National Aeronautics and Space Administration

International Space Station Advisory Committee

December 11, 2014
NASA Headquarters
Washington, DC

OPEN MEETING REPORT

Original signed by

Lt. General Thomas P. Stafford, USAF (Ret.)
Chairman

Original signed by

Mr. Gregory Mann
Executive Director

NASA INTERNATIONAL SPACE STATION ADVISORY COMMITTEE

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MEETING REPORT

Mr. Greg Mann, Executive Director of the NASA International Space Station (ISS) Advisory Committee (AC), welcomed the participants, called roll and then gave the floor to Lt. Gen. Thomas P. Stafford, USAF (Ret.), Chairman of the NASA ISS Advisory Committee:

General Stafford: *Good afternoon and thank you for participating in this open meeting of the NASA International Space Station Advisory Committee. Before we begin, I would like to highlight the recent Joint Statement from the Heads of the International Space Station (ISS) agencies on November 4, 2014, noting the many ways research on the ISS is benefitting people on Earth and reaffirming their support for continued ISS utilization through at least 2020, with the U.S. further committing to at least 2024. This strong showing of support from the Heads of Agencies serves to underscore the importance of the oversight and guidance that the Joint Committee provides to the ISS. The Advisory Committee fully concurs with this statement, and I wanted to highlight it as we begin our meeting this week.*

For our meeting today, the Advisory Committee will be discussing the fact-finding meeting held in Houston in mid-November 2014, where the Advisory Committee and the Roscosmos Advisory Expert Council met as the Joint Commission for the purpose of continuing to evaluate the viability of the ISS, with a specific focus on crew safety and utilization issues. The Joint Commission heard briefings by U.S. and Russian specialists on the current overall status of the ISS program, including overviews of the commercial crew program, certification and extension of the ISS through 2020 and potentially beyond, and FGB (Functional Cargo Block) certification. Additional presentations covered the status of nominal and contingency ISS reentry planning, medical status reports, one-year mission planning, the orbital debris environment model, ISS utilization for deep space exploration, GeneLab (space biology), the U.S. Orbital Segment extravehicular activity (EVA) final report, and the next procurement for commercial cargo services.

For this public meeting today, I will summarize each of the main areas that we reviewed, and then allow the Committee members to ask questions and discuss each topic.

ISS Program Overview – USOS and RS Programs

The Joint Commission received comprehensive briefings from the ISS Program Office and the Russian space program on the current status and operations onboard the ISS. The ISS overview briefing reviewed the ISS flight plan charts, increments 41 and 42, ISS consumables status, utilization crew time, pertinent ISS vehicle issues, research statistics, program risks, visiting vehicles mission status updates, and a detailed look at the ISS response to the Orbital-3 launch anomaly and its impacts to the space station on consumables and manifests.

The ISS program should be commended for its ability to orchestrate visiting vehicles, EVA work, science, and research. The ISS platform is extremely busy with all partners fully engaged. The briefing covered the manifest, revealing that there are periods with as many as four visiting vehicles and EVAs scheduled within a single month. It also provided a status of supplies and consumables and even with the unfortunate loss of Orbital Sciences Cygnus Cargo resupply mission, the ISS teams approach keeps supplies ahead of the requirements with comfortable margin. As well, the launch manifest ensures continued resupply so that the mission is sustained. The briefing also covered the future European Space Agency's Automated Transfer Vehicle (ATV-5), which is the last ATV vehicle manifested. ATV-5, at the completion of its time docked with ISS, will be reentered in a shallow entry configuration to help inform the eventual ISS deorbit.

The Joint Commission was also briefed on past and scheduled EVAs, crew utilization and research. Rodent research was a point of discussion with concerns raised by the commission on the effects of rodent research on air quality and potential of allergic response by the increment crews. This was discussed in depth across multiple briefings to the commission. It is clear to the commission that the ISS presents a challenging environment, with increasing levels of science and research continuing to inform humankind on the challenges to live and operate long term in space.

The crews are very busy balancing maintenance, medical activities, monitoring the environmental, rodent research and many other challenges. The Joint Commission was presented a summary of research statistics revealing a total of 1661 investigations across expedition 0 through 38, and for expedition 41/42, there has been a total of 248 investigations. In the risk discussion, outside of the highest risks carried by the program related to funding and assured access, the ISS program identified two high risks (3x5) related to orbital debris effects given refined understanding of the debris being realized and the structural integrity of the Solar Array Wing Masts due to micro-meteoroid and orbital debris (MMOD) strikes.

