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

October 23, 2018

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

Dear Mr. Bridenstine:

The Aerospace Safety Advisory Panel (ASAP) held its 2018 Fourth Quarterly Meeting at NASA Johnson Space Center, Houston, Texas, on October 9-11, 2018. 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 and Recommendations resulting from the public meeting for your consideration.

Sincerely,

Patricia Sanders
Chair

Enclosure

AEROSPACE SAFETY ADVISORY PANEL
Public Meeting
October 11, 2018
Johnson Space Center, Houston, TX

2018 Fourth Quarterly Meeting Report

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

Telecon Attendees – see Attachment 2

ASAP Staff and Support Personnel Attendees
Ms. Carol Hamilton, NASA ASAP Executive Director
Ms. Evette Whatley, NASA ASAP Administrative Officer
Ms. Paula Burnett Frankel, Technical Writer/Editor

NASA Attendees:
John Sims
Annette Hasbrook
Bernadette Hajek
Eric Meta
Jasmine Provell
Julie Kramer White
Shaneequa Vereen

Opening Remarks
Ms. Carol Hamilton, ASAP Executive Director, called the meeting to order at 10:45 a.m. and welcomed everyone to the ASAP's fourth quarterly meeting of 2018. Prior to the meeting, the public had been invited to provide verbal or written statements; no public comments were made.

Dr. Patricia Sanders opened the meeting by thanking Mr. Mark Geyer, Johnson Space Center (JSC) Director, Ms. Vanessa Wyche, JSC Deputy Director, and JSC personnel for hosting the ASAP's fourth quarterly meeting and insight visit. She noted that the Panel members had been following the morning's aborted Soyuz launch and were relieved that both astronauts have survived the incident. The Panel spent a few days before the meeting in detailed discussions at JSC, focusing on the critical human space flight and exploration programs — namely Commercial Crew, Exploration Systems (with emphasis on Orion), and the International Space Station (ISS).

Dr. Sanders stated that the Panel has not seen the Commercial Crew Program (CCP) make decisions detrimental to safety; however, current projected schedules for uncrewed and crewed test flights for both providers have considerable risk and do not appear achievable given the number of technical issues yet to be resolved, the amount of qualification and reliability tests to be accomplished, and the body of verification work that must be completed. The Panel believes that an over-constrained schedule — driven by any real or perceived potential gap in astronaut transport to the ISS (possibly exacerbated by the morning's events) — poses a danger that sound engineering design solutions could be superseded, critical program content could be delayed or deleted, and decisions of "good enough to proceed" could be made on insufficient data. Dr. Sanders indicated that the Panel is concerned that schedule pressures and the desire to launch pose a potential for the uncrewed test flights to occur without all the critical content to fulfill the role of risk reduction for crewed flight. While the Panel remains confident that NASA leadership intends to continue with a responsible program as planned, it believes that there is the potential for the workforce—striving to meet unrealistic dates and pressures to "get on with it"—will subtly erode sound decision making as proposed launch dates approach.

To illustrate the Panel's reasons for finding the published schedules unrealistic, Dr. Sanders introduced Dr. Donald McErlean, who provided some examples of the technical issues still to be resolved for SpaceX, and CAPT Christopher Saindon, who did likewise for Boeing.

Commercial Crew Program

Dr. McErlean started off with a positive review. He reported that the Panel spoke with Mr. Bill Riley, SpaceX Design Reliability, who provided an update on their vehicle capability evaluation program and use of some very advanced software tools to support their Systems Engineering and Integration (SE&I) efforts. SpaceX's current SE&I approach uses workflow process tools (software), which deliver verification review data via a "Bill of Design" and track changes to the hardware. Any design changes are immediately visible to all design engineers and associated disciplines. SpaceX has allowed NASA almost complete access to this system, and NASA engineers can gain virtually immediate information and insight into the current configuration. While this is a state-of-the-art approach and differs somewhat from the traditional system engineering life cycle V model, there is no question that it provides much the same data and does so more quickly. SpaceX has also shared the statistics on the tool's use. Growth has been phenomenal, going from about 10,000 user entries per quarter to about 50,000 to 60,000 user entries per quarter. It is very clear that members of the technical staff are accessing and using these systems, and they have been a very good improvement.

