes to carry out both uncrewed and crewed test flights by the end of 2019.

While preparing for a key test of its own abort system in April 2019, SpaceX suffered a significant anomaly that resulted in substantial damage to its capsule. SpaceX has formed an Anomaly Investigation Team consisting of technical personnel from SpaceX, NASA, FAA, and NTSB; this team has been working together very well to investigate and to correct both the proximate and root causes of this anomaly. As soon as the investigation is completed, SpaceX will continue the testing needed to certify the vehicle for crewed flight.

In preparation for the crewed flights, both providers have engaged with NASA in joint training of their respective flight crews and ground-support teams, including joint mission simulations and dress rehearsals of launch, flight operation, and recovery phases of the upcoming flights.

Final certification programs are underway, with the CCP continuing to monitor, review, and approve certification data products as they are completed. Completion of this certification process is essential to ensure that both providers have a NASA-certified design to support continued operations. Expanding on Dr. McErlean's report, Dr. Magnus applauded the CCP for its management of the testing and certification process, especially for balancing the workflow in such a way that has ensured careful, quality work without overstressing the workforce. In sum, the CCP continues to show tangible progress toward the goal of commercial crewed flight.

Lt Gen Helms provided an additional point regarding the SpaceX mishap investigation. In effect, as the team works through the investigative 'fault tree', the investigation has offered some opportunities to revisit the design of the Dragon and to make some improvements when warranted. Although these improvements are only opportunities and not necessarily related to the root cause nor the proximate cause of the accident, these improvements do speak to the advantage of the SpaceX design approach and the company's adaptability and agility. The ASAP should hear more about the investigation and its causes at the next meeting.

Lt Gen Helms also noted that, as NASA looks to the Lunar 2024 program, that program plans to incorporate extensive use of commercial partnerships. The lessons learned and best practices developed

through execution of the CCP program should be heavily leveraged as NASA embarks on Lunar 2024 program planning and acquisition strategies. (See page 4 for additional Panel discussions on Lunar 2024). Dr. Sanders concurred with Lt Gen Helms, observing that one of the key takeaways from the CCP — and a lesson for the future — is the close interaction of the government program office and the contractor partners. The recognition of shared responsibility and accountability, the valuable communications and mutual transparency have been critical to progress and will need to carry over into flight operations. This close partnership evolved over the conduct of the program and is a lesson learned for future government- commercial provider partnerships.

Exploration Systems Development

Dr. Sanders emphasized that the Exploration Systems Development (ESD) Program is key to getting to the lunar environment. The Space Launch System, the Orion capsule and the associated Ground Support Systems are the fundamental components necessary to enable that campaign. To provide an update on this program, Dr Sanders introduced Mr. David West and Dr. Sandra Magnus, who summarized the Panel's discussions on this subject. Dr. Sanders reminded the audience that the original nomenclature for the planned flights, EM, has recently been replaced by Artemis, and that the Panel may use both terms as it transitions to the new nomenclature.

A crucial element of spacecraft design for human travel to any space destination, but especially to a destination beyond LEO, is the ECLSS (Environmental Control and Life Support System). Mr. West noted that the panel had a very good discussion with ECLSS subject-matter experts, who provided a thorough overview of the ECLSS design for the Orion vehicle, including a detailed description of the processes for testing and qualifying the various components of the system prior to Artemis 2, the first crewed flight. The panel was especially pleased to see the extensive testing that has already been done, onboard the ISS, of the various components whose functioning could be affected by micro-gravity. The team also demonstrated the utility of the OLIF (Orion Life-Support Integration Facility) test facility at Johnson Space Center (JSC), where hardware and software can be tested as integrated systems, thus enabling a thorough integrated, system-level qualification exercise for the complete ECLSS. The team's report provided the information needed to allay the panel's concerns with the system. ASAP discussed tentative plans to visit the OLIF on our visit to Johnson Space Center later this year.

As the ESD program examines the possibility of launching Artemis 1 in 2020 per the Vice President's direction, the team is investigating every opportunity to optimize the schedule. As such, they have already made changes to the manufacturing flow that improves efficiency without impacting safety. As workflow analysis continues, the panel reiterates its firm belief that the Green Run, a full scale, fully instrumented test of the propulsion system, is a critical safety and mission assurance milestone for the program and must be retained. In addition, as the panel has previously commented, it is extremely important that the program continue to ensure that the Artemis 1 mission incorporates all those test elements required to retire risk prior to the first crewed mission on Artemis 2. One of the changes between Artemis 1 and Artemis 2 that the panel will be investigating in the near future is related to the design and qualification of the Orion side hatch.