A couple of items of particular interest were discussed raised by the Joint Commission: the plan for ISS end-of-life nominal and contingency deorbit, and a status on the certification process for lifetime extension. Both of these topics were covered in depth in other briefings. The Joint Commission noted that end-of-life planning is still in process, and appreciates the progress that continues to be made including coordinating and securing agreements with the ISS partners. NASA and the international partners face significant challenges in sustaining the ISS, but it appears that all of the partners are dealing with the challenges in a most effective manner.

The Russian Segment overview briefing addressed increments 41 and 42, visiting vehicle status, and an update on consumables, as well as highlighting all the issues the ISS has experienced since 1999. Currently there have been a total of 70 issues for 2014, including 17 on end-of-life. Two issues in particular were highlighted: the September failure to deploy one of the two solar arrays on Soyuz 40-S (TMA-14M), and an incremental issue with the "American-Russian converter unit". At this time the Russian segment of the ISS is not working any open issues with the major onboard Russian systems. Regarding consumables, the briefing noted that there are currently plenty of oxygen supplies onboard the ISS, as well as food and water, and plenty of propellant. The Russian presentation concluded that the status of onboard systems and supplies allow for further performance without any additional restrictions.

The Joint Commission noted that the U.S. and Russian presentations provided a detailed summary of the current operating status of the ISS and identified areas of concern in advance of potential failures. The Joint Commission also agreed that both Programs had been very forthcoming, briefing on all of their current problems and anomalies, and observed that those anomalies that had been identified had received immediate and carefully-planned responses to allow full operational capability to minimize any safety issues and to maintain redundancy.

I will now open up the floor for Committee questions or discussion regarding the ISS Program overview. There were no questions or discussion regarding the ISS Program overview.

Commercial Crew Services

The Joint Commission was next given an overview of NASA's Commercial Crew Program and industry partner risk reduction and certification efforts. It was explained that while this program is being implemented with a different approach than previous NASA programs, it is still following the same certification process. The briefing addressed the overall plan for the commercial crew program, its development strategy, the certification process, strategy, and requirements, and the implementation of the contracts.

The Joint Commission learned that NASA is doing independent verifications for the commercial crew program. For requirements development, where there are specific requirements, NASA has given these to its commercial partners. For mission specific requirements, the commercial partners work with NASA to develop these. NASA has levied two sets of requirements on these providers. The first one is the visiting vehicle requirements that all vehicles docking to the ISS have to meet. In addition, NASA has the International Space Station Services Requirements document for vehicles to do crew transport up and back, and lifeboat requirements for the crew vehicle. NASA is also using the same phased safety review process used for all modules and for visiting cargo vehicles thus far. Moreover, NASA is working with the commercial companies to develop and mature their designs, and NASA will certify their crew transportation services.

The Joint Commission was given an overview of the development and risk reduction work completed on the first phase (CCDev1) and second phase (CCDev2) of its commercial crew development program, with specific highlights from all three of the original commercial partners: Boeing, Sierra Nevada Corporation, and SpaceX. While CCDev1 and CCDev2 focused on investments in subsystem maturity, the third phase, Commercial Crew Integrated Capability (CCiCap), is focused on investment in the integrated crew transportation systems, including the launch vehicle and the spacecraft, the ground, orbital and recovery operations, significant development milestones, and critical testing of these integrated systems.

In September 2014, NASA selected Boeing and SpaceX to transport U.S. crews to and from the international space station. Boeing's crew space transportation system is comprised of its reusable CST-100 spacecraft, the United Launch Alliance Atlas V launch vehicle, mission operations and ground systems. Boeing is continuing to develop its integrated space transportation system with design reviews and hardware testing. SpaceX's crew transportation system is based on the Dragon spacecraft and Falcon 9 launch vehicle originally developed for International Space Station cargo missions. Initially designed to carry cargo, systems components are being modified for added safety and crew accommodations. Sierra Nevada

Corporation's crew transportation system, the Dream Chaser piloted lifting body spacecraft, was not selected for further development under CCiCap.

The Joint Commission was also briefed on the certification process and requirements development for the commercial crew program. NASA used its knowledge base to develop a set of ISS crew transportation and services requirements, drawing on lessons learned from the Constellation program and from the Orbital Space Plane requirements, as well as lessons learned from ISS operations. Commission members raised questions on a number of topics, including suit requirements for the commercial crews, period of performance for the awarded contracts, and the possibility of NASA down-selecting to a single commercial crew provider.

