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

August 4, 2017

Mr. Robert M. Lightfoot, Jr.
Acting Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Mr. Lightfoot:

The Aerospace Safety Advisory Panel (ASAP) held its 2017 Third Quarterly Meeting at NASA Headquarters, Washington, DC, on July 20, 2017. We greatly appreciate the participation and support that was received from the subject matter experts and support staff.

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

Sincerely,
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Patricia Sanders
Chair

Enclosure

ASAP AEROSPACE SAFETY ADVISORY PANEL
Public Meeting
July 20, 2017
NASA Headquarters, Washington, DC

2017 Third Quarterly Meeting Report

Aerospace Safety Advisory Panel (ASAP) Attendees
Dr. Patricia Sanders, Chair
CAPT (Ret.) Christopher Saindon
Dr. George Nield
Dr. Donald McErlean
Dr. James Bagian
Lt Gen (Ret.) Susan Helms
Dr. Sandra Magnus

Other Attendees:
Gen (Ret.) Lester L. Lyles, NASA Advisory Council

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

Telecon Attendees: participants – see attached listing

NASA Attendees:
Kathryn Hambleton
Lynne Loewy
Marian Norris

Opening Remarks
Ms. Carol Hamilton, ASAP Executive Director, called the meeting to order at 11:00 a.m. EST. She indicated that there had been no comments or requests submitted prior to the meeting, but there would be time at the end for public comments.

Before starting the meeting, Dr. Patricia Sanders, ASAP Chair, took a few moments to recognize the events of 100 years ago this month that began the NASA journey of exploration, discovery, and magnificent achievements. Those events were initiated with the formation of the National Advisory Committee on Aeronautics (NACA)—which eventually became NASA—and the establishment of its first component at the Langley Research Center (LaRC) [visited by a few of the Panel members the following day]. She noted that the Agency has come a long way since then and continues to push boundaries in difficult areas and to astound the world.

Dr. Sanders commented that the ASAP fact-finding discussions at NASA Headquarters this week again reminded the Panel how challenging NASA's projects are. There is a reason why tackling the near impossible is sometimes characterized as "rocket science." Nevertheless, across the board NASA perseveres. Many of the programs on which the ASAP has been asked to advise are now in a most challenging time frame, with initial hardware built and testing underway. It is a time when paper designs become the realities of production, integration, and sometimes surprises. Yet the NASA team finds solutions and ways to proceed—sometimes requiring additional time and resources—but always drawing on a wealth of talent and expertise within NASA.

Enterprise Protection Program
Lt Gen Susan Helms reported on the Panel's fact-finding on three topics related to Enterprise Protection: the recommendation in the ASAP 2016 Annual Report, the continuing maturation of the Enterprise Protection Program (EPP), and NASA's response to the Executive Order (EO) on Strengthening Cybersecurity of Federal Networks and Critical Infrastructure.

For the first two topics, the Panel met with Mr. James Leatherwood, the Principal Advisor of the NASA EPP, and for the last topic, the Panel received a briefing from Mr. James Ortiz, who leads the Tiger Team that generated the NASA response to the EO.

Lt Gen Helms restated the open ASAP recommendation related to Enterprise Protection:

> *The ASAP recommends that NASA 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.*

Over the last couple of ASAP meetings, NASA has shown a commitment to a comprehensive approach on this matter. They plan to identify, by job position, all personnel who have a need for security clearances and to codify that necessity in the position descriptions. When measuring progress in this area, there are intuitive metrics the Panel can employ. At the last ASAP meeting at MSFC, the Panel had its first look at the number of personnel who had been identified as needing clearances and the number of personnel who already had the clearances they needed. Lt Gen Helms noted that at this meeting, the Panel did not receive refined updates on those numbers, but it did get a sense of how far NASA has yet to go. There are a few hundred people who still appear to need Sensitive Compartmented Information (SCI) clearances in support of Enterprise Protection. Since having clearances is a first step toward protection risk management, the Panel will continue to track this metric.

Mr. Leatherwood also provided an update that showed the continuing maturation of the EPP. As noted in the ASAP's 2016 Annual Report, resources committed to the Program continue to be a concern. At the Panel's last quarterly meeting, it was noted that Mr. Leatherwood, who has done an excellent job of building an organizing construct, will be retiring very soon. Lt Gen Helms indicated that the ASAP is interested in understanding the transition to a successor that will ensure continuing progress. Based on NASA's intent, the ASAP expects that there will be a new principal in place, as well as a plan for appropriate continuity, by its next quarterly meeting. Over the last six months, under Mr. Leatherwood's leadership, the Panel felt that there has been a great start. The ASAP will continue to monitor the effectiveness of NASA's organizing construct for Enterprise Protection.

