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

March 21, 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 First Quarterly Meeting at Kennedy Space Center, Cape Canaveral, Florida, on March 4–7, 2019. 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

Patricia Sanders
Chair

Enclosure

AEROSPACE SAFETY ADVISORY PANEL
Public Meeting
March 7, 2019
Kennedy Space Center, Cape Canaveral, FL

2019 First Quarterly Meeting Report

Aerospace Safety Advisory Panel (ASAP) Attendees
Dr. Patricia Sanders, Chair
Lt Gen (Ret.) Susan Helms
Dr. Sandra Magnus
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
Dr. Mary Beth Saffo, Writer/Editor
Ms. Evette Whatley, Administrative Officer

NASA Attendees
Anthony Harris (KSC)
Sean C. Nichols (KSC)
Gerald Piasecki (KSC)

Other Attendees
Laura Aguiar (PX-C, Apache-Logical)
Irene Klotz (*Aviation Week and Space Technology*)
Joey Roulette (Reuters)

Telecon Attendees – see Attachment 1

Opening Remarks
Ms. Carol Hamilton, ASAP Executive Director, called the meeting to order at 9:30 a.m. EST and welcomed everyone to the ASAP's first quarterly meeting of 2019. Ms. Hamilton informed attendees that they were welcome to make comments at the end of the meeting and reminded all such attendees to introduce themselves by name and affiliation before offering their remarks. 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.

On behalf of ASAP, Dr. Sanders thanked Mr. Bob Cabana and the personnel of the Kennedy Space Center for their hospitality and excellent support of the Insight Meetings and discussions during the Panel's 4-day visit. Although the Center truly has evolved into a Multi-User Spaceport, its main mission for ASAP remains its role in NASA's human space flight program — a mission that continues to be important to the nation and to the world.

The onset of ASAP's program of work for 2019 was delayed by the partial government shutdown, which also had a significant impact on NASA as a whole. The Agency did a superb job of managing through the shutdown, a credit to the dedication and professionalism of the entire workforce. Nevertheless, the disruption clearly took a toll on NASA's key mission, and

the shutdown will continue to have consequences for a considerable period of time. The stress on the NASA work force, the substantial programmatic delays due to the stoppage and restart of critical work – delays that will prove in many cases to exceed in their length the period of the shutdown itself – and the costs of those disruptions were enormous. The impact of the shutdown on the smaller components of the critical industrial base has also had a significant effect on NASA operations.

ASAP was encouraged that NASA managed this disruption well, with emphasis on maintaining the safety of personnel and critical hardware. The Panel was particularly impressed with the steps taken for an orderly restart with a priority on safety. NASA carried out systematic facility inspections to identify any hazards arising during the shutdown, as well as safety stand-downs to refresh the collective memory of the work force about key safety protocols that may have atrophied during their furlough.

Despite the disruption, a great deal of progress has been made since the ASAP's last Insight visit six months ago. The successful launch of Demo 1 on March 2 represents the first stage in a transition from development to an operational posture; these initial steps back to human space flight operations, for the first time since the Shuttle retirement in 2011, are encouraging. At the same time, an extensive program of tests and verification, followed by likely modifications, still lie ahead for the program before a safe and assured launch and return of crew into space can commence. ASAP continues to insist that no corners be cut; that no critical content be dropped; and that no responses to schedule pressure be allowed to influence decisions that may unduly compromise safety.

Enterprise Protection

Dr. Sanders next introduced Lt. Gen. Susan Helms, who reported that NASA has made great strides in addressing issues of Enterprise Protection over the last two years, since the Panel's April 1, 2016 recommendation on security clearance policy:

> *NASA should make it a matter of policy that priority is given to obtaining the appropriate level of security clearance for all personnel essential to implementing the Enterprise Protection Program, including the appropriate program managers.*

Mr. Raynor Taylor, the principal advisor for Enterprise Protection, updated ASAP on NASA progress in this area, including recent progress since publication of ASAP's 2018 Annual Report. Of special importance is the fact that NASA completed an OPM-required review of all Position Descriptions on Dec 31, 2018. NASA is now required by OPM policy to complete a comprehensive review of these positions every 3 years, with mechanisms for interim annotation of security classification requirements as needed during the 3-year cycle to meet the policy requirements and to protect the mission.