Finally, the briefing covered contract implementation for Commercial Crew Transportation Capability (CCtCAP), including the detailed design, development and testing of the crew transportation system through the following major milestones:

- *Provider-proposed key design, development and test milestones*
- *Phased Safety Reviews*
- *Design Certification Review*
- *Flight Test Readiness Review*
- *Crewed Flight Demonstration to the ISS*
- *Operational Readiness Review*
- *Certification Review*
- *2-6 Post-Certification Missions*

The Joint Commission understands that NASA is procuring this capability in a new way, but that the Agency is certifying its systems using standard methods and milestones to ensure that NASA's requirements are being met. Once the commercial providers have achieved NASA certification, they will share the critical task of transporting crews, critical science, and cargo to the International Space Station, and will offer an important crew rescue capability. The Joint Commission considers the extensive work by NASA in support of acquiring commercial services for crew and cargo delivery and return to be indisputably important for the ISS program, and this briefing on the Commercial Crew Program inspired several questions relating to safety and operations.

I will now open up the floor for Committee questions or discussion regarding the commercial crew program update. There were no questions or discussion regarding the commercial crew program update.

Activities to Support the Operation of the Zarya FGB until 2020

The Joint Commission received another status update on the service life extension activities for the Zarya Functional Cargo Block (FGB), the first component launched for the ISS. The briefing covered the completed work on Phase III, as well as the planned work for Phase IV to upgrade equipment and supply the FGB with units to be replaced on orbit in July 2016 - December 2020. This planned work includes drafting procedures to replace equipment on the FGB, developing equipment replacement procedures, and developing procedures on replacing equipment in the FGB radio telemetry system.

The briefing also covered tentative work plans to deliver and replace FGB-specific system equipment and proposed joint work on monitoring and measures to improve the microbiological situation on the Zarya FGB, including the replacement of interior panels. The Joint Commission also heard of the functioning of the FGB in off-nominal situations, including the scenario of depressurization of ISS-pressurized volumes, and was briefed on the storage and transfer of propellant to the propulsion systems of the Service Module and the Progress vehicle.

The Joint Commission understands that the work to extend the service life of the FGB to 2020 has been successfully completed in full. The diagnostic work done has been effective and enabled the service life of critical onboard complex control system and power supply system units to be extended until 2016 without replacement. Work on upgrading and producing spares for 2016-2020 is being done in accordance with the concurred-on work schedule, and a plan has been drafted on delivering equipment to be replaced on-orbit to the FGB.

I will now open up the floor for Committee questions or discussion regarding the Zarya FGB status. There were no questions or discussion regarding the Zarya FGB status.

Status of Certification and Extension of the ISS flight until 2020 and Beyond

The Joint Commission was given a status update on the certification and extension of the ISS until 2020 and beyond. The update covered assessments on the Phase III Life Extension hardware considered to be at greatest risk, an analysis of the P6 Integrated Equipment Assembly, the cupola glass windows, as well as a re-assessment of Phase I and Phase II hardware with new assumptions.

The Joint Commission understands that currently all work is complete to clear the U.S., ESA, JAXA, and CSA ISS hardware to 2020 and that significant progress has been made towards clearing for 2028. In addition, there is work underway to gather necessary data to complete the Russian Space Agency 2020 certification, and plans are in place to mitigate the Mobile Servicing System spares to support operations through 2020. All of the ISS International Partners are responsible for assessing the capability of their hardware to extending ISS operations to 2020 and 2028. At present, CSA, ESA, and JAXA are only committed to 2020, the Russian Space Agency has only committed to 2024, and ASI is currently in works to assess its Permanent Multipurpose Module beyond 2020.

The Joint Commission had several comments and questions on the briefing, including how or if testing for some of this hardware might be utilized as longer-term analysis and planning for future space deep space exploration. The Joint Commission also noted that it would be ideal if all of this knowledge on long-term space radiation, loading, and the effects on material sciences, were able to be captured and shared as part of NASA's "body of knowledge" for future exploration.

I will now open up the floor for Committee questions or discussion regarding the certification and extension of ISS flight until 2020 and beyond. There were no questions or discussion regarding the certification and extension of ISS flight until 2020 and beyond.

End-of-Life Status / Deorbiting of ISS

The Joint Commission also received a briefing on the end-of-life and deorbiting status for the ISS. A controlled de-orbit into the ocean has been the intended disposal plan for ISS since the inception of the program, with the initial plan to use the European Space Agency's Automated Transfer Vehicle (ATV) to deliver the final deorbit impulse. However, with the extension of ISS to at least 2020 and with no more planned ATV's, a multilateral team was chartered to work nominal and contingency end-of-life ISS de-orbit plans. One potential solution utilizing existing propulsive assets has been identified, with the contingency de-orbit case a derivative of the nominal end-of-life ISS de-orbit plan.