Dr. Magnus discussed the Panel's concerns with the decision of the Orion program not to implement a parallel propellant system in the European service module (ESM) after Artemis 3. Because of this decision, the panel requested a detailed discussion of the process and logic flow used to evaluate the pros and cons of serial vs. parallel plumbing on the propellant tanks. The primary challenge of the ESM propulsion system revolves around the need to protect for propellant leaks. Traditionally, parallel architecture has been used to provide fault tolerance in the case of leaks. With the goal of saving weight

and complexity, the program has explored an alternate option for minimizing risk: a serial design that maximizes fault tolerance. These efforts have resulted in a design that has fault tolerance in every part of the system except for a welded area connecting tank plumbing, which NASA has analyzed to be an area where leaks are unlikely. The panel was pleased to see the thoroughness of the process to investigate the problem and to carry out a careful comparative analysis of the various risk postures involved with serial and parallel plumbing approaches. In addition. appropriate processes were utilized to address dissenting opinions, up through the highest levels of the agency.

As exploration missions push humans further and further away from Earth, NASA must put more focus on designing for mission assurance – that is, implementing the full life-cycle engineering process to identify and mitigate any design, production, test, and field support deficiencies that threaten mission success. Several methodologies are available for addressing mission assurance: the use of redundancy in design, implementation of fault tolerance, and striving for very high-reliability components and systems design. As NASA moves to implement these multiple design strategies in its programs, it is critical that the agency clearly and precisely communicates the parameters of and rationale for those approaches, including the processes used for considering and implementing the different methods, and for qualitative and quantitative comparisons of each approach. Because redundancy has been the prime approach for mission assurance and safety design at NASA in recent years, consideration of alternative approaches is a significant culture change for the agency. The panel cannot express strongly enough the importance of effective and thorough communication of these changes in design philosophy to the workforce, especially during this challenging period.

With regard to the philosophy of multiple design strategies, Dr. Sanders added that redundancy is one tool for mission assurance, but it is not necessarily the only solution; it does not help mission assurance if the redundant design adds so much mass to the spacecraft that the vehicle cannot get off the ground. Dr. Sanders emphasized how essential it is that NASA stay focused on completion of all Artemis safety-test objectives, to ensure mission success and to reduce crew risk for Artemis flights and subsequent crewed missions.

Lunar 2024

Turning next to the Lunar 2024 planning, Dr. Sanders observed that there is clearly a great deal of effort going into determining how to meet that mandate. She reiterated what the Panel has said about this challenge. First, the sense of schedule urgency can be positive and effective, but it should not become a pressure that engenders decisions or actions that undermine mission assurance and safety. That success will necessitate embracing lessons learned from emerging business models such as used in the Commercial Crew Program, while maintaining the fundamentals of the effective design, system engineering, and test. And very importantly, the mandate must be accompanied by the resources required to do the job successfully. A national commitment must include the funding needed and funding when it is needed. To attempt to meet a schedule without sufficient resources leads to unacceptable risks. Dr. Sanders then introduced Dr. George Nield, who summarized Panel discussions on the lunar program.

With the Vice President's challenge to NASA to land astronauts on the moon by 2024, NASA is facing a very exciting, but also very challenging opportunity. Given the Panel's responsibility to provide advice on spaceflight safety, the ASAP is looking forward to working with both NASA and the Congress as detailed plans are developed in the days and weeks ahead. Even before all of the specific decisions are made on system architecture, hardware design, operations philosophy, and acquisition, there are a number of observations that the Panel would like to share, and areas where the Panel would like to encourage NASA

to build on the lessons that have been learned from the Commercial Cargo and Commercial Crew Programs, and other recent spaceflight experiences.

1) It will be extremely important for NASA to have adequate funding for this effort. NASA will not be able to accomplish this mission successfully on the cheap. Partnering with industry and using innovative approaches have a lot of potential to ensure that this effort is not merely a gold-plated repeat of Apollo; but gutting the rest of NASA's programs to fund the Artemis Program would not be a reasonable approach. And as the Panel has noted many times in the past, Continuing Resolutions can be very disruptive to program management and the overall budget process.

2) The value of working with multiple providers has been demonstrated on numerous occasions with both Commercial Cargo and Commercial Crew, with each company being challenged to do better on cost, performance, and safety, by its competitors. And the participation of multiple providers also can be very helpful after accidents or unexpected test results.

