

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

February 6, 2020

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

Dear Mr. Bridenstine:

The Aerospace Safety Advisory Panel (ASAP) held its 2020 First Quarterly Meeting at NASA Kennedy Space Center, Cape Canaveral, Florida, on February 4-6, 2020. We greatly appreciate the participation and support that was received from the Center leadership, the subject matter experts, and support staff.

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

Sincerely,



Patricia Sanders
Chair

Enclosure

AEROSPACE SAFETY ADVISORY PANEL

Public Meeting

February 6, 2020

Kennedy Space Center, Cape Canaveral, FL

2020 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 (*via telecon*)
Dr. Donald McErlean
Dr. George Nield
CAPT (Ret.) Christopher Saindon
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 Leeman, Technical Writer/Editor

NASA Attendee:

Mr. Kevin Villa

Opening Remarks

Ms. Carol Hamilton, ASAP Executive Director, called the meeting to order at 2:00 p.m. and welcomed everyone to the ASAP's first quarterly meeting of 2020. Prior to the meeting, the public had been invited to provide verbal or written statements.

Dr. Patricia Sanders opened the meeting by thanking Mr. Bob Cabana, Kennedy Space Center (KSC) Director and KSC staff members for hosting the ASAP's first quarterly meeting and enabling productive insight engagements. Dr. Sanders stated that Mr. Cabana and his personnel have a full agenda with a number of launches scheduled at KSC in 2020. She acknowledged the efforts to expand beyond the NASA missions to the support of multiple users of the Space Port and looks forward to the day when more truly commercial launch providers will invest in the local space launch infrastructure.

Dr. Sanders also thanked Maj. Gen. Lee Levy, who represented the NASA Advisory Committee (NAC) throughout the week's efforts, continuing the ASAP's and NAC's exchange of observers at each other's meetings.

CAPT Chris Saindon — who ended his tenure with the Panel at the conclusion of the first quarterly meeting of 2020 — was recognized for his superb support over the past several years.

Dr. Sanders thanked Captain Saindon, noting that he had been a valued and appreciated contributor to the ASAP.

Commercial Crew Program

Dr. Sanders directed the meeting to discussions concerning the Commercial Crew Program (CCP), stating that NASA is approaching the end-game phases, which include some very critical work in the near future with both SpaceX and Boeing. The Panel's assessment of SpaceX is that NASA is at a point where it is not a question of *if* they will be flying crew in the near term, but *when* and under what risk conditions. Dr. Sanders then indicated that a number of technical issues exist that have been either resolved or managed to the point where there is reasonable rationale to formally accept the residual risk. Composite Overwrap Pressure Vessel (COPV) testing, for example, has progressed to the point where the margins are sufficiently understood and there is confidence that operational conditions can be controlled to remain within those margins. Parachute redesign and testing has also progressed to the point where, with some tests still to be completed, the design will be qualified for flight. Some items, however, still remain to be resolved. Dr. Sanders specified that the interaction between titanium and nitrogen tetroxide, and the Merlin engine gas generation baffle erosion, are still undergoing testing, which must be concluded. The end appears to be in sight. The Panel urges NASA to remain vigilant as they near these important milestones and not skip any of the remaining steps for completing the all-important certification for human space flight.

Dr. Sanders stated that timing for Demo-2, and assuming its success, the timing of the Crew-1 flight, will depend on the satisfactory resolution of outstanding items, whether by eliminating the associated risks or by managing them to the point of acceptance. Demo-2 will also be dependent on completion of crew training and mission operations training, which are both integral parts of the system. Traffic management at the International Space Station (ISS) is another factor in the decision.

Dr. Sanders noted that the status with the Boeing provider is in a different position. She called upon Mr. Paul Hill to discuss the Panel's sense of that status.

Mr. Hill stated that the Boeing commercial crew team has made a lot of progress in development and testing for crew launch services, most visibly with the OFT test flight in December, and, in parallel, with their second spacecraft and booster assembly nearing completion. Although Boeing successfully deorbited the spacecraft, the mission was significantly truncated due to a software-related, in-flight anomaly, as has been widely reported already.