The Joint Commission heard several challenges to contingency deorbit scenarios:

- *ISS contingency de-orbit should be executed such that the ISS re-enters Earth's atmosphere within 180 days of an irreparable ISS depressurization, to stay within avionics certification;*
- *Decision to lower ISS altitude is required within days to weeks after depress event to ensure availability of propulsive stores;*
- *ISS Program is investing in analyses and technical definition studies to assure that sufficient propellant resources will always be accessible; and*
- *Early propulsive decay is planned, followed by natural decay for 4-5 months. During the natural decay period, two or more Progress propellant resupply vehicles may arrive to execute the final burn.*

The Joint Commission was also briefed on the agreement status regarding end-of-life and contingency deorbit for the ISS. The ISS Program Managers Technical Understanding, signed in November 2013, recognizes that the partner responsibilities defined in the Inter-Governmental Agreement and ISS Memorandum of Understanding apply to all ISS operations, including the nominal end-of-life and potential contingency re-entry. In addition, the NASA/Roscosmos Protocol, signed April 2014, agrees to the implementation of the technical team's recommended activities, including NASA funding to Khrunichev in May 2014 to begin work to address concerns related to FGB propellant freezing. Finally, a multi-agency major test campaign for the January 2015 ATV-5 re-entry is planned to improve the understanding of key factors in the ISS shallow entry regime.

The briefing concluded with a summary of the ISS De-Orbit Findings, noting the plan utilizes existing propulsive assets to provide the initial and final impulse burns necessary to de-orbit the ISS, and that the nominal and contingency deorbit plans are largely common in order to minimize rework for any contingency scenario. The most likely contingency scenario that could lead to de-orbiting ISS early is a micro-meteoroid and orbital debris penetration, and the ISS must be de-orbited within 180 days of an unrecoverable depressurization event. The Space Station Control Board will continue to work on end-of-life plans and associated risks, with a major focus on ISS contingency de-orbit planning with a goal of achieving an end-of-life deorbit that best protects the population.

I will now open up the floor for Committee questions or discussion regarding the ISS end-of-life and contingency deorbit status. There were no questions or discussion regarding the ISS end-of-life and contingency deorbit status.

Medical Status Reports (U.S. Orbital Segment and Russian Segment)

The Joint Commission heard medical status presentations from both the Russian and U.S. Programs, including a summary of the recent ISS missions and an overview of the current and upcoming missions. Topics covered included the medical operation carried out between ISS 39-41, extravehicular activities (EVAs) 38, 39, and 40, the ATV-5 docking, microbiological conditions, the quality of the air and the water supply systems, radiation monitoring, the use of exercise equipment, and the work of the Multilateral Human Research Panel for Exploration (MHRPE)".

For the medical operations for ISS-39, ISS-40 and ISS 41, the life support systems on the Russian Segment provide nominal conditions for the ISS crew and the psychological status of crews and the interaction between the crewmembers was assessed positively. The crews of the ISS 40/41 (39S) on "Soyuz TMA 13M" and ISS 41/42 (40S) on "Soyuz TMA 14M" after launch made a rendezvous and docked to the ISS using shortened 4-orbit scheme without any technical and medical problems. The level of physical fitness of the ISS 39/40 during flight was estimated as sufficient to perform the Flight Program and the extravehicular activities 38 and 39, as planned.

The ISS air quality is rated good, and the current procedures have gotten levels under control, far below the maximum allowable. An issue with flaked coating particles during the first crew ingress into ATV5 has been adequately mitigated. Experimental studies on the ISS air quality forecast until 2020 have been conducted by RSC Energia and assessed positively. During the ISS-40 mission, the sanitary-microbiological monitoring of the ISS environment was performed in 48 air zones of the Russian Segment and on the surfaces of interior and equipment in 20 zones of the service module. Microbiological researches have shown that basic mission contamination of the gas interior and the equipment of Russian Segment ISS did not exceeded standard indicators and corresponded to the written requirements.

There are adequate supply levels in the water supply system onboard the ISS, and the analysis of water samples delivered from the ISS no microorganisms were detected. In connection with NASA's inquiry, test measurements of impact of physical training sessions with the use of the Russian treadmill (BD-2) device on the American elements of the ISS are continuing. Roscosmos has determined that the BD-2 does has no effect on the Russian Segment of the ISS, and currently the use of the training device is in a nominal mode; work in this direction is proceeding.