Lt Gen Helms' third topic was NASA's response to the Executive Order issued by the President through the Office of Management and Budget. The Panel received a summary brief from Mr. Ortiz, Cybersecurity Executive Order Tiger Team (CEOTT) Lead, followed by a more detailed version of NASA's cybersecurity assessment under the National Cybersecurity Framework that was created by the EO. The impression of the Panel was that this assessment, which was accomplished on an impressively short timeline, was very revealing to the Agency about its "gaps." In Lt Gen Helms' opinion, the CEOTT did a good job of framing the problem from a NASA perspective, as well as developing a "get-well" plan. For example, to manage risk assessment, the CEOTT defined cybersecurity layers in a very interesting way: one layer is mission elements and programs, one layer is corporate services and networks, and one layer is infrastructure and facilities. It appears that this construct will allow them to organize cyber risk assessments to accountable managers and will show where the integrated seams exist between various parts of the NASA enterprise. After the CEOTT performed these assessments, they also made some recommendations for the get-well plan. The ASAP was told that it is NASA's intent to ultimately take on some high priority and achievable tasks in the next year and create a broader, multi-year implementation plan under its Cybersecurity Risk Management Strategy. Cybersecurity remains one of the four arms of the EPP, the other three being: optimization of Information Technology (IT) assets,

protection of physical and space assets, and protection of critical capabilities and technologies. The ASAP will continue to monitor their progress and approach.

Lt Gen Helms noted that the Panel is looking forward to several EPP updates or revisits at the next quarterly meeting at the Johnson Space Center (JSC). These include the status of the transition of the EPP Principal Advisor, the updated metrics on security clearances, the ongoing maturation of the EPP organizing construct, and the Cybersecurity Risk Assessment improvements in response to the EO. In addition, the Panel wants to see NASA's progress toward answering the recommendations from the NASA Inspector General (IG) Audit Report on Critical Infrastructure Security.

Dr. Sanders observed that one of the notable improvements was the recognition that cybersecurity is not just computer desktops and information technology functions, but includes all the layers—the mission, the operations, and the infrastructure. It was encouraging to see that progress.

Dr. James Bagian added that there was also improvement in how it was communicated—in a way that people up and down the line can understand.

Exploration Systems Development

Dr. Donald McErlean reported on the ASAP's review of Exploration Systems Development (ESD), which consists of several integrated, large programs: Space Launch System (SLS), Orion, and Ground System Development and Operations (GSDO). Progress continues in all three, moving ahead at a continuous pace. The programs must complete a number of milestones in support of the approaching Exploration Mission (EM)-1 flight. There is no question that the activities, while moving ahead without any "show-stopping" failures, is taking longer than was anticipated. The overall launch schedule for EM-1 has slipped—it is moving out and a new date will be established in the near future. There are a number of schedule threats within the three program-critical paths. The principal one migrates through the core stage (the rocket). A number of actions must come together: the fabrication and test of qualification and flight test hardware, fabrication and testing of structural test articles, and the integration of sensors and avionics. There are schedule threats of several months in terms of delivery of hardware to testing. This remains a difficult task to traverse without delay. The second critical path flows through the European Service Module (ESM). Delivery is well behind the original schedule. The total Program is out of schedule margin and thus any slip in a critical path item results in a slip in the final integrated schedule. Unlike the core stage, where much of the work is under NASA's control, the ESM is being delivered by Airbus and is out of NASA's direct control of program execution. It is governed by a series of fixed-price contracts in Europe, over which even Airbus has little schedule control. The third critical path item is Orion software, which is progressing from flight-software build to integrated-software testing. There is only one integrated test lab for the avionics software, hence it is a natural bottleneck to schedule flow. The Program works this on a continuous basis, but every piece of software must go through the Software Integration Lab (SIL), and it will remain a bottleneck in terms of any schedule acceleration.

In every program, there is a question about funding. For ESD, the Fiscal Year (FY)17 appropriation was favorable. Additional funding was appropriated for tornado damage repairs at the Michoud Assembly Facility (MAF), and those repairs are underway. While out-year funding has uncertainties, current funding levels appear to be acceptable.