Mr. Hill noted that despite not being able to rendezvous and dock to the ISS, Boeing's flight operations team did an admirable job resolving the spacecraft control problem and preserving the ability to control the spacecraft and plan a controlled deorbit two days later.

Many of the Starliner test objectives were able to be accomplished. However, during the mission, a second Starliner flight software anomaly was detected during ground testing. Mr. Hill stated that while this anomaly was corrected in-flight, if it had gone uncorrected it would have led to erroneous thruster firing and uncontrolled motion during service module separation for deorbit, with the potential for catastrophic failure.

Boeing and NASA are still evaluating root cause and corrective actions for these flight software anomalies. Beyond these specific anomalies, the Panel has a larger concern with the rigor of Boeing's verification processes. As a result, the Panel recommends that NASA pursue not just the root cause(s) of these specific flight software anomalies, but also a Boeing-led assessment of and identification of corrective actions for Boeing's flight software integration and testing processes.

Further, to ensure confidence in a spacecraft intended to carry humans into space at risk, the Panel recommends an ever-broader Boeing assessment of and identification of corrective actions for Boeing's systems engineering and integration (SE&I) processes and verification testing.

Mr. Hill echoed the Panel's recommendation that NASA complete these assessments – an in-flight anomaly root cause assessment of the flight software, and an assessment of SE&I processes and verification testing – as required input to a formal NASA review to determine flight readiness for either another uncrewed flight test or proceeding to CFT-1.

Given the potential for systemic issues at Boeing, Dr. Sanders noted that NASA has also decided to proceed with an Organizational Safety Assessment with Boeing, as previously conducted with SpaceX. The review with Space X proved to be valuable to both NASA and to the company.

Dr. Sanders indicated that the current situation with Boeing is one instantiation of a more prevalent issue that faces NASA as well as any developer of modern systems. NASA is no longer building hardware into which a modicum of enabling software is installed; NASA and its partners are actually building software systems, which are wrapped up in enabling hardware. Furthermore, NASA and its space flight partners have not yet matured to the point where rigorous systems engineering principles are uniformly applied to the design of that software. Dr. Sanders emphasized that this is a serious and pervasive issue that NASA will need to address in all its programs and certainly will be critical in the deep space exploration endeavors.

Dr. Sanders pointed out another challenging aspect of the CCP, which has been the clarification of the roles and responsibilities of the government and the contractor providing services. Clarification becomes increasingly important as the program transitions from development to operations. It also has ramifications for future programs that seek to learn from CCP experience. Dr. Sanders introduced Dr. George Nield, who discussed the Panel's thoughts on this topic.

Dr. Nield noted that the Panel continues to see tremendous progress in the CCP. At this point, it appears that there is a very high likelihood that commercial human launches will be taking place during the next 12 months. A lot of work remains, but the Panel is confident that NASA and its commercial partners will work together and figure out how to get it done. Dr. Nield observed that in the months ahead, a number of changes will be taking place. The Panel encourages NASA to deliberately focus on and think about those changes, especially in terms of roles and responsibilities; that is, who will be doing what, and who is directing the effort in each case. Dr. Nield listed a few examples of near-future efforts.

Although Dragon and Starliner will soon be "certified," there will still be significant risk involved on every flight, and continuing vigilance is warranted. After the first test flights with crew

onboard (Demo-2 for SpaceX and CFT for Boeing), the plan is for all missions (post-certification missions) to be licensed by the Federal Aviation Administration (FAA), just like all cargo missions have been. NASA will still be engaged, but that will be a big change. Dr. Nield indicated that the Panel expects both SpaceX and Boeing will soon have opportunities to fly paying customers into orbit, whether as space tourists, research scientists, or as operators and/or inhabitants of free-flying commercial space station modules. Some of those missions may have nothing to do with NASA — with no NASA astronauts, no NASA payloads, and no NASA experiments. When space flight reaches that point, it will be important for NASA to have clearly communicated to all of its key stakeholders (including the Congress, the White House, the press, and the general public) what their role will be on those missions, if any. Dr. Nield recognized that in the event of a mishap, a number of organizations may participate in crew rescue and recovery efforts, including the Department of Defense (DoD), NASA, and the commercial provider. Under current law, a Presidential Commission may potentially be required, even if no NASA casualties are involved.