3) Acquisition mechanisms: There is no doubt that the use of Broad Area Announcements, Space Act Agreements, and Other Transaction Authority arrangements, along with firm fixed- price contracts, and performance-based milestone payments, can result in significantly lower development costs. At the same time, that approach puts much more responsibility on the government to make sure the requirements are correct at the start of the program, and to guarantee that there is a provision for the government to step in and to respond appropriately to unexpected developments or technical surprises during the program.

4) Performance-based requirements: The government traditionally likes to specify a large number of very detailed, very prescriptive requirements. But I,f instead, NASA can articulate what it wants the system In question to do rather than exactly how to do it, the resulting system can very often take advantage of innovation and advanced technologies in a very beneficial way.
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5) Scheduling. Having a set of clearly articulated and communicated objectives, ambitious but attainable schedule goals, and a sense of urgency in the workforce can be a very good thing. At the same time, the Panel does want NASA to avoid launch fever and the kind of overwhelming schedule pressure that can lead to shortcuts that compromise safety or inappropriate programmatic decisions.

6) Early engagement with industry. With the commercial cargo and commercial crew programs, it took a while before NASA and its commercial partners were able to build a sense of mutual trust. But having government representatives embedded with key providers early, and communicating regularly and frequently, can really pay off, as opposed to merely exchanging paperwork between parties and/or having quarterly teleconferences. Thus, the Panel would love to see that kind of relationship between NASA and industry right from the start on this program. as well.

Expanding on Dr. Nield's comments, Dr. Sanders offered an additional example of the benefits of multiple space providers. An important component of any lunar campaign will be the lander: for this crucial component of the mission, it will be highly beneficial to carry multiple and dissimilar concepts through to flight.

As Dr. Nield indicated, an aspect of achieving an earlier presence on the moon is moving forward some components of the architecture, while deferring others to a second phase of the campaign. The Panel has frequently expressed the concept of a risk - value equation. The risks that a given mission may be

willing to accept in the early phase of deep space exploration must be balanced against the objectives and benefits of such exploration. To the extent that attributes of the architecture are deferred, NASA should not lose sight of the importance of those aspects and should maintain a constancy of purpose for long-haul deep space exploration.

International Space Station (ISS)

Dr. Sanders noted that the ISS clearly continues to fill an important role in understanding and buying down the risk for long duration deep space exploration; for these reasons, the Panel remains supportive of maintenance of a persistent sustained presence in LEO for that purpose.

Dr. Sanders introduced CAPT Chris Saindon to summarize the Panel's discussions with the ISS Program's Operations Integration Manager, Mr. Kenny Todd. Mr. Todd and his team provided an update on the current status of Station, as well as a look at some of the major evolutions planned for Station in the near-term.

The International Space Station continues to perform brilliantly as a platform for continuous human presence in LEO. Day in and day out, the ISS team manages to make the complex and challenging task of executing space operations appear routine.

As the only platform available to conduct research in the microgravity environment, the ISS serves as an invaluable testbed to study the physiological impacts of long-term spaceflight on humans, as well as evaluating performance of key future-spacecraft system components. Both of these areas of research are helping to pave the way for future missions beyond LEO. Two particular examples, offered during other sessions of the meeting, illustrate the research importance of the ISS for current and future spaceflight missions:

1. ISS has allowed NASA to test critical Orion capsule ECLSS components (for instance, the Phase Change Module/wax sublimator) on-orbit. The results of those tests have informed design refinements to be carried out well before assembly of what will ultimately become the EM-2/Artemis-2 spacecraft.
2. Regarding the physiology of human spaceflight, the ISS has enabled development of a more in-depth understanding of the physiological impacts of long-duration spaceflight. Later in the meeting, Dr. Rich Williams presented further details on this research program (see page 7, "Health and Medical Safety," below).

In 2019, the ISS team has been extremely busy planning, coordinating and executing numerous crew rotations, cargo resupply events, and EVAs (extravehicular activities) in addition to conducting routine maintenance on orbit. The ISS crew remains highly productive, with over 200 investigations carried out during Increments 59 and 60, and over 2800 investigations performed over the lifetime of the ISS. With the presence of at least 3 United States Operating Segment crewmembers planned for most of 2019 through increments 60 & 61, crew utilization is projected to remain high. The berthing schedule has included recent completion of NG-11 Antares and Space-X 17 Cargo missions; Space-X 18, HTV-8, and NG-12 missions will be coming to the ISS within the next few months.

In summary, the ISS has proven to be a remarkably resilient and successful platform and serves as the benchmark for all future multinational space exploration efforts. ISS continues to serve as THE proving ground for long-duration space flight, and its value in that regard cannot be overstated.