Dr. McErlean discussed the three ESD programs in greater detail. Some of the progress being made on Orion includes launch abort motor successfully hot-fired in June, the crew module moving towards its power-on test later this summer, the thermal protection shield completely fabricated, and installation

well underway for completion in December. The crew module and the service module structural test articles have been fabricated and shipped out for testing. The crew module adaptor and the ESM, when it arrives, is scheduled to be integrated and taken to NASA's Plum Brook Facility for thermal vacuum testing. Dr. McErlean shared some anecdotal information regarding an "old fashioned" problem—transporting very large aerospace items. Getting the huge Orion stack to Plum Brook, Ohio, for testing represents a significant technical challenge. Because of its size, it must be transported by barge and special carrier. This was mentioned because with our natural concentration on high technology space hardware, we sometimes overlook the more common problems facing the program team right here on Earth.

Dr. McErlean reported some good news on the SLS. At the last meeting, the ASAP learned about some difficulty with an industrial process called friction stir welding. The SLS liquid oxygen (LOX) tank is the largest and heaviest piece of material that has ever been manufactured using the friction stir welding technique. In using this technique, NASA found that they were getting anomalies in the weld—weak points that could not be tolerated in the tank. The SLS team launched an investigative program and believe they have found the source of the problem—a new tool that was thought would be an improvement, but something in the design of the new tool was creating the difficulty. When that was resolved, new welds were produced and have passed the pull-test criteria. The Program is moving ahead with fabricating the new LOX qualification tank, and the flight tank will follow. At the last meeting, NASA also reported on a mishap with the LOX dome. The qualification dome was dropped and its sides were "dimpled" by its holding fixture. At first, this was thought to be a catastrophic failure, but when the team pulled the dome out of the fixture, the dimples popped out. After considerable analysis by NASA and the prime contractor, the LOX dome was deemed suitable for qualification testing. It will be attached to the qualification tank and that assembly will go to Stennis Space Center for structural testing. The booster segments for the EM-1 main engines are nearly completed. Three of the four main engines have been green run, and the entire green run will be complete by August. The software integration test facility is working, but as mentioned earlier, there is only one SIL. As the software loads become larger, that will become a 24/7 operation.

The GSDO is currently engaged in testing umbilicals at the Launch Equipment Test Facility (LETF). The LETF is a complex, large-scale test facility that is performing testing six days per week, two shifts per day. Testing has been successful, but the LETF capacity remains a tracked item for the Program. The Mobile Launcher, the Vehicle Assembly Building, and the Pad are working very well, and the modifications are nearing completion. None of them are on the overall Program critical path at this time. However, they are huge mechanical operations with tons of steel involving massive jobs with hundreds of construction workers, and they are being closely watched.

Program integration is a special activity that looks at the interfaces between the three programs. One of the important procedures is the launch commit criteria—the conditions under which one will or will not launch. Baselining the launch commit criteria is underway. The Program has found that the processing capability (the throughput of the GSDO telemetry processing system), which was originally designed to be twice that of the Shuttle, has now been determined to be insufficient. They are in the process of doubling the capability again, and that activity is proceeding.

Dr. McErlean commented that the overall Program issues involve the three critical paths. NASA is working diligently on all of the bottlenecks on those critical paths, but admits that the schedule is slipping. The new date has not been firmly established yet. A number of important activities and milestones are upcoming. A considerable amount of structural testing is about to be underway. The

structural test articles for most of the major components of the rocket are now complete, and most of the structural test facilities at the Marshall Space Flight Center (MSFC) are as well. One of the next phases of the Program is to complete all of the major structural testing on the components, which will qualify them for manufacture of flight hardware. When those activities are complete, there will be a considerable advance in the state of the Program.

Dr. McErlean reported that the Panel had a great review with Mr. George Gafka, the ESD Safety and Mission Assurance (SMA) Manager. His organization continues to assess the ESD residual risk. They use the term "Loss of Orion Vehicle" (LOOV) for EM-1 rather than Loss of Crew (LOC), because there is no crew on EM-1. They check the LOOV periodically and update the models. They have recently gone through another update and have briefed it to NASA leadership. Currently, the LOOV risk is within their technical performance metric, i.e., it is within acceptable range.

