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

May 8, 2019

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

Dear Mr. Bridenstine:

The Aerospace Safety Advisory Panel (ASAP) held its 2019 Second Quarterly Meeting at NASA Marshall Space Flight Center in Huntsville, Alabama, on April 23–25, 2019. We greatly appreciate the participation and support that was received from the Center leadership, the subject matter experts, and support staff.

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

Sincerely,

Patricia Sanders

Patricia Sanders
Chair

Enclosure

AEROSPACE SAFETY ADVISORY PANEL
Public Meeting
April 25, 2019
Marshall Space Flight Center, Huntsville, AL

2019 First Quarterly Meeting Report

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

ASAP Staff and Support Personnel Attendees
Ms. Carol Hamilton, NASA ASAP Executive Director
Dr. Mary Beth Saffo, Writer/Editor

NASA Attendees
Jody Sanders (NASA-MSFC)
Jeremy Del Greco (NASA-MSFC)
Shannon Segovia (NASA)

Non-NASA Attendees
Miles Doran (CBS News)
Darrell Johnson (CBS News)
Makanga Njagi (CBS News)

Telecon Attendees (60) – see Attachment 1

Opening Remarks
Ms. Carol Hamilton, ASAP Executive Director, called the meeting to order at 9:30 a.m. CDT and welcomed attendees to the ASAP's second quarterly meeting of 2019. Ms. Hamilton informed attendees that they were welcome to make comments at the end of the meeting and reminded any commenters to introduce themselves by name and affiliation before offering their remarks. She also noted that the public has an opportunity to submit formal verbal or written reports to the Panel; none, however, were received for this meeting. Ms. Hamilton then turned the meeting over to the ASAP Chair, Dr. Patricia Sanders.

On behalf of the ASAP, Dr. Sanders thanked Ms. Jody Singer and the personnel of the Marshall Space Flight Center (MSFC) for their hospitality. She also thanked the MSFC staff for their leadership and dedication to the NASA mission, especially in the vital area of propulsion, and for their excellent collaboration with the greater Huntsville community.

Dr. Sanders expressed her special thanks to Ms. Evette Whatley of NASA headquarters for her administrative support to the Panel over the past several years. The Panel wishes Ms. Whatley the very best in her retirement from federal service.

Although there is never a dull moment in the pursuit of space exploration, this is a particularly exciting time for the U.S. space program. Not only are both the Exploration Systems Development (ESD) and Commercial Crew Programs (CCP) both closing in on launching uncrewed and crewed flight tests, but at the fifth meeting of the National Space Council, held in Huntsville, on March 26, 2019, Vice President Pence announced that "it is the stated policy of this administration and the United States of America to return astronauts to the Moon within the next five years." This declaration adds an urgency and vibrancy to an already complex and ambitious endeavor.

As NASA develops the plans to implement this exciting, but clearly aggressive goal, and as Congress assesses its support for such an endeavor, the Panel spent some of its time this week discussing the safety ramifications of this challenge. Dr. Sanders offered the Panel's initial thoughts on some of the factors to be kept in mind for the successful accomplishment of this mission.

The first such factor is the importance of setting challenging, but achievable schedules. As the Panel pointed out in its first Quarterly meeting in early March 2019: "Targeted launch dates should be chosen to impart a sense of urgency, and to convey the importance of holding to the planned schedule. At the same time, it can be very bad for employee morale if the official dates are clearly not achievable, given the work that needs to be accomplished. Unrealistic schedules can also result in bad decisions, at least from a safety perspective, if meeting these deadlines results in unnecessary or imprudent shortcuts, or elimination of important testing." Although these particular comments were specifically related to NASA's planning for Exploration Mission-1 (EM-1)**,** the same general philosophy applies to schedules being laid out for a return to the moon.