In many ways, the CCP has been a pathfinder for NASA in terms of how the Agency works with industry. Considering this status, it can help smooth the way for future national space programs, including Artemis, the Moon to Mars, and other programs that may follow. Dr. Nield stated that the Panel will be closely watching as NASA continues to evolve from the premier designer, developer, and operator of space systems to — at least in some cases — an informed, supportive, but demanding customer of commercial products and services. That will not be an easy transition.

Dr. Sanders agreed that these are important considerations for NASA to heed. Another program that is nearing significant milestones is Exploration Systems Development. Dr. Sanders turned to Dr. Don McErlean for a summary of the Panel's interchange with that program.

Exploration Systems Development

Dr. McErlean referred to the briefing received by the Panel on the Human Landing System (HLS) that included an explanation of the process, which would utilize commercial practices (like the CCP) and then certify the designs as satisfactory (i.e., safe) for human transport. Dr. McErlean pointed out that with a system this complex, establishing precise requirements the contractor must meet for certification was of great importance. He further recommended that the program establish a "Certification Plan" that lists all requirements needing Agency approval. Further, the plan should stipulate precisely *how* evidence of satisfaction of those requirements would be met (through test, analysis, etc.). Once created, this certification plan should be signed-off by both NASA (as the certifying agency) and the contractor to signify agreement on the requirements. The plan should then be placed under configuration control, wherein it could be changed, but only via an agreed-to process of review.

Dr. McErlean also discussed the significant progress the ESD program has continued to make. For example, the Orion and Service Module assembly is undergoing thermal vacuum testing at the NASA Plum Brook Station. Now nearing completion, this test, with the exception of a few minor leaks, has been very successful to this point. Another example of program progress is illustrated by the core stage delivery from the Michoud Assembly Facility to the Stennis Space Center for a Green Run test. This test will involve full duration firing of all four engines. To date, the core stage has been inserted into the SSC B-2 test stand and is undergoing instrumentation.

It is estimated that this critical test will take place in late summer or early fall of 2020. Dr. McErlean noted that the Panel reviewed the program's schedule plan and is pleased to comment that sufficient margin appears to have been allowed to handle any uncertainty or unexpected events.

Additionally, the Panel reviewed the ESD risk analysis and tracking system. Dr. McErlean indicated that prior identification of program risks, as requested by the Panel, did not fully delineate all factors potentially affecting safety. The Panel found that some technical safety risks, as opposed to programmatic risks, are tracked in a hazard analysis system, which is a separate database from the risk tracking system. At the Panel's request, the ESD program agreed to provide a more detailed analysis of the contents of the risk tracking system at a future ASAP meeting, including a review of hazards themselves and a burn-down plan. Dr. McErlean further commented that the Panel is aware the entire program schedule is being re-baselined. Given this, the Panel encourages a plan to include adequate margin to allow for uncertainty, thereby avoiding undue schedule pressure.

Dr. Sanders mentioned that during the first quarterly meeting of 2020, the Panel requested a discussion with Moon to Mars program leaders on two specific topics: (1) challenges to be addressed in order to achieve the nation's Mars exploration objectives and how testing in Low-Earth Orbit (LEO), that is, on the ISS, could help buy-down the associated risks; and (2) update on the HLS. Based on those discussions, Lt. Gen. Susan Helms reported on the exploration risk picture and a strategic hazard framework for the exploration mission enterprise.

Lt. Gen. Helms listed the following five hazards related to Moon to Mars Program human space flight, which were presented by Mr. Marshall Smith to the Panel:

1. Distance from Earth and the increased difficulties with communication, in addition to the fact that a premature return to Earth — to manage a broad systems failure or a health issue — may be impossible.
2. The short- and long-term effects of radiation on humans and equipment.
3. Altered gravity fields and the impact on both human reactions and equipment performance.
4. Long-term closed environment and having the long-term reliability to safely sustain human environment systems, including sustained food and water supplies.
5. Psychological hazards related to isolation, crew relationships, and small space confinement.