The ASAP had an opportunity to look at SpaceX's hardware progress, and it continues to proceed. For example, the hardware for Demo-1 and Demo-2 is progressing quickly and moving through manufacturing and assembly processes. Some of what is dedicated to Demo-1 has been delivered to Cape Canaveral for preliminary processing. This is a positive trend and appears to be proceeding well. However, while current hardware continues to move along, there are serious difficulties and challenges to the schedule in terms of technical issues. Dr. McErlean cited some examples. One is the lack of final resolution of the composite overwrapped pressure vessel (COPV) failures, which are generally considered to have been the cause of a launch pad accident and to affect the total safety of the "load-and-go" launch concept. The root cause of the failures remains under investigation. SpaceX is working on improved configurations, but open technical issues remain. Ultimately, the configuration must be accepted and certified, judged by both parties to be free of characteristics that caused the failure. This remains an open technical item that the Panel firmly believes must be resolved before proceeding to crewed launch. If configuration changes are in question, they need to be finalized before the uncrewed demonstration launch. In addition to this issue, recent parachute testing, both during the CCP qualification (qual) testing regimen and with some anomalies witnessed in the resupply contract (also handled by SpaceX), show difficulties and problems with parachute designs. Clearly, crew cannot be risked without complete confidence in the parachute design. It is an integral part of capsule return for both providers and a crucial element of crew safety.

Dr. McErlean noted that there has always been a Program requirement that before Demo-2 (the first crewed launch), there must be an uncrewed flight test of all the critical systems that are scheduled as "risk mitigations" for crewed flight. The parachute system is one of those. Whether or not investigation of the recent parachute anomalies results in redesign, it is the Panel's view that the parachute system used in the uncrewed flight test must be the same as that used in the crewed flight test. Redesign drives regression testing, additional qual testing, and flight testing, which can clearly lead to schedule impact. At the moment, the ASAP does not know what the solutions to those problems will be—whether they are complicated, whether they involve redesign, or whether they can be resolved by simple modifications. A potential redesign, which may be required, would drive a requirement for additional qual and certification testing. The Panel remains adamant that the Program requirement for crew certification mandates an uncrewed flight test of the crewed configuration first. It is the

Panel's impression that the Program continues to support that as well. These issues may or may not affect launch dates or have schedule impact.

Dr. McErlean commented on what is sometimes heard about "certification paperwork." While certification may involve "paper," the work is not paperwork in the sense of filling out forms or writing memos. In any certified design, the contractor is required—via the Certification Plan—to submit data to NASA (in this case, the certification agency). When that data is submitted, the NASA engineers review the data and validate that the contractor has shown that the certification condition has been met. Then and only then does that engineer sign off on that condition or design as adequate. While this may be described as paperwork, it is the essence of NASA's technical certification of the design, which must be completed before crew flies on the system. It is extremely important and should not be thought of as a bureaucratic time delay. This is true for both providers. A considerable amount of technical work must be done before NASA can say that the design is safe enough to carry crew.

CAPT Saindon noted that like SpaceX, Boeing is making tangible progress toward flight, working through critical qual testing and validation/verification items on both Spacecraft #3 for Orbital Flight Test (OFT) and Spacecraft #2 for Crewed Flight Test (CFT). Nevertheless, there are some critical "long poles" that need to be addressed before OFT/CFT can occur: parachute testing, launch abort engine propulsion system anomalies discovered during qual testing, and pyro initiator fractures. This is not an all-inclusive list, but some of the key testing areas remain. At the system level, this includes structural test article completion, which involves forward heatshield and parachute impact testing and the ascent cover separation test series. At the subsystem level, two parachute qual tests remain to be completed in addition to six reliability tests, service module hot fire testing, and an array of other testing for ISS integration, including integrated software stage tests, radio frequency interface, and data and audio verification. Boeing has completed a number of operational simulations, including on-pad crew emergency egress drill, generic ISS rendezvous docking simulations, and landing/field equipment integration and training at White Sands. However, several operational tests are yet to be done, such as OFT mission rehearsal and mission-specific ISS rendezvous docking and departure simulation. All of these must be completed before OFT.