Second, as NASA tackles the technical challenges, it is crucial that these ambitious technical efforts are accompanied by steady national commitment and consistency of purpose, including appropriate resources over the entirely of the effort. Budget inadequacies and uncertainties — including partial-year Continuing Resolutions – add complexity to program management and inefficiency in execution, detracting from NASA's ability to achieve the technical goals with the requisite focus on safety and mission assurance.

Third, as NASA initiates this next phase of its deep space exploration effort, it has both the opportunity and the necessity to apply the lessons it has learned from other recent programs, including the Commercial Resupply Service (CRS), the CCP, and ESD. For example:

- The use of alternative procurement mechanisms, public-private partnerships, Space Act Agreements, Broad Agency Announcements, or other processes that allow contract flexibility and have the potential to result in lower costs and shorter development times than traditional contract arrangements.
- An early establishment of trust between the government and industry partners. Development of the CCP has demonstrated the significant potential of such partnerships and the progress that can be made with the employment of "badgeless teams" (integrated teams of qualified experts working together in a single location, regardless of institutional affiliation), transparency, and the early engagement of government.
- In addition to the benefits provided by diversity of approaches, and healthy competition for design, cost, and safety, the pursuit of multiple service providers can also be extremely important to avoid the possibility of significant delays should one provider's approach encounter technical problems.

Fourth, NASA should be willing to embrace, where appropriate, the inclusion of already developed, or nearly mature, technology and components and not feel the need always to pursue the development of new, potentially more capable, but more risky technologies. Improvements to these technologies can then be spirally incorporated over time.

Finally, in its pursuit of a human presence on the Moon by 2024, NASA should neither lose sight of the longer-term goals for exploration, nor of the critical steps needed to achieve them. Return to the Moon should not be an end in itself, but a part of a longer-term strategy. The lunar endeavor must be used to learn what is necessary to buy down risk for further excursions, to Mars or elsewhere.

Pursuant to the Vice President's direction, the Panel is aware that NASA has been exploring options for launching EM-1 as early as possible. This examination will no doubt yield some useful procedural improvements, such as a more rapid decision pace, a resequenced work flow, and a more streamlined approach overall. Nevertheless, as NASA evaluates different paths to potentially accelerate the launch date of the EM-1 flight, it cannot lose sight of the essential fact that the ultimate objective of that flight is to mitigate risk and arrive at a clear understanding of the risk posture prior to the first crewed flight. The Panel believes that several critical data sets are required to ensure, as much as is possible, a safe EM-2 mission. As the ASAP 2018 Annual Report stated: "Similar to the Panel's Recommendation (2018-04-01) on CCP, we feel that the ESD Program should clearly identify which systems or components must absolutely be present on EM-1 for them to be considered qualified for operation on EM-2. Crew risk mitigation on EM-2 depends on the flight demonstration of some elements of various systems. It is our position that those components, parts, or systems need to be directly identified by the Program and those essential elements be incorporated before the EM-1 flight is launched."

The Panel identified several important milestones that must be achieved before a crewed flight. One of the most critical such milestones is the Green Run test of the rocket's core stage at Stennis. There is no other test approach that can gather the critical, full-scale, integrated propulsion system operational data required to ensure safe operation of the vehicle. Shorter duration engine firings at the launch pad will not achieve an understanding of the operational safety margins, and incomplete information on engine function could result in severe consequences in a much less controlled environment, if those margins are exceeded. Dr. Sanders emphasized the Panel's urgent recommendation that NASA retain this crucial test component in its program of work.

Another important milestone is the thermal vacuum tests at Plum Brook. During its visit to the MSFC this week, the Panel examined the SLS core stage structural test article in the test stand. The panel has previously applauded the approach that ESD has taken in full-scale structural testing, extensive parachute testing, ascent abort tests, and others. This is no time to jeopardize the program by introducing unwarranted risk for the sake of meeting proposed launch deadlines.