The Russian Segment briefing also covered the Multilateral Human Research Panel for Exploration, an ISS Program created to promote evaluation and mitigation of medical risks related to exploration. The MHRPE coordinates the exploration fly-off plan for multilateral ISS human biomedical research, coordinates the common rules and guidelines to achieve the common goals and objectives of ISS biomedical research across the partnership, bridges medical operations coordination as it applies to the human research exploration fly off plan, and determines the utility of data acquired during medical operations. The Panel strives to reach consensus on common requirements for human research, including research protocols, hardware and data sharing, and increased efficiency of use of ISS crewmember subjects toward common exploration goals.

The Joint Commission also heard a presentation on medical operations on the U.S. Orbital Segment, which covered topics including space weather, environmental status, the ISS food

system, habitability, extra-vehicular activities, the one-year science mission, and the ISS medical project.

Expected radiation levels for space weather are projected for each mission, and generally have been close to NASA's projected targets. Concerns remain that for the deep space environment for solar radiation will be one of the major limiting factors for trips to Mars and other deep space destinations. NASA is trying to keep the increased risk for cancer for our crews to 1% or lower for these missions, but there are models that show when astronauts leave low earth orbit, they will go above these levels for a period of time. The challenge is that these cosmic rays are hard for NASA to study when we are in the protected environment of the ISS. The U.S. doctors are monitoring astronauts in low-Earth orbit over time to assess if there is any increased risk in cancer due to space exposure, and so far do not have any evidence of increased risks.

No major issues to report for the environmental acoustics assessment. One recurring issue in the U.S. Orbital segment is the stalled inter-module ventilation fans caused by dust accumulation; while stalled, the high noise levels increase the risks for degraded voice communications and habitability. The waste hygiene compartment-toilet) noise levels have returned to nominal, and the noise levels in U.S. Orbital Segment meet requirements except in Node 3. Noise levels in Russian segment are above requirements, but low risk for permanent hearing damage.

On microbiology operations, the air, surface, and water analyses indicate that levels and types of microorganisms recovered in the U. S. Segment pose little or no threat to crew health, ISS environment, or systems performance. Despite the recent Orbital failure occurred, the ISS food system still meets requirements and no issues are anticipated with the planned expect resupply with Progress and SpaceX.

For the planned one-year mission, both crewmembers have received informed consent briefings for each of the planned medical testing protocols; a final complement update will include a projected post-flight schedule and inflight blood draw tables for the crewmembers.

The U.S. Orbital Segment briefing concluded that from a human health and performance standpoint, ISS remains a habitable and viable microgravity laboratory. Future developments to be monitored include additional commercial vehicles resulting in increased payload capability and sample return capacity. In addition, the one-year mission (featuring a U.S. crewmember with an identical twin – and former NASA astronaut – who will serve as a "control") will test exercise countermeasure effectiveness, human behavior and performance and ground teams support effectiveness. I would personally like to note that all the coordination on the NASA-Russian partnership has been commendable.

I will now open up the floor for Committee questions or discussion regarding the medical status reports. There were no questions or discussion regarding the medical status reports.

ISS Micro-Meteoroid and Orbital Debris Status Briefing

The Joint Commission was briefed on the status of micro-meteoroid and orbital debris (MMOD) risk assessments for ISS based on the newest version of the NASA Orbital Debris Engineering

Model, ORDEM 3.0. The briefing covered the MMOD environment through end-of-life, the MMOD risk projection through end-of-life, recent MMOD impacts to the ISS, and issues such as visiting cargo and crew vehicles).

The new Orbital Debris Environment Model represents the best understanding of the current and near future orbital debris environment. One significant addition is the addition of steel particles in debris flux required impact tests to assess capability of ISS shielding. ORDEM 3.0 is planned for risk assessment for future launches (crew and cargo) to the ISS. The briefing also contrasted the past environment versus future risks associated with MMOD larger than three millimeter, for both the ISS altitude of 400 km and an altitude of 705 km. The detailed specificity of the new model is based on observed strikes from returned spacecraft, and replicating strikes in laboratory to determine sizes.

While the addition of steel particles in ORDEM 3.0 debris flux increases overall risk to ISS compared to results using previous debris model (ORDEM 2000), the ISS MMOD risks with new debris model demonstrate an overall trend is for lightly-shielded items to have higher risk and better-protected items have lower risk. Questions were raised regarding the vulnerability of the Russian Progress and Soyuz vehicles, given their "shielded position" when docked "behind" the ISS, but it was noted that the risk of side impact is actually quite high, thus minimizing the "safety / shielding" aspect of the positioning behind the ISS.