CAPT Saindon reported that the Panel spent time looking at the details of what the CCP considers key risk items with the Boeing program, some of which have emerged during the qual test program. Specifically, the areas mentioned earlier: parachutes, launch abort engine hot fire testing, and pyrotechnic separation bolt initiator device qual failures.

With regard to parachutes, during Parachute System Qualification Test-3, the system did not function as expected. Root cause investigation is underway, and Boeing is still working to understand the exact cause. Testing is on hold until that issue is understood and resolved. Per the original test schedule, two more tests are required for qualification and then six additional parachute reliability tests once the configuration is locked down, all of which must be completed before CFT. Another area of concern with parachutes has been addressed—late stage 1 alpha aborts. Boeing and CCP worked diligently through this issue together to develop a risk-reduction strategy that appears to address these key areas. The focused risk mitigation strategy includes additional test points in the high-q regime, as well as adjustments to the abort concept of operations to reduce exposure to transonic wake for parachute deployment.

With regard to the launch abort engine, an anomaly was discovered during hot fire testing. CAPT Saindon reported that it was what could best be described as an harmonic resonance across the system—or a waterhammer effect—causing the engine to shut down unexpectedly. Boeing feels that they have identified key drivers and are working to understand the exact source of the resonance and what needs to be done to address

it. The Process Control Board has approved some engineering changes, and they are working on a modified test plan to understand the phenomenon and move forward.

The pyro qualification failures were failures of pyrotechnic initiator bolts, which are designed to separate the crew module from the service module. There have been some materiel failures during qual testing, and the team is still working to understand why they occurred. The team has what they believe is an interim solution to mitigate the effect of the failure. Despite the failures, the separation bolts functioned, but the initiator was liberated from the assembly and could became a foreign object damage (FOD) hazard. Once the fix is in place, additional qual testing will be needed and the residual risk accepted by the CCP.

CAPT Saindon noted that these three examples are illustrative of the challenges that remain to work through the qualification process. He indicated that the Panel looks forward to hearing more about the progress of the Boeing and CCP team in these key areas as well as the remaining milestones required to fly OFT and CFT.

CAPT Saindon reiterated what Dr. McErlean said—the burn-down curve of certification products remains fairly steep for verification and validation (V&V), and that V&V process is not simply a paperwork drill. Much work is ahead. All the tests that need to be done (and some re-done) require detailed analysis of the data provided by the Boeing team, and could, in-fact, result in addition testing and/or data requirements should the current test plan expose additional issues or unexpected results. There is some concern with maintaining the schedule profile given these considerations.

Dr. Sanders introduced Dr. George Nield, who presented two Panel recommendations that she noted are consistent with the ASAP's previous statements.

Dr. Nield noted that given the progress explained and the challenges remaining, the ASAP had two recommendations to put forward: one concerning the plans for the uncrewed demonstration tests—Demo-1 for SpaceX and OFT for Boeing—and one related to schedule: what the constraints are and what the options are going forward.

> *Recommendation 1: NASA should confirm and then clearly communicate the required content and configuration for the upcoming CCP test flights (Demo-1 and OFT), specifically those items that must be successfully demonstrated prior to the first crewed flights.*

Dr. Nield noted that there is no evidence to this point that NASA is taking a different direction, but the ASAP believes it is important to emphasize the approach to activities going forward.

> *Recommendation 2: Due to the potential for delays in the schedule for the first CCP flights with crew, senior NASA leadership should work with the Administration and the Congress to guarantee continuing access to ISS for U.S. crew members until such time that U.S. capability to deliver crew to ISS is established.*

Dr. Nield indicated that the Panel is not specifying a particular course of action, but it believes that communication, coordination, and collaboration on the part of all the key stakeholders would be appropriate.