All that being said, in considering the schedule for a critical flight test like EM-1, there is a critical judgment that needs to be made. On one hand, there is a conservative approach that argues for not flying the test until all components have been qualified and all subsystem tests have been completed, and until there is reasonable assurance that the flight test is performed with the anticipated final configuration. An alternative "spiral development" approach is to launch a flight test earlier in the design process so that data on integrated performance can inform design decisions on the final configuration.

In the first case, the test is essentially a "dress rehearsal" of the flight hardware, in a manner that most closely resembles the final design**;** but this approach commits to a design configuration before understanding how the individual components perform in an integrated environment. In the second case, early integrated test data can advise final design decisions. However, in providing only one integrated flight test opportunity prior to a design commitment, this approach runs the risk of more significant differences between the test article and the final configuration.

Both test approaches have merit. But, whatever the approach to design and testing, determining the proper timing of an integrated flight test requires a deliberate, detailed and important dialogue on the risk trade-offs for the overall program, including achievement of a full understanding of the design margins by the end of the test and certification program, and a comprehensive strategy for operating within the margins. Whether the tests concern EM-1, an uncrewed flight test in the Commercial Crew Program such as Demo-1 or the Orbital Flight Test (OFT), or some other future program, the risk picture must be holistic across the entire development timeline and requires reasoned judgment about program risk trade-offs that maximize safety and mission assurance.

In concluding her remarks, Dr. Sanders addressed the recent mishap in the SpaceX test program. The event occurred during a static fire test conducted prior to the In-Flight Abort Test. The firing was intended to demonstrate integrated system performance of the SpaceX Super Draco engines and 2x vehicle-level vibroacoustic life for abort environments.

Firing of twelve service-section Dracos were successfully performed. Firing of eight Super Dracos resulted in an anomaly. The test site was fully cleared and all safety protocols were followed. The mishap did not result in any injuries. Both NASA and SpaceX immediately executed Mishap Plans per the Agency and the company guidelines.

SpaceX is leading the accident investigation with active NASA participation. Early efforts are focused on site-saving, data collection and reduction, and development of the anomaly timeline. The investigation will take time before the root cause analysis can be completed to determine the impact of this mishap on Demo-2 and the In-Flight Abort Test.

Commercial Crew Program (CCP)

Dr. Sanders introduced Dr. Sandra Magnus, who discussed the status of the CCP. Dr. Magnus expressed the panel's appreciation for their constructive dialogue with the CCP program. The pace of program operations has continued to increase, especially in recent months. Although there has been considerable progress, there are still technical issues to be resolved by both providers as they pursue qualification.

As a crucial element especially of crewed flight, parachutes remain a critical challenge for both providers, because parachute design is difficult to understand technically, and parachute effectiveness is difficult both to measure, and to model. Complicating the issue is the fact that both NASA and its contractors must resolve how to appropriately qualify the system in the contractual environment of the CCP. Both the providers and NASA must resolve several additional ongoing issues as well**.** The panel received an update on problems involving the composite overwrapped pressure vessels (COPV) in the SpaceX vehicle. It appears that the program is converging on a resolution of the problem. For this and other open technical items, the panel will continue to demand that all parties demonstrate an understanding of the margins driving the risk, how to control those margins, and how to restrict operations to the appropriate envelope.

Dr. Magnus reiterated the differing development approaches taken by each provider. SpaceX has adopted a spiral development path, targeting an iterative design, manufacturing and test process that incorporates the interim data and learning points into the next generation of design. Boeing has taken a more traditional route, investing more effort prior to integrated testing to establish a more mature design from the outset. Consequently, the cadence of and approach to the different test milestones are vastly different between the two companies. As always, the Panel encourages both teams to be on guard against the dangers of schedule pressure.