The Joint Commission was also briefed about ISS MMOD loss-of-crew and evacuation risks. Loss-of-crew risks include the following failure modes: catastrophic failure of external pressurized vessels and stored energy devices; hypoxia loss of crew due to large hole/cracks in pressure shell or window failure; catastrophic failure of internal equipment; crew loss due to fragments and other internal penetration effects; module unzip due to critical crack; and thrust induced angular velocity causes loss-of-crew during departure. Evacuation risks include the following failure modes: MMOD damage that leads to either Service Module or Node 3 depress (critical equipment loss); non-fatal injury of crew from fragments or secondary effects from penetration of crew module; and loss of ISS attitude control due to failure of attitude control system.

I will now open up the floor for Committee questions or discussion regarding the micrometeoroid and orbital debris status. There were no questions or discussion regarding the micrometeoroid and orbital debris status.

I would like to add that Mr. Gerstenmaier (NASA Associate Administrator for Human Exploration and Operations) *has noted in the past that "at times the solar panels look like west Texas road signs."*

Status Update on One-Year Mission Planning

The Joint Commission was also briefed on the status of the one-year mission planning and the Human Research Objectives for ISS. The primary objective is to utilize the ISS efficiently to reduce the risks to human space exploration missions beyond low Earth orbit. To achieve this, NASA needs to capitalize on the multilateral capabilities and resources on ISS to expedite biomedical risk reduction. The plan is to implement a one-year mission by two ISS

crewmembers to assess biomedical, training, scheduling, certification and implementation issues associated with increased flight durations.

The three major areas of biomedical concern are medical events, physiological deconditioning, and behavior and performance. The Space Station Control Board chartered the Multilateral Human Research Panel for Exploration (MHRPE) to facilitate multilateral in-flight investigations for all remaining ISS increments, starting with the 2015 year-long mission as a demonstration.

A key element of the MHRPE coordination efforts is data sharing with multilateral participation, with relevant data to be shared between designated investigators representing participating agencies and crewmember participation. The three categories of multi-lateral collaboration for the one-year mission are:

- *Joint investigations with collaborating co-PIs from Roscosmos and NASA, and featuring Roscosmos and NASA crewmembers as subjects;*
- *Cross-participation investigations led by one partner (Roscosmos or NASA), and featuring Roscosmos and NASA crewmembers as subjects; and*
- *Data exchange investigations within national programs (with no cross-participation).*

The ISS is currently being utilized to reduce risks of human space exploration missions beyond low Earth orbit. This risk reduction can be reduced further through the utilization of multilateral capabilities and resources on all future ISS expeditions. MHRPE has recommended clinically-driven biomedical research on long duration missions, including additional one-year missions to provide a foundation for understanding and mitigating medical risks and the ability to plan exploration-class missions in the future. I would like to add that the JC has pushed for one-year missions for a long time, and had previously pushed for 9-month missions. I'm am glad to see these finally happening.

The Joint Commission notes the continued success of MHRPE integration and cooperation in scientific and biomedical programs. The joint group continues to prepare and plan for the study of the nature and prevention of critical risks in human flight. This includes the one-year studies and other efforts pertinent to prolonged flight beyond low earth orbit.

I will now open up the floor for Committee questions or discussion regarding the ISS one-year mission planning. There were no questions or discussion regarding the ISS one-year mission planning.

ISS Utilization for Future Exploration

The Joint Commission also heard a briefing on how the U.S. Orbital Segment is utilizing the ISS in preparation for future exploration. With hundreds of ISS investigations reporting that all their results have been published, it is possible to determine the results that show scientific demand and compelling applications to improve life and health on Earth. The briefing provided the Joint Commission with information on why these areas of application are compelling (in terms of the numbers of people that could be helped and the economic benefits to be obtained). There are eight areas of increasing high impact / high demand research, based on the current results: medicine, cell and tissue biology, protein structures, disaster reduction and response,

combustion, nanomaterials, metal alloys, robotics.

Also briefed were the current activities targeted at communicating the benefits of the International Space Station. All partners need to communicate the benefits of their investment in ISS in more traditional return-on-investment type of terminology. NASA has proposes the assembly of a multilateral steering committee to develop a strategy for communicating benefits of the ISS in a more tangible way, including:

- *Identifying specific common subject areas that should be jointly assessed for consistency across all International Partners;*
- *Considering use of independent outside experts or third party assessments;*
- *Assessing the perspectives of cost, performance, opportunities, unique capabilities; and*
- *Identifying the cost to global economies of the problems ISS can solve.*

The Joint Commission was also given a separate presentation on how NASA's Space Life and Physical Sciences Research and Applications Division (SLPS) has been formulated to execute high quality, high value research and application activities in the areas of space biology, physical sciences, and human research. These programs conduct fundamental and applied research to advance basic knowledge and to support human exploration in the environment of space. SLPS also serves as the agency liaison with the ISS National Laboratory management organization, the Center for the Advancement of Science in Space (CASIS).