The ISS program discussion highlighted a number of important EVA (Extravehicular Activity) events that are planned for increments 60 & 61. This fairly busy EVA schedule is slated to kick off in late August and will run through the end of 2019. Some of the more complex tasks, such as battery upgrade/replacements on the outboard arrays, will require 5-6 EVAs alone; installation of a new International Docking Adapter #3 will require at least 1 EVA, and repairs on the Alpha Magnetic Spectrometer (AMS) will also require about 5 EVAs.The Crew will be busy, not only with actually conducting the EVAs, but also with all of the required EVA preparation and Post-EVA EMU (Extravehicular Mobility Unit or EVA suit) processing.

To support this EVA schedule, there are currently 4 EMUs on-orbit. All 4 of those EMUs are currently GO for EVA. One EMU (#3003) did have a minor issue with a suit pressure sensor during EVA #52 and is being held in "ready spare" status until it is replaced by SN# 3009 which is manifested on the Space-X 18 cargo flight slated for July. Additionally, a spare Fan Pump Separator Unit will be delivered on SX-18. The Panel will be very interested in seeing the results of EMU performance following these planned EVAs, particularly if the suits exhibited any unexpected behavior during this period of increased utilization.

Legacy EMU suit-life extension and upgrades remain in work, with planned capability extension to 2028. Development of the next-generation xEMU prototype "Demo suit" is underway, with deliverables consisting of 1 development, 1 qualification and 1 flight unit, with ISS flight demonstrations planned for 2023. The xEMU is an organic NASA design-and build-project that will ultimately be produced by a manufacturer yet to be determined. No contract has been awarded yet for final design production of this suit. In addition to replacing the legacy EMU, a derivative of the xEMU will likely be the suit used on the Artemis missions to the moon.

At the 2nd quarterly meeting of the ASAP, Lt Gen Helms made a recommendation regarding transition to the next generation EVA suit. The panel continues to emphasize the importance of a focused effort toward bringing the next generation EMU on-line. The xEMU may eventually be part of that solution and continuing to push to get an xEMU prototype off the drawing board and into testing is vitally important.

Mr. Todd also outlined the progress of the Commercial Resupply Services 2 (CRS-2) contract. ISS integration milestones are tracking for all 3 providers and the ISS team looks forward to taking advantage of some of the improved capabilities that the CRS-2 providers will bring to the table, such as quicker recovery of life science rodent subjects.

The Panel is pleased to see that the ISS program continues to make good progress with its plans for ISS nominal and contingency deorbit. Open items for both the Russian and US segments are in work, especially concerning propulsion systems. The program's relevant guiding document, the "ISS Deorbit Strategy and Contingency Action Plan," is nearing completion and is out for final review and signatures with the international partners.

Dr. Sanders concurred that the ISS continues to fill an important role both in accomplishing current LEO space activities, and for conducting research critical for planning long-duration deep space exploration.

Health and Medical Safety

To summarize Panel discussions on the topic of Health and Medical Safety, Dr. Sanders introduced Dr. Rich Williams, who presented the highlights of those discussions, including the buy down of risks in human space travel. The health risks of human space flight, NASA's efforts to mitigate those risks, and the activities of the Health and Medical Technical Authority are of ongoing interest to

the Panel. Dr. James Polk, NASA's Chief Health and Medical Officer, and Dr. William Paloski, Director of NASA's Human Research Program, provided updates on the clinical and research activities of their office.

The Health and Medical Technical Authority (HMTA) was originally configured to support the International Space Station and Shuttle programs. HMTA personnel are currently engaged with every program, and they are working diligently to provide full support. It is imperative that HMTA experts become involved early and remain engaged throughout the life of every human space flight program. Delayed involvement of any technical authority can result in reduced responsiveness with the risk of increased programmatic cost and negative impacts to schedules. NASA also needs to comprehensively review human health spaceflight standards, some of which are out of date or not appropriately applicable to currently envisioned mission architectures. This review is critical to assure provision of the best human health related programmatic requirements.

Space Flight Associated Neuro-ocular Syndrome (SANS) continues to be a major concern for long duration space flight. No change in attack rate has been noted, and research continues in an attempt to understand the underlying physiology and etiology of this threat and to develop mitigations. A head-down bedrest study completed in Europe in a high CO2 atmosphere has produced some ocular changes similar to those seen in SANS, which may represent the beginnings of a ground-based model to study this condition. Venous thrombosis in the head and neck may be an associated and emerging spaceflight related concern. Plans are in work to monitor long duration crewmembers for these conditions.