SpaceX executed a successful flight of Demo 1 in March 2019, yielding a combination of developmental verification and validation data. During the Demo 1 flight, the SpaceX team successfully demonstrated its ability to integrate and execute with the International Space Station team, as well as conduct operations involving the end-to-end process of launch, docking, deorbit, splashdown and recovery as this process relates to crewed mission parameters. However, prior to the Demo 1 launch, as pertaining to the SpaceX spiral development process, NASA and SpaceX identified the configuration changes and subsequent qualification work needed for completion before launch of Demo 2. Notwithstanding the recent incident, there remains a large body of work to be completed between Demo 1 and the crewed Demo 2 flight. It is still too early to speculate what additional alterations may be needed in response to recent events.

Boeing is scheduled to fly its uncrewed mission (EM-1) in early August 2019, with a crewed mission (EM-2), comprising a nearly identical configuration, planned before the end of the year. While Boeing has made progress in addressing many of its technical issues, both NASA and the Boeing team still face the processes of submission and analysis of the required data for the final processes of certification and verification; because of Boeing's development approach, many aspects of these analyses cover both the uncrewed and crewed vehicle configurations simultaneously.

Up to now, the CCP has been able to manage the effects of the workload on the workforce as they process the design and safety data submitted by Boeing and SpaceX. Nevertheless, these issues require constant attention, especially because the same NASA personnel are involved in assessment of both programs.

Both providers still have significant work to be accomplished before crewed operations can be implemented. The CCP has specified to both contractors the specific data that must be submitted to validate the safety of the design. Crewed flight cannot proceed until delivery of these data. In the meantime, NASA has appropriately established a contingency plan, to ensure continued U.S. crew access to the International Space Station (ISS) through late 2020, providing some temporal margin as the SpaceX and Boeing initiatives advance towards crewed flights.

The Panel is aware of substantial interest in the cause and ramifications of the recent SpaceX mishap, and urges patience as the teams carry out their investigations. The Panel emphasizes its support for the CCP's continuing position that crewed missions will not be cleared for launch until the program has received the data it requires to ensure that the margins are understood and can be controlled and that the flights will operate in the environment that the margins require.

International Space Station (ISS)

Dr. Sanders introduced Lt. Gen. Susan Helms who discussed the Panel's recommendations for the ISS. The ISS continues to maintain a continuous human presence in Low Earth Orbit (LEO). It remains humanity's best asset for understanding the complexities of living in space, including the ability to develop and test technology in microgravity, to perform research, and to study human responses to spaceflight. ASAP continues to advocate for the utilization of ISS as a risk-reduction testbed for longer-distance, long-term space exploration.

During its visit to MSFC, the panel received status updates on crew transport schedules, current consumable margins for nominal and contingency planning, and science utilization. The program continues to heavily leverage the cargo resupply vehicles for research opportunities, and the crew is currently conducting science at a slightly higher rate than originally planned. For example, a new, second glovebox for life science is now installed and available for experiments, and the Northrup Grumman cargo resupply program has recently added the capability to add rodents to a cargo mission, thus providing an important additional dimension to the science potential of the ISS. ISS program managers also summarized a recent analysis of component failure rates, an effort that provides important insight into maintenance and logistics trends, and facilitates maintenance planning for future exploration efforts.

Expanding on Dr Magnus' earlier comments, Lt. Gen. Helms noted that the ISS leadership shared the view of the SpaceX Demo-1 flight test as a success, especially for its successful demonstration of several integrated operations between the ISS program and a commercial crew provider. The opportunity to coordinate and demonstrate some aspects of crewed launch and mission operations jointly with the Commercial Crew program and the ISS programs was immensely valuable**.** ISS will be 'flight following' the Dragon mishap investigation to monitor the implications of this event for Cargo Resupply missions.

The Panel also reviewed the spacewalks (extravehicular activities, or EVAs) that had taken place since the last quarterly meeting in early March 2019, including details about a battery charger swap necessary to sustain the ISS power systems at full capacity. The next notable EVA task set, planned for summer 2019, is installation of the newest docking assembly onto the zenith port of Node 2.