The Commission learned that SLPS is moving to an Open Science approach, which is a paradigm shift away from the traditional approach of enabling science for one specific Principal Investigator (PI) at a time. Open Science allows NASA to enhance science returns by developing high-content science community reference experiments (flight data for advanced modeling, analysis, and discovery) that will later support large numbers of investigators to conduct ISS-derived research. NASA is funding a national research announcement (NRA) to encourage translation of ISS-derived research to multiply discovery and enable exploration and commercialization. While SLPS is working to implement Open Science initiatives across the whole program, the three initial pathfinders include GeneLab (Space Biology), MaterialsLab (Physical Sciences), and Physical Science Informatics.

The Joint Commission had questions regarding the decision process for the research subject matter, and was briefed on the role of the Decadal Survey and how the science community works with NASA program management to make decisions for what is to be studied.

I will now open up the floor for Committee questions or discussion regarding the use of the ISS for future exploration research or on NASA's Space Life and Physical Sciences Research and Applications Division. There were no questions or discussion regarding the use of the ISS for future exploration research or on NASA's Space Life and Physical Sciences Research and Applications Division.

<u>EVA Final Report</u>

The Joint Commission was also given a presentation on the U.S. extravehicular activity (EVA-23) incident mishap investigation and return to planned EVA status. This incident was considered one of the most serious mishaps in the history of extra vehicular activity. During

U.S. EVA #23 in July 2013, EV2 experienced a build-up of free water in the EMU helmet. During translation to the Airlock, water migrated to EV2's face, covering his eyes, ears and nose. This accumulation of water resulted in EV2's communications and vision being degraded. The Crew report of ~1.5 liters of water in the helmet at helmet doffing was confirmed by the post-EVA water recharge of the Extravehicular Mobility Unit (EMU) feed water tanks. Post-EVA, the crew reported the water was very cold, indicating that it came from the EMU cooling loop and not the in-suit drink bag. An expedited suit doffing was performed.

The failure was well in excess of previous water in helmet experience, which in the past has manifested as streaks or "rain" on the visor, and not as a significant volume of water in the helmet. EV2 was using EMU s/n 3011, which was launched to ISS in May 2010 and had been used on five prior EVAs. Silica-based contaminants blocking the fan pump water separator drum holes were confirmed to be the cause of the water carryover. Premature saturation of the Airlock Cooling Loop Recovery (ALCLR) Ion Bed was believed to be the cause for the silica contaminants.

Initial findings indicated a number of potential practices and/or system configurations that could lead to poor quality water use for EMU ion bed processing. A most significant finding was that the use of potable water was allowed for some flight hardware processes that should use only controlled De-Ionized water. During the investigation, a fault tree was developed that contained 44 possible failures and/or events. Analysis of returned hardware and water samples pointed to the ALCLR ion exchange beds as a primary source of excessive silica that was blocking the fan pump water separator drum.

The Joint Commission learned that a broad approach has been taken to tighten up quality controls for certain aspects of EMU processing. New processes have been put in place (charcoal cleansing/rinse plus continuous monitoring of water quality) to produce clean ion exchange beds. Hardware has been replaced with cleaned and processed components. Ion bed processing has been improved resulting in higher quality water use for ion flushing. In addition, a conductivity meter is placed after the last DI bed to remove any doubt when exceeding the conductivity level.

The root cause investigation identified 27 corrective actions to address the findings. Extensive corrective actions have been taken to ensure water quality exceeds the desired and required purification levels. Currently all U.S. Orbital Segment on-orbit EMUs are "Go" for planned EVAs. Also, the ISS Program and the Agency conducted a comprehensive review and concluded that nominal EVA capability could be restored. The Joint Commission congratulates and commends the mishap team for its attention to detail, skill, investigative work, and thorough assessment and analysis of the incident.

I will now open up the floor for Committee questions or discussion regarding the final report on the EVA mishap investigation. There were no questions or discussion regarding the final report on the EVA mishap investigation.