From the detailed Enterprise Protection report provided to the Panel, ASAP is satisfied that the process for determining security clearance requirements appears to be adequate to meet the intended goals of the recommendation. ASAP would now like to see verification of successful *implementation* of this process as well. NASA has offered ASAP the opportunity to perform a

'spot check' to monitor progress; hopefully, NASA will also provide sample outcomes of the position-review process that would reassure the Panel about the effectiveness of the OPM review process. Because the ASAP recommendation speaks explicitly to program manager positions, it would be especially helpful to see evidence of the effect of this process on position descriptions for program managers.

In summary, the ASAP recommendation pertaining to security clearance policy is on the path to resolution. Dr. Sanders said that the Panel expects to be able to close this recommendation once it receives metrics confirming implementation of the requested policy.

Mr. Taylor also updated the Panel on two new policies related to the Enterprise Protection Program (EPP). The first policy memorandum, released June 13, 2018, and signed by Mr. Taylor, relates to Operational Technology (OT, also known as industrial control systems) and applies to the infrastructure layer of NASA Enterprise Protection. Intended, in part, to respond to recent NASA OIG recommendations on improving governance of operational technology, this policy provides agency-wide policy updates on the management of OT.

The second new policy memorandum, dated February 2019 and signed by the Associate Administrator, outlines several new protection requirements for robotic spacecraft, including program direction for command uplink protections and mission data protection. These new requirements represent an important step toward strengthening protections for the mission layer; they will be fully integrated into the technical and risk requirements for NASA missions. Protection requirements related to this policy will be normalized into NASA's standard processes for waivers and deviation approvals by technical authorities, with appropriate risk assessments.

The ASAP also received a cybersecurity update from Ms. Renée Wynn, Chief Information Officer (CIO) and Mr. Mike Witt, Associate Chief Information Officer, who provided a useful, comprehensive overview of the NASA IT Strategic Plan, including articulation of excellent strategic objectives and promising improvement plans. Ms. Wynn and Mr. Witt reported that NASA's Federal Information Security Modernization Act Scorecard (metrics to identify, protect, detect, respond to and recover from security breaches) has shown significant improvement over the last 4 quarters. The information officers indicated that, by the objective metrics of the scorecard, there has been about a 25% improvement in cybersecurity strategic processes, such as detection of intrusion, responses to intrusion, and recovery from cybersecurity incidents. The Panel requested additional details from the information officers; nevertheless, all evidence thus far points to strong improvements and significant progress over the last 1 ½ years.

The NASA CIO implemented a set of initiatives in FY18 to continue progress in adding mission-enabling capabilities while improving NASA's ability to protect its systems and data. To that end:

- NASA hosted cybersecurity town hall briefings at its various centers in 2018. It also increased cybersecurity compliance, mitigated vulnerabilities, improved

characterizations of high value network segments, implemented the Office of Cybersecurity Services (OCSS), to define, implement, promote, and optimize a consistent model for enterprise cybersecurity services, and set in motion a number of projects designed to improve awareness, training, supply chain management, configuration control, credential management, and OT inventory. All of these activities align with the 2017 Executive Order to improve cybersecurity across the government. In short, the CIO is not only talking about improvements, but implementing them as well.

- In addition, NASA established the position of, and hired, Chief Cyber Risk Officer to implement an enterprise-wide view of cyber risk across the Agency.

The CIO also mentioned several comprehensive initiatives designed to improve NASA's overall cybersecurity posture from 2019 onward. ASAP has requested a 'Deep Dive' on Enterprise Protection, hopefully by mid-year 2019, so that the panel can evaluate in more detail continuing improvements in governance, processes, and risk reductions in this area. Overall, the Panel sees good progress in Enterprise Protection, and it looks forward to continuing dialogue with the program.