Dr. George Nield commented that in listening to the briefings and recalling ASAP discussions with NASA, he felt it might be appropriate to share his views on some of the NASA challenges over the next few years. On large, complex programs like this, there is normally a natural evolution or transition of the program from phase to phase, especially from design and development to operations. This affects the nature of the work, the way the team communicates and interacts, how issues are resolved, etc. In looking at the ESD Program, it will be important for NASA to consider and closely watch the "decision velocity"—how long it takes to make decisions. In the design phase, it is normal to have debates and try to reach consensus, but at some point, decisions must be made. There may be an evolution between regularly scheduled meetings and face-to-face interactions, to emails or telephone calls, to having engineers and supervisors on the shop floor to give immediate direction when needed. In an ideal world, a successful program would have a sense of urgency without having schedule pressure or "launch fever." Dr. Nield also expressed his views regarding how dissent is handled within the Program. It has been over six years since the last Shuttle mission. There is a different way that NASA needs to think about how to deal with technical dissent among the workforce. Dr. Nield observed that today, there is a natural tendency to allow everyone to express opinions, engage in debates, and escalate any dissent to the top of the organization. As NASA moves into the operational phase, it will be important for all the information and concerns to be brought to the appropriate forum for review, but then for an accountable individual to make the decision—with perhaps an option for a single appeal to the next level—and then move on with the program, rather than continuing to debate and deal with technical issues on a repeated basis. It will be important to stay focused on this challenge and transition to operations in a suitable manner.

Dr. Sanders agreed that the transition issue is an important one. Dr. Sandra Magnus highlighted an ASAP question about how well the individual Programs are talking with each other and whether there are any integration or communication concerns. The Program indicated that the teams are actually communicating more effectively, because they know there is no umbrella program or "master" program integrator. Although counterintuitive, the unique ESD structure encourages more proactive approaches.

Dr. Sanders observed that clearly, there is schedule slip in ESD with respect to the EM-1 milestone. However, the ASAP is encouraged by the fact that the Program is taking the ASAP recommendations seriously and is holding the required test content fixed. NASA has taken advantage of some things that can be moved forward for EM-2, such as the ascent abort test. Unfortunately, there is an "iron bar" on the timeline between EM-1 and EM-2 due to the time needed to reconfigure the Mobile Launcher platform. The Program would have significant schedule and technical advantages if resources were made available to build a second launcher.

With regard to the schedule, Dr. Bagian noted that the programs are extremely complex and many things are not under NASA's control. In reviewing ESD with Mr. Bill Hill, the ESD Deputy Associate Administrator, the ASAP discussed the "success-oriented" schedule. NASA is aware of it and that there is very little contingency margin. However, the Programs have not let the schedule constraints put a "squeeze" on any safety issues, although schedule is still a concern. NASA acknowledged the schedule sensitivity and that schedule pressure could have a deleterious effect on safety.

Dr. McErlean added that from his experience, when one begins to see schedule pressure applied, it is not to eliminate a test, but to accept results test results that may not be as successful as envisioned or desired. To date, the ASAP has not seen that, but will continue to monitor and track this issue.

Office of Safety and Mission Assurance Update

As an introduction to this topic, Dr. Sanders provided some background. The Panel conducted an insight visit to Glenn Research Center and the NASA Safety Center (NSC) in early April and engaged with them on their audit process. The ASAP had some concerns at that time, and those concerns were revisited at this meeting. Dr. Magnus reported on the topic. She noted that the Panel was concerned about how the Agency was tracking whether safety requirements in the programs were being met, appropriately applied, and adhered to. At the last ASAP meeting in May, the Panel made the following recommendation:

> *NASA should establish, prioritize, resource, and implement a rigorous schedule of audits, executed by OSMA and conducted at the Center level, to ensure that documented safety requirements, processes, and procedures are consistently applied across the Agency.*

At this meeting, the Panel was updated on SMA audits by Mr. Rob Ellison, Director of the NSC Audits and Assessments Office. He gave a very thorough briefing and discussed the audit schedule and process. He provided an extensive list of the quantity, type, and frequency of audits conducted at the Centers by both internal and external groups. The briefing satisfied the ASAP's need for understanding what kind of audits are conducted throughout the Agency, how frequently they are occurring, and how the system works. In listening to the briefing, the Panel made several observations. The audit program is on a reasonable, time-based rotation. However, the audit programs in place were described as "compliance audits" to verify the fact that requirements are being addressed in some manner by local policies and procedures, but they do not verify that the requirements are appropriate or how well they are achieving their intended goals of the safety aspects of the programs. Voicing that concern, the ASAP heard about a proposed approach being developed that would focus on system safety, involving subject matter experts at a more detailed level. The Panel looks forward seeing how that process, including deeper dives into the NASA programs, evolves over the next year.