<u>CRS2 Procurement History - Commercial Cargo Services</u>

The Joint Commission received a briefing on the Commercial Resupply Services (CRS2) procurement status, including an Industry Day and draft and final Requests for Proposals.

The final proposals were due to NASA on December 2, 2014, with an anticipated award date in May 2015. Key messages to the participants on Industry Day noted that Commercial Resupply Services are critical to the execution of the ISS Program to provide crew supplies and research payloads to the ISS, and that the partners must fly on time, provide flexibility for cargo manifesting, and be reliable. NASA is seeking the kind of reliability presented by the Progress and Soyuz, and additionally is looking for larger vehicles that the ones currently being used by SpaceX and Orbital for commercial cargo delivery.

Additional key messages detailed that the combination of upmass, volume and number of flights per year is critical to the success of the ISS program. The research requirements to perform high quality science and technology development drive the unique capabilities for the resupply service vehicles, and these are critical for ISS to be a platform for discovery that will improve life on earth and allow exploration beyond low earth orbit. The external dependencies required to provide this service can limit the robustness of a solution. Finally, the political, social, economic, or environmental impacts or events that constrain the ability to meet these needs will be carefully evaluated for risk reduction approaches.

The Joint Commission raised several questions regarding CRS2, and looks forward to an update status on the CRS2 Procurement at its next meeting.

I *will now open up the floor for Committee questions or discussion regarding the commercial cargo services procurement.* There were no questions or discussion regarding the commercial cargo services procurement.

Conclusion

Once again, the Joint Commission commends the ISS Program and the International Partners for the continued successful operation of the ISS and for maintaining an international crew of six with the existing flight vehicle assets. The Joint Commission also stresses that continued vigilance is necessary to maintain safe and productive operations of the space station.

The Joint Commission has made tentative plans to meet again in Moscow for another fact-finding meeting on ISS safety and utilization issues.

This concludes the current report and summarizes the work accomplished by the Working Group during the recent fact-finding meetings in Houston. Given this report, do any Advisory Committee members have any final questions or comments? Do the Committee members have any objections to the conclusions and findings of this report?

Very well then, based on the recent fact-finding meeting in Houston and our discussions here today, the ISS Advisory Committee concurs with the assessment outlined here.

Thank you all again for the expertise you bring to our Committee. Now, I'll turn this over to the Executive Director to wrap things up.

CLOSING

Greg Mann: *I do want to say thank-you once again to the ISS Advisory Committee members for all of your hard work on this assessment. I look forward to your participation at future meetings. We have begun tentatively planning for our next meeting in Moscow next year. I look forward to see all of you, and our Russian counterparts, in Russia in about six months.*

This meeting is adjourned at 3:10pm.

Attachment A

NASA International Space Station Advisory Committee

NASA Headquarters
Washington, DC
December 11, 2014

ADVISORY COMMITTEE MEMBERSHIP

Chairman

Lt. Gen. Thomas Stafford, USAF (Ret.)

Members

Col. James Adamson, U.S. Army (Ret.)
Mr. Hal Bell
Mr. Joseph Cuzzupoli
Dr. Charles Daniel
Dr. Michael Foale
Col. Kevin Ford, USAF (Ret.)
Dr. Daniel Heimerdinger
Dr. Ronald Merrell
Capt. Bill Readdy, USN (Ret.)
Dr. Josef Schmid

Technical Advisors

Maj. Gen. Joe Engle, USAF (Ret.)
Maj. Bob Maiberger, U.S. Army (Ret.)

Executive Director

Mr. Greg Mann

Dep. Executive Director

Ms. Holly Stevens

Attachment B

NASA International Space Station Advisory Committee

NASA Headquarters
Washington, DC
December 11, 2014

Members Participating

NASA International Space Station Advisory Committee *(via telecom)*

Gen. Thomas P. Stafford
Mr. Jim Adamson
Mr. Joe Cuzzupoli
Mr. Bill Readdy
Mr. Ron Merrell
Mr. Chuck Daniel
Mr. Mike Foale
Mr. Kevin Ford

Executive Director

Mr. Gregory Mann
Ms. Holly Stevens *(via telecon)*

Technical Advisers

Gen. Joe Engle *(via telecon)*
Mr. Robert Maiberger *(via telecon)*

NASA Attendees *(in person)*

Patrick Finley (OIIR)

NASA Attendees *(via telecon)*

Mr. Ven Feng (ISS Program)

Media *(via telecon)*

Stephen Clark
Spaceflight Now

Industry

Kimberly A. Terrell
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Katz International Mgmt Solutions LLC

General Public

Mary Lynn Dittmar *(no current affiliation)*