The Human Research Program continues ISS and ground-based research to understand and mitigate human health risks in spaceflight, in close collaboration with the Office of the Chief Health and Medical Officer. Acute and chronic effects of space radiation, SANS, behavioral health considerations, food and pharmaceutical stability, autonomous medical capabilities, and integrated food/microbe-host/immune system considerations remain of high interest and priority. The recent acceleration of NASA's lunar program may present opportunities for the HRP to learn more about human health in lunar orbit and in the reduced gravity of the lunar surface. The effects of partial gravity in mitigating the risks of microgravity are unknown, and missions to the lunar surface may provide insight into this question.

The Panel appreciates the collaboration between NASA's medical and biomedical research authorities in support of astronaut health. Previously unknown human health threats continue to manifest with increasing duration of flight. Human health and physiology during missions longer than one year in space is unknown territory, and it seems certain that additional health threats will continue to emerge. The Panel believes that every opportunity to study human health and to perform biomedical research in long-duration space missions should be exploited. Once again, the Panel notes the crucial role of the ISS as the only available research venue in space capable of developing the database necessary for understanding and mitigating the human health risks of long-duration space travel. This knowledge is essential to current and future mission safety and success of human space travel, especially as NASA plans expeditions to the Moon and beyond.

As a sign of the inadequacy of our knowledge of space health, Dr. Magnus observed that researchers are still learning even which questions to ask. Dr. Nield noted the uncertain, but limited lifetime of the ISS, and reiterated the continued importance of a LEO research platform for investigating the effects of microgravity on both human health and on spacecraft instrumentation.

Dr. Sanders praised the multi-pronged efforts to address the medical issues identified to date. Since there are limits to the ability to prevent radiation exposure entirely in space travel, efforts to at least mitigate its effects seem especially important; she suggested that the solutions to problems such as these are likely to be found outside of NASA. To address these challenges, Dr. Sanders also reiterated the importance of early engagement of medical personnel in all phases of human space flight programs. Delayed or insufficient involvement of medical staff in spacecraft and project design can result in increased programmatic costs, schedule delays, and potentially greater risks to safety. Overall, it is clear that the space environment poses real health risks for space travel of long duration. Yet NASA and other spacefaring nations will continue to brave that environment, because of their belief in exploring and understanding this universe in which we exist.

In conclusion, Dr. Sanders briefly discussed the safety hazards posed by Micro Meteorite and Orbital Debris (MMOD). MMOD continues to pose one of the highest risks for space activities. Although NASA is certainly aware of this problem and takes it into account in program and spacecraft design, as well as in space operations, this hazard is largely out of its control. Despite the fact that National Space Policy Directive 3 acknowledges the criticality of this hazard, the ASAP continues to await U.S. leadership to take meaningful action to address the problem.

Closing remarks

Dr. Sanders thanked the Panel for its dedication and continuing participation. Advising on the best ways to manage risk is a continuing challenge for ASAP, knowing that complex space systems operating in an inherently hazardous environment will never be completely safe, compared to expectations of safety on Earth.

Having received no public comments, Ms. Hamilton adjourned the meeting at 10:20 a.m.

Attachment 1

Telecon Attendees:

PARTICIPANTS (36)

Alicia Brown	Senate Commerce Committee
Amy Lentz	N/A
Ben Sellari	N/A
Bill Harwood	CBS News
Bob Duhle	Boeing
Brian Harey	Associates
Chris Davenport	*The Washington Post*
Diane Rausch	NASA HQ
Dillon Macinnis	SpaceX
Doug Breckenridge	N/A
Eric Berger	*ARS Technica*
Erin Kennedy	BAO
Gene Mikolka	*Talking Space*
Gerald Everett	Retired
Henry Kelly	*Florida Today*
James Dean	N/A
Jared Stout	Venable LLP
Jared Stout	Venable LLP
Joey Roulette	Royders
Josh Barrett	Boeing
Joy Kim	GAO
Kathryn Hamilton	NASA
Kristin Van Wychen	USGAO
Linda Karanian	Karanian Aerospace Consulting
Lynne Loewy	NASA HQ
Marcia Smith	Space Policy on line.com
Mariam Kramer	Axios
Maribeth Davis	Boeing
Mark Carreau	Aviation Week and Space Technology
Mary Dittmar	CDSE
Maryann Chevalier	NASA
Michael Lapidus	SpaceX
Mike Curie	NASA
Patricia Soloveichik	Boeing
Rebecca Regan	Boeing
Tremayne Dais	NASA