In summary, Dr. Magnus observed that the ASAP was provided with a good overview. The Panel is ready to dive down to the next level as well as review the proposed approach in its implementation phase. The Panel has requested a list of audits that have been conducted over the last four years and will continue to explore the audit process at another layer of detail and pursue the intent behind the recommendation.

Commercial Crew Program Update

Dr. Nield reported that the ASAP had a very detailed and in-depth discussion with Ms. Kathy Lueders, the Commercial Crew Program (CCP) Manager. She shared with the Panel a considerable amount of the

progress made over last quarter. Currently, mission planning and preparation is underway for eight crew missions, with SpaceX and Boeing each working on a demo flight to the ISS without crew, a demo flight to the ISS with crew and two post-certification missions. With regard to the official schedule, SpaceX is planning its first demo mission (without crew) in February 2018, and the demo mission with crew in June 2018. Boeing's uncrewed orbital flight test mission is scheduled for June 2018 and the first crewed test mission in August 2018. The ASAP recognizes that these schedules may slip and many challenges remain, but there is every indication that the Program is approaching the "home stretch."

Recovery trainers for both providers have been delivered and rescue training is underway. NASA continues to engage with the providers on critical test and verification events. Progress is being made on key certification products; however, much work remains. Dr. Nield noted some specific accomplishments reported by Ms. Lueders. Boeing has conducted arc jet testing, landing qualification tests, and pressure tests on the crew structural test article. Spacecraft 1 has completed its pre-mate interface tests, and the mockup trainer has been delivered to JSC. SpaceX has completed acceptance testing of demo 1 components, performed the first demo on joint simulation exercise with Mission Control Houston, and installed lightning protection on Launch Complex 39A. Four Dragon modules are in production, and the qualification module structure testing is complete.

There are still a number of concerns. NASA shared the top three programmatic and safety risks with the Panel: inability to meet Loss of Crew (LOC) metrics, DoD's Search and Rescue posture and capability, and the possibility of aborts taking place in sea states that would be unsafe for rescue. The Panel had an in-depth discussion on the programs current estimate of LOC for both providers. The Agency's LOC threshold number is 1:150 and LOC requirement is 1:270. Currently, both providers are showing numbers that are somewhat worse than those targets. However, those numbers are being worked, and the Program is identifying potential design changes or workarounds that would improve the situation. It is interesting to note that for both providers, the primary threat is micrometeoroid and orbital debris (MMOD), which dominates the LOC calculation. The Program teams are looking at areas for improvement and are continuing to study operational mitigations that could improve the numbers they have today.

The Panel had two general areas of concern—the certification process itself and Systems Engineering and Integration (SE&I). With regard to the certification process, the Panel looked at what needs to be done in terms of the products to be delivered, reviewed, and accepted. Much of the easier work has already been accomplished, and the tougher things remain to be done in a limited amount of time. Regarding SE&I, the ASAP had provided NASA with a recommendation at its February 2017 meeting:

> *The Panel recommends that NASA require the Commercial Crew providers to produce verifiable evidence of the practice of rigorous, disciplined, and sustained SE&I principles in support of the NASA certification and operation of commercial crew transportation services to the ISS.*

NASA has responded and concurs with the ASAP recommendation and has developed an action plan to address this issue. Currently, the Panel remains concerned about the action plan and whether it can be successful. The ASAP will continue to monitor NASA's progress and will be providing additional feedback and assessments to the Agency.

Dr. Sanders noted that the Panel recognizes that the commercial partners may not follow the same SE&I processes that NASA might have traditionally followed. What the Panel is looking for is evidence that hardware is properly qualified, that it is qualified within the range it is expected to be used, and that the

configuration is understood and consistent. In other words, the Panel is looking for some evidence of basic, underlying SE&I principles instead of any one specific methodology.

Mr. McErlean agreed and elaborated on the largest contributor to the current LOC estimate—MMOD. One of things Panel has begun to observe and discuss is the considerable statistical distribution between the probabilities that are used in the model. As an example, one of the current calculations uses a value of 1:300 as calculation for overall risk, but statistically, that number can vary between 1:140 and 1:1200. Analysis must deal not only with the various contributions of different components, but even the values used, which have a wide statistical distribution. The Panel agrees with the Program that they can use LOC estimates as a guide and to drive activities, e.g., to identify where minimal investments could be made to improve the number. However, the LOC estimate should not be used as an on/off switch based on a specific number alone.