Exploration Systems Development (ESD)

Dr. Sandra Magnus discussed the Panel's observations and insights from its engagement with the Exploration System and Orion programs, where there are similar challenges to be faced as launch dates approach. She indicated that the Panel had asked for additional insight into ESD's integrated SE&I process. Each program

element—Orion, the Space Launch System, and Ground Systems—manages risk at its program level. However, risks that reside in the 3x5 and 4x5 portion of the risk matrix are automatically elevated for review by NASA Headquarters senior leadership. While the Panel was pleased to see that there was a good chain of communication for risk discussions and a fairly clear process for what gets elevated and why, it was not clear to the Panel how the elevated risks were integrated at the NASA Headquarters level. The risks appeared to be "added together" into one chart, but the methodology to analyze the risk interdependencies from one program element on other program elements remained unclear. In addition, many of the top-level risks appeared to be programmatically oriented—related to cost and schedule—rather than technical. Dr. Magnus noted that the Panel looks forward to continuing its discussions with the integrated SE&I team to understand their processes and work through this topic at another level of detail.

Since the ASAP was at JSC for this meeting, it took advantage of the opportunity to focus on the Orion Program. The Orion managers provided an update on several areas of concern previously raised by the Panel. In general, the ESD program was designed very carefully with an approach to methodically collect data and expand operational experience to build confidence in the complete, integrated space system. The large-scale integrated system tests, including the flight tests, were designed to ensure that important data and knowledge were required and would be obtained before committing to sending humans beyond low Earth orbit. For example, the Exploration Flight Test-1 returned valuable information on the heatshield design and the aerothermal environment in which it must operate. This led to a completely different approach to the design and manufacture of the heatshield system. As the Panel was discussing with the Orion Program the upcoming Exploration Mission (EM)-1 flight test and its many objectives, it focused on the heatshield. One of the critical objectives of the EM-1 flight test is to perform the full-scale test of the redesigned heatshield to demonstrate its performance in the actual environment of use. The full-scale flight test is really the only place this information can be obtained, and it is very valuable. Dr. Magnus observed that it has come to the Panel's attention that recent decisions about launch commit criteria could result in a potential situation where the EM-1 flight test could happen without proper functioning of the avionics box that collects and stores the data from the heatshield instrumentation. Without the avionics box and the critical data collection, one of the main objectives of the flight test is compromised. In the case of the avionics box failure, the back-up plan for heatshield verification is to visually examine the EM-1 heat shield for damage and/or potentially deploy an airborne asset during the re-entry phase to attempt to acquire infrared imagery of the Orion capsule as it returns to Earth. Neither option provides any guarantee that sufficient information will be gathered to meet the full scope of the flight test objectives and provide understanding of the heatshield performance. While the desire to gain some flight experience with the new space launch system is an important aspect of the EM-1 launch—and understanding the lack of desirability in delaying a launch to address the complexities related to replacing a faulty avionics box—the Panel firmly believes that NASA should carefully consider the type and scope of data and experience it must collect at each planned test point before adjusting plans that were previously defined as necessary before launching crew. Redefining flight test scope and requirements must be done with a thorough understanding of the change in risk posture for subsequent human flights. Dr. Magnus noted that this is a very similar issue to what Dr. McErlean and CAPT Saindon mentioned with respect to Commercial Crew—understanding clearly what must be done to certify systems and ensure they are applicable for human flight.