The Panel also continued its discussion on a problem of growing urgency, namely the undeniable fact that the 40-year-old extravehicular mobility units (EMUs) used in ISS operations are reaching the end of their useful life. In its 1st quarterly meeting in March, the Panel noted the challenges of maintaining an ambitious yet necessary EVA schedule for sustainment of ISS, while simultaneously managing a program for extending the suit-life of the aging EMUs. Over the years, the Panel has commented on the highly innovative and often heroic approach that NASA has taken to devise EMU component upgrades and suit life extensions; it has also noted the small but productive steps accomplished by development program for the next-generation xEMU prototype. As noted in the first quarterly report, however, it is increasingly apparent that the usable life of the EVA suits is limited; in this session, the Panel reviewed the increasing challenges of difficult upgrade efforts, loss of component vendors over time, lack of critical refurbishment parts, and life extension analyses that will grow in uncertainty as the suit hardware continues to age. The current plan is to extend EMU use to 2028. However, ASAP has become increasingly concerned with the risk posture that NASA has adapted with the current suits, and it has concluded that the current suit is now outside its design life. The Panel therefore recommends that NASA begin an immediate transition to a next-generation EVA suit system before the risk becomes unmanageable.

Dr. Magnus observed that the EMU issues highlight the importance of independent panels in providing fresh perspectives to NASA management; she encouraged NASA to step back from day-to-day management issues to view this urgent issue from a broader, more holistic outlook. Lt. Gen. Helms added that making things work in suboptimal situations is hard-wired into NASA culture; but it is clear to the Panel that it is time to retire the current EVA suit and move one to a new EMU. Offering an engineering perspective, Dr. McErlean emphasized that the problem does not lie simply in the fact that the suits are old**;** the fact that manufacturers of several critical suit components, including the very fabric of the suits, have now gone out of business, creates real urgency for transitioning to new EVA suit systems. Dr. Sanders emphasized that new suits are needed not only for future space exploration: NASA cannot even maintain the necessary, ongoing low-earth orbit (LEO) operations without fully functional EVA suits.

Finally, the Panel was pleased to learn of impressive recent progress on the ISS Deorbit plan. ASAP has long recommended that the ISS program and its international partners develop a contingent deorbit strategy to be implemented should a short notice deorbit be required. To that end, the NASA and Russian teams have successfully managed a tremendous amount of operational, technical and analytical tasks, and the Panel looks forward to completion of a feasible plan in the near future. The team is to be commended for its comprehensive and productive efforts to address this issue.

Status update on NASA aviation

To summarize the Panel's review of NASA aviation activities, Dr. Sanders introduced Dr. Don McErlean, who reminded his colleagues that NASA's mission includes aeronautics as well as space exploration. He applauded NASA's continued innovative efforts in aeronautics, including its efforts to improve, innovate, and support a vibrant aviation industry upon which the country depends for transportation.

As ASAP has previously noted, the NASA Aircraft Management Information Service (NAMIS) is essential to proper flight operation. This critically important computer system tracks aircraft usage and assesses and certifies aircraft, crew, and flight readiness. ASAP is pleased to report that NAMIS has in the past two years achieved budget stability, which is essential for sustaining expertise and contractor support. The panel will continue to monitor the support for and operation of NAMIS, whose smooth functioning is critical for aviation.

In an update on the present and future NASA planes, Dr. McErlean noted that this fleet is eclectic in age, size, type, and function. Many NASA aircraft, such as the DC-8, are no longer in widespread commercial service, but are maintained by NASA as a vital component of its scientific research operations. Others, such as the Super Guppy cargo plane, are unique. Maintaining these diverse, specialized, and often older aircraft poses challenges similar to maintenance of EMUs; but careful maintenance of this fleet is essential for core NASA operations as well as for safety.