Dr. Sanders added that the LOC has been interesting in the way it drives design behavior and the way it points to areas where investments can be made. She observed that using it as an absolute number to judge system safety is probably a misuse of the LOC estimate.

Human Exploration and Operations Mission Directorate (HEOMD) Standards for Deep Space Habitation Capability and Transport

Dr. Sanders introduced this topic by remarking that at the last ASAP quarterly meeting, Mr. William Gerstenmaier introduced the Deep Space Gateway and Deep Space Transport concepts. Part of the Program is involved in development of some standards to facilitate commercial and international cooperation and partnerships.

Dr. Magnus reported on the ASAP's discussions with Ms. Andrea Riley, who provided the Panel with a short presentation on the HEOMD's thinking and approach on how to create "standards"—and one could debate whether these are standards, interface control documents, or requirements—or a set of understood methodologies by which entities could engage with the Deep Space habitation and transportation system. The thinking is that by providing standards, international partners or commercial providers would know how to design their systems to interface with or contribute to the program. Their plan includes collaboration with international partners and industry to create the right "ecosystem." How the information is gathered and how the ecosystem is built is very important, and the ASAP will continue to provide feedback to NASA as this program develops.

International Space Station Update

CAPT Christopher Saindon reported on the update on the ISS. The Panel had a good overarching discussion with the ISS Program Manager, Mr. Kirk Shireman. Mr. Shireman outlined the current schedule including upcoming crew rotations via Soyuz, planned Commercial Resupply (CRS) missions by both SpaceX and Orbital, as well as work completed and planned for Increments 51 and 52 crewmembers. Significant upcoming events include: a Soyuz launch on July 28 with Expedition 52/53 crew, and two CRS missions—SpaceX-12 in August carrying consumables as well as the Cosmic Ray Energetics and Mass (CREAM) sensor, and Orbital/ATK (OA)-8 in the October timeframe, also carrying consumables and other missions.

Present crew time utilization is averaging just over 53 hours per week. This effort should yield completion of 330 scheduled investigations during Increments 51 and 52. Mr. Sherman pointed out that since ISS has been on-orbit, more than 2300 investigations have been conducted, representing over 3000 participating investigators and 98 nations.

In terms of consumables and supply, there were no significant issues noted at this time, and all critical items are at or above reserve levels. The manifested cargo for SpaceX-12 will serve to increase those margins, and OA-8 will improve that as well.

CAPT Saindon noted a couple of recent ExtraVehicular Assembly (EVA) activities. EVA 42 (May 12) included replacing the ExPRESS pallet controller assembly, located on the starboard-3 truss, and installing a connector designed to route data to the Alpha Magnetic Spectrometer. Most significantly, Astronauts Whitson and Fischer completed installation of a protective shield on Pressurized Mating Adapter-3. This is the adapter that was moved from the Tranquility to the Harmony module in March. This work is significant because it marks continued progress toward ISS achieving the capability to receive commercial crew spacecraft via the international docking port. During EVA 43 (May 23), the crew successfully completed removal and replacement of a failed External Multiplexer/Demultiplexer and also installed some wireless communications antennas. The next U.S. EVA is not planned until the fall timeframe. It will include work on Node 3 and laboratory communication antennas and removal and replacement of some of external, high-definition cameras. CAPT Saindon noted that there are currently four Extravehicular Mobility Units (EMUs) on-orbit that are "go" for EVA. There have been some indications that Metal Oxide CO2 removal (METOX) canisters were performing at a lower level than anticipated. To mitigate this risk, starting capacity limits were lowered on EVAs 41, 42, and 43 to ensure sufficient operational margins. Two METOX canisters were returned on SpaceX-11 to be analyzed by the EVA Office. SpaceX-11 delivered one replacement and SpaceX-12 will deliver a second. Additionally, during EVA 41, there was an anomaly experienced with a helmet mounted light (EHIP) during EVA 41. It appears that fasteners on a mounting band backed out. Interim procedures have been added to ensure security of the EHIP lights prior to the future EVAs until root cause is determined.

Mr. Sherman indicated that the previous ammonia leak on the External Active Thermal Control System (EATCS) Loop B, which had been active since its discovery in 2013, has effectively been stopped by isolating and venting a Radiator Beam Valve Module (RBVM). Teams are still watching the data closely, but at this point, the leak rate has stabilized at less than 0.9 lb. per year, which is insignificant.