Exploration Systems Development

Dr. Sanders thanked Lt. Gen. Helms and introduced Dr. George Nield, who provided an overview of the Exploration Systems Development (ESD) program. The Kennedy Space Center venue allowed ASAP to focus specific attention on the Exploration Ground Systems segment of ESD, in addition to updates on the current status of ESD as a whole.

Dr. Nield noted that the Exploration Systems Development program is very active, with major progress even during the last few months. For example, the Critical Design Review was completed for the European Service Module (ESM), and ESM hardware has now been delivered to KSC. The Orion crew module for EM-1 (Exploration Mission 1) had its initial power-up test last month. The Vehicle Assembly Building high bay construction is now complete. In addition, a series of eight air-drop tests of the Orion Capsule Parachute Assembly System has been completed, with the System Acceptance Review for the EM-2 parachute system scheduled for September of this year. Although much work remains before launch of these flights, the progress in delivery and testing of hardware is very promising

Dr. Nield highlighted three ESD issues of special interest to the Panel:

- The Orion Environmental Control and Life Support System (ECLSS). In its 2018 Annual Report, ASAP expressed concern about the readiness of the ECLSS for crewed flight – more specifically, whether it would be fully tested, qualified, and ready to support the crew on EM-2. Because of the crucial importance of ECLSS function for successful crewed flight, ASAP had asked earlier for more information on the ECLSS systems or components that would actually be installed in EM-1. Since the EM-1 flight will not have any astronauts onboard, NASA has decided not to fly the full ECLSS system on that flight. Along with a detailed description of the current plan, NASA offered their rationale for their decision to delay flight testing of the full ECLSS system: (1) the Orion System is much simpler than that of previous vehicles; (2) the spaceflight environment

would not significantly impact system performance compared to what is seen during ground testing; and (3) the current timeline for the EM-2 flight would allow 24 hours or more to test the ECLSS system in Low-Earth Orbit (LEO) prior to continuing on to the moon. For these reasons, NASA concluded that no specific element of ECLSS hardware requires successful testing on EM-1 prior to EM-2. This conclusion may well prove to be correct; nevertheless, the Panel believes that the more that critical life-support systems and subsystems can be tested in an end-to-end fashion before they are used in crewed flight, the better. Especially if the EM-1 launch date is delayed, ASAP recommends that NASA should continue to assess whether additional ECLSS hardware could be incorporated on the EM-1 flight.

Dr. Sanders added that some testing of ECLSS components has been carried out in the microgravity environment of the International Space Station (ISS); ASAP encourages more of such microgravity testing. Dr. Nield agreed, emphasizing that the complete ECLSS system has not yet been tested on the ISS – only similar components, in conditions projected to be relevant to the new spacecraft. The Panel again emphasizes the value of end-to-end microgravity testing of the ECLSS system prior to EM-2.

• Design of the propulsion system on the European Service Module. In 2018, ASAP expressed concern over NASA's apparent decision to continue with a serial propellant system design that incorporated several zero-fault tolerant design aspects. This plan represented a change from previous plans to revert to a parallel system design after the first three flights. After considerable study of the issues, NASA has agreed to make several improvements to the original design; it has nevertheless concluded that, at least in some cases, such as the Deep Space Exploration missions, highly reliable single string systems (verified by extensive screening, testing, or other methods) may still be a better approach than the traditional policy of a two-fault-tolerant design. Should NASA decide to adopt this approach, ASAP stresses that the need for additional, stringent testing and for other reliability enhancement steps is imperative, and that the crucial importance of this testing be communicated to the entire NASA workforce. In addition, stringent testing must continue to be implemented consistently in all flights, not merely in the first test flights. A danger is that, over time, the rationale for such policies is forgotten; to ensure safety, it is essential that such testing remains an explicit and integral component of all flights, and of the culture of the NASA workforce.