Reflecting the increased use of drones, NASA now includes Category 4 and 5 unmanned aerial systems (UAS) within NAMIS supervision, and it is working to expand its NAMIS coverage to smaller drones as well. ASAP applauds NASA's efforts to bring UAS under NAMIS supervision and to communicate to drone operators the importance of aviation safety.

As in other federal agencies, the use of commercial air services by NASA continues to expand. Contracting out aviation support to an outside operator can be an excellent and efficient way of obtaining services, especially in carrying out short-term experiments that do not warrant purchase of aircraft. When commercial services do operate for NASA missions, their planes become public use aircraft, and it is NASA's responsibility to assure that these aircraft are operated safely. All CAS flights, including those contracted by other federal agencies, are required to comply with NASA NPR 7900.3D and with the requirements of part 121 or 135 FAA certification; these flights also must be vetted by the NAMIS flight operational readiness review process. ASAP views continued compliance with these regulations as an essential component of flight safety and of the regulatory structure for CAS.

Dr. McErlean also reported renewed interest in the development of experimental aircraft. ASAP applauds these NASA efforts. One example of the several aircraft in development is the X-59, currently in construction, and designed in partnership with Lockheed Martin as a "low-boom" commercial, supersonic plane. By design, some X-59 test flights will need to operate over populated areas, in order to test the community impact of the noise level of this supersonic plane; the necessary route of these test flights raise a set of safety concerns unusual for test planes, which usually operate in remote area. Thus far, the preparation and planning process for the X-59 has been excellent; nevertheless, ASAP will continue to monitor the flight safety process for this and other experimental aircraft.

Status update on NASA safety management

Dr. Sanders introduced Mr. David West, an expert on system safety, to summarize the Panel's discussions of NASA safety management systems.

In early 2018, the Panel closed a 2017 recommendation about implementing safety audits and replaced it with a new recommendation, 2018-02-01, that NASA's Office of Safety and Mission Assurance (S&MA) should use a coordinated, in-depth system of safety assurance tools and processes to verify effective programmatic safety compliance, system safety practices, safety process function, safety culture, and overall safety posture at all levels of the organization. S&MA responded to the 2018 recommendation by committing to completing an assessment of NASA's capabilities in the area of Safety and Mission Success (SMS).

During their visit to MSFC, the Panel discussed the progress of the S&MA assessment. To assess NASA's SMS capabilities, S&MA administered an agency-wide survey, characterized the various ways that safety requirements are communicated through the agency, and conducted a deep analysis of selected SMS functional areas at four selected NASA centers. The Panel is impressed with the systematic approach of these efforts, with the amount of work that was accomplished, and with the useful information captured by the surveys, including both weaknesses and strengths, about current SMS capabilities. The Panel encourages S&MA to devise strategies for implementing the best practices noted in the surveys and disseminating them across the agency for wider adoption.

As it begins to address the weaknesses identified in the general survey, S&MA has initiated a second project: development of an SMS Assurance Assessment Process to establish success criteria for use in ongoing evaluations. ASAP learned that NASA centers have diverse safety plans with a wide variety of SMS requirements. The Panel will be interested to learn how S&MA will create a strategy to clearly and comprehensively communicate the SMS requirements to the workforce, and to implement those requirements consistently across the workforce.

The Panel believes that NASA's safety culture is solidly at the "calculative" stage, in which systems and processes are in place to carry out the safety work that is required. However, there is still much work to do to implement a fully "generative" safety culture, where the safety policies are embraced and implemented at all levels of the organization, as is the practice of commercial businesses. Reaching a fully generative safety culture requires all NASA leaders to take full ownership and accountability for

SMS systems and processes, and to enforce their use. As S&MA develops their assurance assessment processes, addressing the weaknesses identified in their analyses, the Panel looks forward to ongoing discussions and to continued monitoring of NASA progress in this area. The Panel will continue to leave recommendation 2018-02-01 open while SM&A continues to improve and to implement its safety management tools.