With regard to future crew rotations, the ISS program has secured seats on Soyuz through 2018 with options for an additional three seats beyond 2018. While the CCP is making excellent progress toward achieving the capability to routinely transport NASA crew to the ISS, there is certainly some risk associated with that timeline. If that schedule should slip to the right, one could envision a scenario where there would not be U.S. crew aboard Station at some point. With no U.S. crew aboard Station, Mr. Sherman indicated that there would be considerably greater Loss of Vehicle (LOV) risk for Station--at least an order of magnitude higher than the current estimates. The Panel believes it would be prudent to exercise the options for the previously mentioned three seats as insurance to mitigate risk of commercial crew schedule changes and, most importantly, to relieve unintended schedule pressure on the CCP.

In addition to the update on ISS status, the Panel reviewed the ISS Deorbit Plan progress with the Deorbit Plan Project Manager, Mr. Charlie Grey. In 2012, the ASAP presented NASA with a recommendation for the Agency to develop a contingency plan to execute a controlled deorbit of ISS in the event of foreseeable anomalies. The ISS Program has been actively working on this plan and continues to make progress toward having the software, guidance/navigation control "flight rules," and sufficient propellant in reserve under a depressurized scenario to safely execute a deorbit maneuver. Interim flight rules are being developed ahead of the updated flight guidance software and are slated for

a "paper simulation test" this October. The Panel believes the ISS Program is making good progress toward achieving a viable deorbit plan. However, more work needs to be done, specifically with respect to obtaining software documentation from Roscosmos, which is required to trigger the Functional Cargo Block (FGB) module depressurization and initiate Service Module (SM) reconfiguration to support the deorbit burn.

Dr. Bagian noted that although the Program is making significant progress on the plan, they are not there yet. Most of what remains is not within NASA's direct control, because they are waiting for support from the Russian side. However, this plan is not just for scheduled End-Of-Life (EOL), but for contingency circumstances. Depending on the worst-case scenario, there may be as little as two weeks to prepare for deorbit. Therefore, it is important to be diligent in looking at this issue and completing the remaining work as soon as possible. If an unforeseen, de-crewing circumstance occurs, no one wants the ISS to be put in a precipitous situation.

CAPT Saindon continued with his report on Mr. Eric Christiansen's discussion with the Panel on MMOD risk assessment for ISS. Orbital Debris remains the predominate threat to the ISS or any other vehicle in low-Earth orbit. The ORDEM 3.0 model is the primary tool that the ISS Program uses to evaluate MMOD risk to Station. Orbital debris obviously presents a dynamic and ever-changing risk equation. As an example, the COSMOS and IRIDIUM collision in 2009 and other events in the 2006 timeframe contributed significantly to an increase in debris population. Currently, the one-year, on-orbit risk to ISS for MMOD penetration is estimated to be 1:33. The risk for a crew evacuation scenario is estimated to be 1:71. To help mitigate this risk, there are several hundred MMOD shields protecting critical parts of the ISS, with heavier shielding on the front and sides of the Station. To date, this shielding has effectively protected the ISS from significant damage, although the Service Module (SM) is considered "high risk for penetration." Previous EVAs installed 28 augmentation shields to help reduce SM MMOD penetration risk by an estimated 30 percent. ISS continues a multi-faceted approach to mitigating MMOD risk including maintaining robust shielding around the U.S. Orbiting Segment, the European Space Agency (ESA) module, and the Japanese Space Agency (JAXA) module. There has been augmented protection for the Russian Functional Cargo Block (FGB) and SM, enhanced protection on commercial cargo vehicles, operational mitigations (orbital debris maneuvering protocol) for ground-trackable debris with significant collision probability, and additional damage control response training and hardware. The MMOD risk briefing further highlighted the importance of the ISS Program continuing its efforts to attain an executable and safe deorbit plan.

Office of Chief Health and Medical Officer (OCHMO) Human System Risk Assessment Process and Preliminary Assessment of Human Research Program (HRP) Strategy for Exploration Missions

Dr. James Bagian reported on the ASAP's interactions with Dr. James Polk, the Chief Medical Officer (CMO), and Dr. Bill Paloski, the Human Research Program (HRP) Manager. Before beginning his report, Dr. Bagian noted that today was the 48th anniversary of NASA's landing on the Moon.

The ASAP received two very good briefings from Dr. Paloski and Dr. Polk. The two presenters gave sequential briefings that were tied together in a logical, systems-based manner. Dr. Paloski laid out how they manage risk and how they look at human system risk. In any place where humans are involved, impact on their health and welfare weighs into how programs are designed and how LOC limits are established. Dr. Bagian noted that this is the first time Panel had such an integrated briefing. Dr. McErlean added that this is also the first time the Panel has seen a cogent and funded plan to develop the knowledge needed for a journey to Mars.