Dr. Magnus added that ASAP will continue to follow this new policy closely, because it represents a fundamental, philosophical shift in design principles from NASA's historical reliance on redundant, parallel systems. For any new policy, it is important to establish the parameters of system design – specifically, in this case, the parameters for testing and improving system reliability of propulsion systems. ASAP will investigate the details of proper testing, of these new systems and monitor the consistency with which definitions of "high reliability" are implemented in both present and future missions.

•The importance of setting challenging but achievable schedules. Targeted launch dates should be chosen to impart a sense of urgency, and to convey the importance of holding to the planned schedule. Employee morale can also suffer if the official dates are clearly not

achievable, given the work that needs to be accomplished. Unrealistic schedules can also result in bad decisions, at least from a safety perspective, if meeting these deadlines results in unnecessary or imprudent shortcuts, or elimination of important testing. These considerations are especially relevant to assessments of the projected launch schedule for EM-1.

In thanking Dr. Nield, Dr. Sanders mentioned the key relationship between ESD and the proposed direction of the overall exploration program — the purposeful return to the lunar region with the intent not merely to return to the moon's surface, but to conduct research and to develop the means for further exploration, such as expeditions to Mars. The Panel has begun evaluating the plans for Gateway and is considering what attributes of activities in the lunar region might contribute most effectively to long-term mission objectives and to reducing the risks of deep space exploration.

Gen. Helms agreed that the general strategy of the exploration initiatives was promising, but also noted the need for additional consideration of the specific attributes needed for a successful program. For instance, in infrastructure planning, it is important to remember the diverse interests of the various players in these initiatives, including entities interested in scientific aspects of the missions and others with interests in their economic or technological dimensions. The program will need to support these multiple needs and still be sustainable. A key component of long-term infrastructure planning includes considerations of risk reduction in further exploration missions. For safety and logistical considerations, and for the general good of the nation, such planning also must recognize the ties of the lunar infrastructure plan to the goals of future, pioneering exploration, including expeditions to Mars.

International Space Station

Dr. Sanders next introduced Dr. Richard Williams, who outlined the current status of the International Space Station (ISS). The ISS continues to maintain a continuous human presence in Low Earth Orbit (LEO), daily carrying out the deceptively "routine," but in fact extremely difficult task of space operations. Dr. Williams noted that the ISS remains humanity's best asset to observe human health changes in space, to develop and to test technology, and to perform research in space, serving as an invaluable test venue for support of eventual missions beyond LEO and to improve life on Earth. Research and development utilization of the ISS remains high, with 216 ongoing investigations during Increments 57 and 58, and a total of more than 2700 investigations performed thus far over the lifetime of the ISS. With the anticipated presence of 4 United States Operating Segment crewmembers throughout 2019, utilization of the ISS is expected to remain high over the next year. Of particular interest is the LambdaVision project, leveraging the microgravity environment of the ISS in the development of high resolution, protein-based artificial retinal implants, with the goal of restoring vision in patients with degenerative diseases such as retinitis pigmentosa and age-related macular degeneration; these experiments represent a major leap forward in ophthalmology, with real potential for implementation of a significant clinical advance. These and other ISS projects clearly demonstrate the value of ISS research to life on Earth. The ISS program was able to continue operations and support activities as an excepted activity during the recent government shutdown, with employees continuing to work through the shutdown without pay. For these

reasons, adverse programmatic impact of the shutdown on the ISS was minimal. The Panel is again highly impressed with the dedication and resilience of the nation's space workforce.