The Panel was encouraged to learn that the European Service Module (ESM) will soon be shipped to the U.S. It is an important milestone for the ESD program as it works towards the EM-1 flight test. The Orion program has been systematically evaluating and addressing the several areas of concern related to the ESM propulsion system that the Panel identified earlier. The amount of work involved in analyzing the system at a very detailed level to understand the flow paths, physics, and system behavior is very impressive. Dr. Magnus acknowledged the engineering team for the amazing work they have done and the thoroughness with which they have tackled the problem. In many cases the Program has—through engineering analysis—achieved a greater understanding

of the system that allowed them to retire risk, increase hardware inspections to understand reliability, or make modifications to increase performance. The Panel applauds these actions and feels comfortable with many of the resolutions. However, a major area of concern remains regarding the ESM propulsion system serial propellant system design, along with several of the zero-fault-tolerant design aspects. The Panel understands the rationale and constraints that drove the decision for a serial system in the initial stages of the Program. Several additional failures related to valve performance and integrated system behavior, in addition to these single point failures, have only served to underscore the inadvisability of relying on a single-feed system for crewed missions to deep space for the longer term. The Panel's understanding had been that the Program would move to a parallel system after the first three flights, but indications the Panel received this week are that the Program may be reconsidering this approach. At this point, it is not clear to the Panel that the Program has a thorough understanding of the risk posture, reliability, and crew survivability with the current serial approach. The Panel encourages reconsideration of the parallel system for the longer term.

Mr. David West discussed another technical issue that the Panel learned about this week: the design, development, and assembly of the Orion side hatch. The side hatch is a complex assembly—it includes a gear box, several linkages, and some sixteen hatches around the latch perimeter. A manufacturing decision had resulted in the EM-1 side hatch being designed as a flat item fitting into the Orion capsule's curved surface. Concerns had been expressed that this makes the side hatch susceptible to structural deformation. There are precise rigging requirements and machine tolerance vulnerabilities that created assembly challenges such as interfaces at several locations and moving parts with the side hatch mechanisms. A number of upgrades are planned for the EM-2 side hatch, which are intended to provide improvements in flexibility, producibility, and safety. The EM-2 side hatch may be redesigned as a curved structure. This redesign, still under consideration, would eliminate displacement and make the assembly more efficient. The Program office indicated that it learned valuable information in addressing the assembly challenges of the EM-1 side hatch design. The Panel looks forward to learning more about the redesign of the side hatch at its next quarterly meeting.

International Space Station

Lt. Gen. Susan Helms reported on the Panel's discussion with the ISS Program. She noted that the morning's news had clearly changed the nature of what she had to convey—there are implications to the ISS as a result of the Soyuz MS-10 rocket failure and launch abort. From the news stories, the Panel learned that Roscosmos has convened an investigation board and the details will evolve. There will be considerable forward work by NASA to re-plan how ISS will be operating for the next several months. Lt. Gen. Helms noted that NASA has long-established relationships and defined processes to work with the Russian Federal Space Agency (Roscosmos) in cases such as this. NASA should be able to gain the transparency required to understand the details of the investigation and work with Roscosmos on forward options for ISS operations. However, in the context of this morning news, it seems likely that ISS will only have a crew of three—a Russian, an American, and a European Space Agency astronaut—for at least the short term. Lt. Gen. Helms asserted that the Panel would need to get a status briefing from NASA to understand all the facts, but at first look, it doesn't appear to the ASAP that there are any immediate safety issues that come to mind for the smaller crew on orbit because of this aborted launch. However, NASA would need to confirm that to the Panel.

Lt. Gen. Helms briefly reviewed the ISS schedule, utilization, planned maintenance, Extravehicular Mobility Unit (EMU) upgrades, consumables status, and some recent vehicle issues. She concluded her report with an update on deorbit planning.

Because of today's event, the ISS schedule is now subject to change, and the schedule presented to the Panel the previous day needs to be re-planned. There is a vehicle transport plan, which includes the unberth and release of the H-II Transfer Vehicle (HTV)-7, the arrival of the Northrup Grumman commercial resupply vehicle

10, and the SpaceX-16 resupply vehicle within the next few months. The ISS Operations Integration Manager, Mr. Kenny Todd, had briefed the Panel on how the SpaceX Demo-1 mission might fit into the priority of the overall transport plan, but as of yesterday, he indicated that the SpaceX-16 resupply mission would have a priority over the SpaceX Demo-1 flight. In any case, everything briefed to the Panel is now subject to readjustment pending NASA's analysis of the launch abort event.