Lt. Gen. Helms noted that the Panel had previously discussed a myriad of activities on the ISS that are essential contributors to the risk reduction strategies for Moon to Mars. Specifically, NASA is testing exploration life support systems, environmental monitoring equipment, radiation sensing, fire safety, next generation space suit components, capabilities to aid in logistics reductions such as 3-D printing, and aspects of crew health and safety, such as the lettuce-growing AstroGarden. Lt. Gen. Helms stated that it was great to see the ISS being used for so much exploration activity, and as always, the Panel continues to advocate for the importance of the ISS platform as a critical exploration risk-reduction test bed.

However, some aspects of these five identified hazards cannot be answered solely by ISS risk-reduction efforts. For example, one hazard of space exploration positions crew on a path, whereby, should a major problem occur, such as a medical emergency, unlike the situation with the ISS, the ability to quickly abort and return to Earth may not be an available course of action. So, in future meetings, the Panel will have an interest in hearing about the risk mitigation waterfall strategies and how all these current efforts will tie together as a comprehensive strategy to manage the five strategic-level exploration hazards.

NASA is procuring the rapid development and crewed demonstration mission to return humans to the lunar surface using a firm fixed-price Broad Agency Announcement (BAA). In its intent, NASA is leveraging the speed and operating models of the commercial space industry while applying NASA expertise to ensure safety and mission success.

Lt. Gen. Helms echoed the sentiments of the Panel by stating that NASA has been executing this acquisition at a pretty breathtaking pace. An initial source selection to identify a reasonable pool of possible providers is expected to be complete within the next several weeks. That milestone will mark the start of a phased acquisition for the integrated lander demonstration mission, expected to reach the Moon by 2024. A certification baseline review for each provider will be accomplished about three months after award, and an agreement has been reached that the providers of the HLS demonstrations will either meet or exceed NASA-provided performance standards or propose alternate standards that meet the intent. Several months after source selection, NASA will review the HLS demonstration design concepts and offer an opportunity to adjust and update HLS designs and approaches.

Lt. Gen. Helms added that seeing NASA execute this approach is very impressive in showing their ability to do business in a way that innovative commercial providers can better plug into culturally. She cautioned that when the Panel looks at the BAA and the requirements that are to be addressed in the responses, it was noticed very little guidance or articulation of requirements exists surrounding the type of test and evaluation program that would come with the development.

Lt. Gen. Helms noted that in looking at how the CCP unfolded, it is a lesson learned that a core component of human space flight program risk reduction is the reliance on flight-like operational integrated testing. Once the source selection process is complete, the Panel will have an interest in how NASA moves forward in concert with the providers to ensure that a comprehensive flight-like test program is accomplished in a way that provides confidence and assurance that performance margins are known and risks are managed.

Lt. Gen. Helms recognized Dr. McErlean's previous statement concerning the importance of a certification plan for the HLS. She finalized her discussion stating that NASA has identified the overarching principles for risk management for development by commercial providers of various architecture components.

Dr. Sanders stated that meeting attendees would hear later about comments from Dr. J.D. Polk concerning some aspects of the bio-medical hazards Lt. Gen. Helms discussed. Dr. Sanders then referred to recent Panel discussions concerning how important the LEO arena is to learning and

risk burn-down for deeper space exploration. Currently, the available platform for deep space exploratory efforts is the ISS. Dr. Sanders turned to Mr. David West who addressed the Panel's thoughts on the platform.

International Space Station

Mr. West indicated that the ISS continues to be a remarkable example of NASA's success conducting valuable research and maintaining a sustained human presence in LEO while working with numerous international partners. Increment 61 of the ISS has just transitioned to Increment 62 with the return to Earth of crewmembers Christina Koch, Luca Parmitano, and Aleksander Skvortsov. Christina Koch now holds the record – 328 days – for the longest single space flight by a woman. For Increment 62, crewmembers Oleg Skripochka, Jessica Meir, and Andrew Morgan remain aboard the Station.