Among current ISS challenges, maintenance of extravehicular activity (EVA) suits is a high priority. Three of the 4 Extravehicular Mobility Units (EMUs) currently on orbit are usable for EVA. The 4th EMU experienced a fan pump separator failure
and is being remediated with an on-orbit spare separator unit; testing and analysis are currently in progress, with the goal of returning this suit to service as soon as possible. There is an ambitious EVA schedule in the coming months, with planned tasks including such activities as battery replacements and installation of Truss utility jumpers; functional EMUs are essential for carrying out these missions. Scheduled EVA suit-life extension upgrades are ongoing, with planned capability extension to 2028. Nevertheless, despite what Dr. Magnus described as heroic efforts to extend the life of the EMUs, the usable life of these EVA suits is limited. The xEMU ISS Demo suit project is underway, with deliverables consisting of 1 development, 1 qualification, and 1 flight unit, with a planned ISS demonstration EVA in 2023. The Panel strongly encourages development of a new exploration mission-capable EVA suit for demonstration on the ISS.

Dr. Sanders stressed that ASAP not only encourages the continued development of the xEMU: it also urges NASA to prioritize and to expedite its development, by reducing the resources devoted to extending EMU suit life and by devoting more resources to development of the new xEMU suits. A new suit is needed not only for use in future exploration-class missions, but also for support of the important, ongoing EVA activities in Low Earth Orbit as well.

The ISS program continues to make progress with its plans for nominal and contingency ISS deorbit. Open items for both the Russian and US segments, especially items concerning propulsion systems are proceeding. The program's relevant guiding document, the "ISS Deorbit Strategy and Contingency Action Plan," is nearing completion and concurrence by all partners. Dr. Sanders expressed optimism that ASAP will soon be able to close its recommendation on ISS deorbit planning when the final International Partner signatures for the deorbit plan are obtained.

In summary, the ISS has proven to be a remarkably resilient and successful program: it is the benchmark for all future multinational space exploration efforts. With the recent successful docking of the SpaceX DM-1 mission and the prospects for additional crew transport vehicle support in the near future, the ISS is in an excellent position to continue laying the foundation for exploration beyond Low Earth Orbit.

Concurring with Dr. Williams about the value of ISS accomplishments, Dr. Sanders further emphasized the continuing importance of maintaining a persistent human presence in LEO. A continuing LEO presence enables important explorations of both the risks and benefits of living and operating in the space environment, and the development of strategies to increase our ability to manage those risks and to maximize the benefits.

Commercial Crew Program

Dr. Sanders then introduced Dr. Sandra Magnus, who summarized the Panel's observations of the Commercial Crew Program (CCP). In their extensive discussions with the CCP, panel members were very impressed with the amount of work that has been accomplished since the last quarterly meeting in October 2018. Both providers, Boeing and SpaceX, have made remarkable progress on several fronts in the last few months, in addition to the significant milestone of the recent SpaceX DM-1 flight. ASAP continues to monitor and to discuss the safety concerns tracked both by CCP itself and by the safety community. There has been progress in understanding the contexts of design, manufacture and operation with composite overwrapped pressure vessels (COPV). Boeing and SpaceX are each working to resolve a number of issues with their respective propulsion systems. In addition, both providers are continuing to refine, test, and understand their reentry-parachute designs. These parachutes are a critical safety design element, especially for crewed flight, and are an ongoing challenge for both providers. The Panel will continue to monitor progress in parachute development to verify that, as various qualification processes are accomplished, each provider understands the safety margins for parachute operation, can demonstrate that those margins were established with the appropriate processes, and that they are controlling those margins as they progress from qualification to flight. A significant amount of work still needs to be completed before CCP is fully ready to launch humans into space. In the meantime, ASAP is pleased to see that NASA has taken steps to ensure continued U.S. presence on the ISS, which mitigates any perceived schedule pressure on the CCP program.

As the program approaches human flight, NASA, Boeing, and SpaceX personnel have been busy finalizing designs, and manufacturing, testing, and qualifying the vehicles to be used in these flights. The enormous scope and intense pace of these projects demand sustained effort by all members of the workforce, and indicate the need for vigilance regarding the wellbeing of these hardworking personnel. ASAP will continue to monitor the health of this workforce with this concern in mind. Fortunately, the schedule of work to date has been phased in such a way that the work flow thus far has been manageable; but given the intensity of the work schedule, maintenance of workplace health will continue to be a management challenge for the program.