HRP is in the operations organization (under Mr. Gerstenmaier) because it supports operations, rather than a "blue-sky" research program. Dr. Paloski described how the HRP integrates with the OCHMO (Dr. Polk's area) that owns the Human Risk Board, which decides what is acceptable risk for crew. Those entities advise the Health and Medical Technical Authority (HTMA), which is chaired by the CMO.

Dr. Paloski discussed how the team decided to categorize risks. Dr. Bagian noted that it was a very thoughtful approach that considered operational functional capacity. There were several categories: health factors related to altered gravity, radiation, distance from Earth (psychological and crew-interaction issues), isolation/confinement (also related to psychological and crew interaction issues), and hostile/enclosed environment (toxics, equipment on board, etc.). The Program has laid out a 3 x 4 risk matrix where they look at consequence and likelihood (somewhat similar to the risk matrices in ESD and CCP). They map these out over the fiscal years and rank them by importance and the time needed to solve them. Until recently, the Program believed it would have until FY27 to solve some of these. With changes in the schedule, they determined that they needed to look at the primary issues and prioritize the actions that are needed. Dr. Bagian observed that they did this in a very methodical, appropriate, and technically justifiable way. They determined that there were some areas that needed to be accelerated and other areas either where NASA knows enough to be able to adequately deal with the issue or there was sufficient non-NASA research being devoted to the subject. In Dr. Bagian's opinion, they did a good job with prioritization. Some areas are not needed right away and can wait until some future date; some areas can be phased out, because they are not needed from an operational standpoint. Dr. Polk and Dr. Paloski described how this prioritization was done. From a list of 100 risks or risk areas, they proposed to phase out research on 7 risks and 2 concerns, and delay research on 5 risk areas. The biggest risk areas are radiation (discussed many times) and, interestingly, cognitive/behavior (crews with diverse backgrounds in close environments). Also noted as important were the visual impairment issue (identified as an issue on the ISS) and storage of pharmaceuticals on long duration missions (a preservation issue).

The OCHMO examined some of the previous assumptions that had been made about risk factors, e.g., allowable CO2 level. Dr. Polk explained that when they traced what led to the establishment of CO2 limit requirements, they discovered that the CO2 level was established in the Gemini program and was set because that is the level that could be achieved due to the limited space available for only one lithium hydroxide CO2 scrubber. Surprisingly, programs have been living for 65 years with a limitation on CO2 that was not based on physiological limits but rather on what was possible due to technical limitations in the Gemini program. The team has started to examine many of the other assumptions regarding "physiological limits" and what they are based on. Dr. Bagian observed that this is a laudatory move, but one of the obstacles to the success of this approach is that it takes work, and there is not enough funding to do it. This an area where NASA may have been "penny wise and pound foolish," because the programs may be paying a price to work around or solve problems that is not really justified. The OCHMO will come forward with plans to perform this investigative work. Dr. Bagian applauded this and observed that good risk mitigation looks at primary prevention rather than secondary prevention.

Dr. Bagian summarized that the Program is headed in the right direction, it is well-integrated, and it examines what the operational needs really are. In his opinion, this is a very healthy way to run the Program.

Before moving to the public comments part of the meeting, Dr. Sanders noted that Gen Lester Lyles, Chair of the NASA Advisory Council (NAC), had attended the ASAP fact-finding sessions and was attending this public meeting. On behalf of the Panel, she thanked Gen Lyles for his participation. Gen

Lyles remarked that this was his first opportunity to attend an ASAP meeting since becoming Chair of the NAC at the beginning of the year. He noted that it was a great opportunity to see the depth of activities in which ASAP is involved. Gen Lyles stated that he already had a high admiration and respect for the Panel members and their expertise and that his level of appreciation was even higher after listening to all of the things that the ASAP is doing and the advice it is providing to NASA. He noted that the next NAC meeting would be the following week at LaRC. Over the three-day meeting, the NAC will get an in-depth look at all of NASA's activities. One of the highlights on the first day will be feedback and input from Dr. Sanders (who will be attending the NAC meeting) on what has taken place at the ASAP meeting here at NASA Headquarters. He thanked Dr. Sanders for the opportunity to attend the ASAP meeting.

Dr. Sanders opened the meeting to comments from the public. There were no comments, and she adjourned the meeting at 12.36 p.m.

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