With regard to science and utilization, most of the discussion was about forward work for the next two increments, which is now subject to re-planning. However, it was noteworthy that for this last increment, the utilization was slightly better than predicted.

On planned maintenance for the interior, there are some rack swaps that must occur before the HTV-7 unberth, which will take the older racks with it. On planned maintenance for the exterior, two extravehicular activities (EVAs) were planned for later this month—P4 battery removal and replacement and other "get-ahead" tasks—but since Astronaut Nick Hague was to be one of those EVA crew members, the Panel will await to hear about NASA's re-planning for these EVAs and how it will re-plan tasks for ISS operations.

The Panel received a status update on EMU hardware upgrades, and proactive risk reduction work on the EMUs is being done in a number of areas: pending battery upgrades to mitigate thermal risks, a data recorder project to increase the breadth of EMU telemetry to mission control, certification of an EMU feed water supply filter to reduce risks of contaminates that affect the sublimator, a CO_2 sensor replacement, helmet upgrades related to polycarbonate obsolescence, and a wireless HD camera installed on the suit to enhance video performance. Currently, there are four EMUs on board that are "go" for EVA. There is also some ongoing activity to utilize the ISS for Exploration EVA suit development, building on the lessons learned with current EMU technology. This reflects the advantage of having the ISS for activities that can help with risk reduction for exploration.

Lt. Gen. Helms reported that overall ISS consumables are currently in good shape, but the implications of the launch incident will have to be worked into the forward planning for consumables in the context of the crew resupply vehicle schedule. The Panel does not have the information at this time to understand those implications, but it does have enough information to understand that consumables are not an immediate issue.

As a part of the Panel's normal quarterly briefings, Mr. Todd had reviewed numerous (mostly minor) ISS vehicle issues. One in particular caught the Panel's attention: a power fluctuation anomaly in one of the EXPRESS racks related to a payload that had updated its internal design, but that design change did not promulgate into an updated integrated power analysis of the overall rack. No notable safety issue ensued, and the payload was taken offline; however, this event does speak to the need to remain vigilant about hardware and software configuration control. NASA is reemphasizing that need to its payload customers.

The Panel also learned more about the hole that was found on the Soyuz 55, which has received considerable public attention. NASA has formed an independent investigation team, and it is prepared to assess the results of the Roscosmos Commission's output and provide risk assessments to the ISS program. The repair performed by the crew seems to be very effective, and damage to the pressure shell is not considered at risk of growth or crack propagation. To monitor thoroughly, the crew is performing daily leak site monitoring using the on-board ultrasonic leak detector equipment. At this time, NASA and Roscosmos are fully consistent on analysis and risk assessments about this situation.

Finally, the Panel received an update on the ISS Deorbit Strategy and Contingency Action Plan. Since the last update, NASA has received some good information from Roscosmos related to this strategy, is currently ingesting the new Roscosmos information, and is requesting International Partner concurrence with existing

documentation through the Cosmos Change Request review system. Some of the open work includes Functional Cargo Block (FGB) propellant maintenance at vacuum; software updates to enable reentry and burn functionality; ISS guidance, navigation and control (GNC) studies; ISS survivability at vacuum; and some draft operations products for regular and contingency deorbits. The effort is moving forward, and the ASAP felt the progress was comforting and acceptable.

In summary, Lt. Gen. Helms acknowledged a great Program update but conceded that much of the update has been overcome by the morning's events and the effects remain to be seen. Recognizing that, Lt. Gen. Helms recommended that the Panel receive periodic updates from NASA—between this week and the next quarterly meeting—to stay abreast of any rapid developments in ISS status and its safety posture.

Dr. Sanders added that she continues to be impressed at the ability of the ISS program to deal with the challenges of operating in the space environment in such a way to make it seem "normal" business.