The ASAP notes that the Boeing and SpaceX programs have different goals and divergent approaches to implement those goals. Because of these differences, it is not possible to make a direct comparison of the two un-crewed flights and their milestones. Each provider has targeted different objectives for the un-crewed test flights, based on their respective design philosophies. The CCP has deliberately adopted a flexible posture to accommodate the different approaches of these two providers, while still ensuring that the rigor and logic of each path will lead to a well understood, verified, safe vehicle before placing humans on board. ASAP is monitoring the different approaches taken by the two providers as they move through the qualification and verification process, progressing from uncrewed to crewed flight.

The ASAP would like to congratulate the CCP and SpaceX on the recent launch and docking of DM-1. In addition to the technological success of this flight, ASAP notes that the team worked

well together throughout the process. Thus, the launch was an important learning exercise on several fronts; in addition to tests of the spacecraft itself, the flight was a test of teamwork and an opportunity for evaluation of the many technical and operational complexities related to launching humans once again into space. Even though the space community has extensive experience launching cargo, NASA has not had recent direct experience, since the retirement of the Shuttle, with the additional level of rigor related to launching humans. The DM-1 mission provided the team an opportunity not only to reactivate old skills, but to do so in a new paradigm. From the Panel's viewpoint, this exercise was also important for establishing a strong safety baseline as the CCP program moves into the operational phase. The ASAP looks forward to a similar exercise with the Boeing team later this year.

With these programs moving into the operational phase for the first time, the ASAP will be monitoring the programs as they transition to crewed flight operations. During this visit, for example, the Panel was introduced for the first time to the crew interfaces for each vehicle, and Panel members learned about the operational concepts being pursued by each provider.

Overall, there has been great progress in the CCP; the workforce has shown diligence and commitment and the program has been managed well. The greatest challenge for both providers in the next year will be applying the lessons from uncrewed flight to the next crucial phase of certification to crewed flight.

Dr. Sanders thanked Dr. Magnus for her presentation and brought up an additional design issue: for both providers in the CCP as well as for ESD, NASA has taken an aggressive and concurrent approach to development —in all cases, hardware is being integrated before all the qualification tests are completed. This approach is more efficient in some ways; but it also creates the risk of discovering issues during qualification that would require undoing integrated design features late in the production process.

Closing remarks

In closing, Dr. Sanders observed that while much has been done, much work also still lies ahead. This is a time for both optimism and caution; it is not a time for haste.

At the end of the meeting, comments were solicited from the public; no comments were offered.

Dr. Sanders adjourned the meeting at 10:20 a.m. EST.

Attachment 1

Telecon Attendees:

Alyssa Seiffert	NASA OIG
Bill Beckman	Boeing
Carlo Torres	NASA OIG
David Newman	[unaffiliated]
David Rann	U.S. D.O.T.
Diane Rausch	NASA
Eric Berger	*Ars Technica*
Frank Ledbetter	NASA
James Dean	*Florida Today*
James Gleeson	SpaceX
James Zimmerman	NASA (retired)
Janet Walsh	Signal Group
Jared Stout	Venable LLP
Jeff Foust	*Space News*
Julie Arnold	University of Louisiana
Kerri Arnold	Boeing Communication
Kevin Fagedes	NASA
Kristin Van Wychen	US GAO
Letisha Antone	NASA OIG
Linda Karanian	Karanian AeroSpace Consulting
Marcia Smith	SpacePolicyonline.com
Mary Lynne DIttmar	Coalition for Deep Space Exploration
Maribeth Davis	Boeing Communication
Michael Lapodis	SpaceX
Mike Curie	Commercial Crew Program
Stephanie Schierholz	NASA
Stephen Clark	Space Flight Now
Steven Siceloff	Boeing ISS Houston
Susan Bachle	NASA OIG
Theodore G. Kronmiller	Attorney, Virginia
Trisha Solveichi	Boeing
Dimitra Tsamis	NASA OIG
Wayne Hale	NASA Advisory Council