Mr. West stated that the ISS program has been managing an extremely complex flight plan that includes overlapping visits by multiple cargo vehicles. Several extravehicular activities (EVAs) have recently been completed, including the fourth in a series of spacewalks to make some very difficult repairs on the Alpha Magnetic Spectrometer, and another series to replace numerous Station batteries. After one of the battery EVAs, a battery charge discharge unit (BCDU) failed to activate and had to be replaced with one of three on-orbit spares. The Panel noted this as yet another example of the ISS program effectively managing day-to-day risks.

While there have been plenty of stunning successes with the ISS, there are also ongoing challenges and concerns. Budget uncertainties, Mr. West specified, are the number one risk facing the ISS. Without assurance that upcoming funding requirements will be met, program options are considerably more limited, and management decisions are extremely difficult. A significant ongoing concern, and one that the Panel has previously brought up, involves the need for assured access to the ISS. With the current flight plan, there is a risk that the ISS will be operating with only one U.S. Orbital Segment (USOS) crewmember for a period of time. This potential reduction in U.S. crewmembers would introduce risk and challenges, including difficulties in planning and conducting EVAs, negative impact to contingency EVA capability, impact to visiting vehicle operations, response to unplanned anomalies, and reduction of available crew time. Mr. West noted that after the Soyuz return planned for October of this year, no more U.S. seats are planned on Soyuz. Lack of personnel with the requisite skill sets and training to operate the USOS will place the entire Station at risk. Assured access to the ISS was the subject of a 2018 Panel recommendation that remains open.

2018-04-02

Action to Ensure U.S. Access to the International Space Station (ISS) Given Commercial Crew Program Schedule Risk: Due to the potential for delays in the schedule for the first Commercial Crew Program (CCP) flights with crew, senior NASA leadership should work with the Administration and the Congress to guarantee continuing access to the ISS for U.S. crewmembers until such time that U.S. capability to deliver crew to the ISS is established.

OPEN NASA responded on 3/29/19, concurring with the recommendation. NASA is actively developing, assessing, and implementing options to protect the presence of American crew on the ISS to support the U.S. On-Orbit Segment.

Along with the ISS discussion, the Panel received an update on the status of the transition to next-generation extravehicular mobility units, or xEMUs. Required transition to the xEMUs was the subject of a Panel recommendation made last year. Mr. West acknowledged that while NASA has done impressive work planning the development and manufacturing of the new xEMUs for the Artemis missions, efforts to develop and acquire them have not yet been established as a formal and funded NASA program. The Panel continues to urge that NASA make this a priority. Furthermore, the inability to get certain replacement parts and materials for the current EMUs on the ISS is an ongoing concern.

In summary, Mr. West stated that the Panel continues to monitor the status of work on the ISS Deorbit Strategy and Contingency Action Plan. This was the subject of another Panel recommendation from several years ago that remains open. Technical aspects of the deorbit strategy have been resolved. Final edits to the plan are not expected to affect approvals previously obtained from most international partners. The document is being rereleased for review and signature by all partners.

Dr. Sanders reminded the audience that while NASA continues to make operations on the Station look “easy,” they remain, in fact, incredibly challenging and it is excellent management, training, and expertise that make the amazing achievements of the Station possible. Uncertainty about the funding and longevity of the Station is a concern.

Dr. Sanders acknowledged the Panel’s insight examinations at this meeting, including engagement with Dr. Polk, the NASA Chief and Medical Officer, with respect to risks of long duration human space presence with implications for exploration plans. Dr. Sanders stated that the Panel is privileged to have Dr. Williams as a member, representing the talent who fully comprehends the complex bio-medical issues. Dr. Williams was introduced and reported on this interaction.

Dr. Williams explained that as experience in longer duration flight increases, previously unknown and unappreciated health risks are emerging. Recently, thrombosis in the left internal jugular vein was found in an asymptomatic astronaut incidentally during ultrasound examination as part of a vascular research study two months into an ISS mission. This astronaut indicated no unique physiologic risk or predisposition for venous thrombosis. The clinical incident was managed successfully through mission completion with no adverse mission impact.