In closing, Dr. Sanders conveyed the Panel's thoughts going out to the NASA and Roscosmos personnel dealing with this morning's aborted mission and its appreciation of the challenges ahead in understanding and recovering from the event.

Dr. Sanders adjourned the meeting at 11:30 am.

ASAP RECOMMENDATIONS, FOURTH QUARTER 2018

2018-04-01 **Required Actions for Crewed Flight Test Risk Reduction** [ASAP Point of Contact: George Nield]

Findings:
There are serious challenges to the current launch schedules for both SpaceX and Boeing. For SpaceX, one challenge is the lack of final resolution of the composite overwrapped pressure vessel (COPV) failures, which are generally considered to have been involved in a launch pad accident and which affect the total safety of the "load-and-go" launch concept. In addition to this issue, recent parachute performance, both during the CCP qualification testing regimen and during the resupply contract, indicates potential problems with parachute designs. A potential redesign, which may be required, would drive a requirement for additional qual and certification testing. The Boeing program also holds key risk items, some of which have emerged during the qual test program; specifically: parachutes, launch abort engine hot fire testing, and pyrotechnic separation bolt initiator device qual failures. The burn-down curve of certification products remains fairly steep for verification and validation (V&V), and much work is ahead. Schedule pressures and the desire to launch pose a potential for the uncrewed test flights to occur without all the critical content to fulfill the role of risk reduction for crewed flight.

Recommendation:
NASA should confirm and then clearly communicate the required content and configuration for the upcoming CCP test flights—Demo-1 and Orbital Flight Test (OFT)—specifically, those items that must be successfully demonstrated prior to the first crewed flights.

Rationale:
Despite a desire to launch the uncrewed test flights (Demo-1 and OFT) as soon as feasible, it is important to keep in mind that the primary purpose of those flights is to fly the vehicles in a configuration as close as possible to the first crewed flights in order to reduce risk. If content important to that purpose is not flown in a test that essentially duplicates the conditions of the first crewed flights, uncertainty is increased, and safety could be compromised.

2018-04-02 **Action to Ensure U.S. Access to the International Space Station Given Commercial Crew Program Schedule Risk** [ASAP point of contact: George Nield]

Findings:
As outlined in the findings for Recommendation 2018-04-01, serious technical difficulties and challenges pose considerable risk to both providers' schedules for crew transportation to the ISS in CY 2019. Currently, there are no Soyuz seats available for U.S. crew after 2019.

Recommendation:
Due to the potential for delays in the schedule for the first CCP flights with crew, senior NASA leadership should work with the Administration and the Congress to guarantee continuing access to ISS for U.S. crew members until such time that US capability to deliver crew to ISS is established.

Rationale:
Without commercial crew flights in 2019, the U.S. will have no other means of access to the ISS unless other options are identified and approved, or existing constraints are waived. Although they may not be needed, having back-up plans in place for such contingencies could be extremely important if the CCP flights are significantly delayed.

ATTACHMENT 1

Telecon Attendees:

Barbara Egan	United Launch Alliance
Brent Jett	NASA Aerospace Safety Advisory Panel
Caleb Weiss	United Launch Alliance
Dan Beck	Boeing
Daniel Lentz	N/A
David Millmen	N/A
Diane Rausch	NASA HQ
Emre Kelly	
Eric Ralph	
Eva Behrend	SpaceX
Hal Bell	NASA
Homayoon Dezfuli	NASA
Joshua Brost	SpaceX
Julie Arnold	ULA
Kelly Kabiri	NASA OSMA
Kristin VanWychen	USGAO
Lynne Loewy	NASA HQ
Maryann	NASA
Maryanne Chevalier	NASA
Michael Lapidus	SpaceX
Michael Massey	Conference Room Operator
Michelle Green	NASA
Mike Curie	NASA Commercial Crew Program
Rebecca Regan	Boeing
Richard Williams	NASA Aerospace Safety Advisory Panel
Shawn Pit	SpaceX
Stephanie	NASA PAL
Stephen Clark	Space Flight Now