Dr. Williams stated that jugular venous thrombosis on Earth is usually associated with disease states such as cancer, instrumentation of the jugular venous system, and some abnormal hormonal states. Spontaneous thrombosis of the jugular system is uncommon. Venous thrombosis commonly occurs in the lower extremities and pelvic venous systems. Some risk factors may exist for venous thrombosis in the head and neck associated with human space flight. Dr. Williams presented the following risk factors as examples: elevated intracranial pressure (the Space Flight-Associated Neuro-Ocular Syndrome or SANS phenomenon), venous stasis due to fluid shift, use of birth control medication, and possible interface between the crewmembers and exercise equipment, such as the treadmill harnesses [used on the ISS]. This is the first time, however, that venous thrombosis in the head and neck has been observed in a crewmember in flight. Recently, the results of a research study conducted on ISS entitled “*Assessment of Jugular Venous Blood Flow Stasis and Thrombosis During Spaceflight*” were published. Findings included stagnant and retrograde blood flow in the internal jugular system

of about half of the astronauts participating, with evidence of thrombosis in two astronauts. Whether or not this is associated with SANS, and its relationship to intracranial hypertension, is unknown and is under investigation.

Dr. Williams indicated that this clinical incident and study clearly demonstrate the great value of the ISS in understanding the human health risks associated with increasing duration of flight. The Panel recognizes the imperative of maximizing the health observation and research potential of the ISS as the best opportunity to discover and mitigate health risks prior to exploration class missions to the Moon and to Mars.

Before concluding the meeting, Dr. Sanders reiterated some persistent concerns of the Panel, which were addressed in the 2019 ASAP Annual Report and remain a high priority. One concern is the continuing budget uncertainty. The 2021 President's Budget will soon be released, and the Panel can only hope there will be a subsequent and timely Appropriation by the beginning of the fiscal year.

Dr. Sanders emphasized the Panel's stance to continue to push for a reexamination of the specifics of the requirement for a Presidential Commission for Human Space Flight Independent Investigations to reflect the evolving environment since the NASA Authorization Act of 2005. The Panel continues to recognize micrometeoroids and orbital debris as a major space flight hazard. While there is broad awareness of this hazard, the Panel still does not see meaningful steps being implemented to address its mitigation.

The Panel again advises NASA leadership to deliberately focus on transparent engagement with the workforce that, in undertaking multiple complex, simultaneous developments and operations, is in danger of stress, leading to unwise risk management. Dr. Sanders concluded the meeting stating that the careers of NASA personnel with Shuttle experience — and certainly of anyone with Apollo experience — is nearing an end. At the point of time when NASA is undertaking the simultaneous development and execution of an unprecedented number of complex and challenging programs, NASA must continue to develop the workforce and talents needed to meet the emerging challenges it faces.

Dr. Sanders adjourned the meeting at 2:55 p.m.

ATTACHMENT 1**Telecon Attendees:**

Alicia Brown	Senate Commerce Committee
Ann Zulkosky	Lockheed Martin
Anne Kierig	Venable
Bill Beckman	Boeing
Bill Harwood	CBS News
Brendan Byrne	WMFE
Caitlyn Torres	Boeing Communications
Chris Murray	Observer
Dan Silianoff	Asterbotic Tech
David	Unaffiliated
Diane Rausch	NASA HQ
Dillon Macinnis	SpaceX
Eric Berger	ARS Technical
Gene Mikulka	Talking Space Podcasts
Jeff Foust	Space News
Joel Engle	BAM
Joey Roulette	Reuters
John Kross	Ad Astra Magazine
Josh	
Joy Kim	GAO
Katherine Verona	US Senate
Leroy Cain	Boeing
Linda Karanian	Karanian Aerospace Consulting
Loren Grush	The Verge
Marcia Smith	Spacepolicyonline.com
Mark Carreau	Aviation Week
Marsha Dunn	AP
Michael Lapidus	SpaceX
Michelle *	
Mike Curie	Ram Commercial
Miles Doran	CBS News
Nicholas Cummings	SpaceX
Patrick Mccarthy	Space Florida
R. Schaffer	NASA
Ravi Chaudhary	FAA
Richard	NASA
Sammy Lentz	
Susie Espena	European Space Agency
Tremayne Days	NASA JSC