Dr. Magnus commented that the survey provided very useful information, but that the next step – implementation and enforcement of safety requirements across the centers –is not just a problem for SM&A, but one that requires the engagement across all of NASA, at all levels of organization. ASAP hopes to see this implementation as a NASA-wide mandate.

Closing remarks

At the end of the meeting, Ms. Hamilton solicited comments from the public; no comments were offered. Dr. Sanders thanked the panel members for their participation in the long, intense meetings. In closing, she reminded attendees of the Panel's aim: to advise on methods to drive down risk to the lowest reasonable level consistent with accomplishing the mission.

Space exploration is inherently hazardous, the space environment is hostile, and the systems needed to survive in that environment are complex. NASA's task is not avoid that risk at all cost, but to manage that risk intelligently.

The meeting adjourned at 10:15 a.m.

ASAP RECOMMENDATIONS, SECOND QUARTER 2019

2019-02-01 Required Transition to Next Generation Extravehicular Mobility Units (EMU)
[ASAP Point of Contact: Susan Helms]

Findings:
The ASAP has become increasingly concerned with the risk posture that NASA has adapted with the current Extravehicular Mobility Units (EMUs) used in ISS operations, and has concluded that the current EMUs are now outside their design life.

Recommendation:
NASA should begin an immediate transition to a next-generation Extra Vehicular Activity (EVA) suit system [Extravehicular Mobility Units (EMUs)], before the risk to EVA becomes unmanageable.

Rationale:
It is an undeniable fact that the 40-year-old EMUs used in ISS operations are reaching the end of their useful life. The Panel reviewed the increasing challenges of difficult upgrade efforts, loss of component vendors over time, lack of critical refurbishment parts, and life extension analyses that will grow in uncertainty as the suit hardware continues to age. Over the years, the Panel has commented on the highly innovative and often heroic approach that NASA has taken to devise EMU component upgrades and suit life extensions; it has also noted the small but productive steps accomplished by development program for the next-generation xEMU prototype. The current plan is to extend EMU use to 2028; however, it is increasingly apparent that the usable life of the current EVA suits is limited. The Panel encourages NASA to step back from day-to-day management issues to view this urgent issue from a broader, more holistic outlook. The problem does not lie simply in the fact that the suits are old**;** the fact that manufacturers of several critical suit components, including the very fabric of the suits, have now gone out of business, creates real urgency for transitioning to new EVA suit systems. New suits are needed not only for future space exploration, but also for its current space activities. NASA cannot maintain the necessary, ongoing low-earth orbit (LEO) operations without fully functional EVA suits.

Attachment 1

Telecon Attendees:

Al Conde	NASA
Anthony Colangelo	Main Engine Co
Antonia Gonderez	Florida Today
Art Egan	nasaspaceflight.com
Ashley Wikins	House of Representatives
Ben Sellari	N/A
Bill Beckman	Boeing
Bill Harwood	CBS NEWS
Brendan Byrne	WMFE (Central Florida Public Radio)
Cam Whitney	Science Committee
Chabeli Herrera	*Orlando Sentinel*
Chris Davenport	Washington Post
Christopher Lim	Space Exploration Technologies
Comsir Caracosicar	ParaboicArc.com
Dan Beck	Boeing
Dave Huntsman	NASA
Dee	Boeing
Diane Rausch	NASA
Dillon Macinnis	SpaceX
Dillon Macken	SpaceX
Dimitra Tsalis	NASA Office of Inspector General
Doug Isbell	NASA JPL
Emily Wasster	Lockheed Martin
Emre Kelly	*Florida Today*
Eric Berger	*Ars Technica*
Erin Kennedy	GAO
Evette Whatley	NASA Headquarters
Gene Mikulka	*Talking Space*
Homayoon Dezfuli	NASA
Ivan Couronne	ASP
James Dean	*Florida Today*
James Gleeson	SpaceX
Jarred Smith	Private Citizen
Jean Kranz	Representative Brian Babin
Jeff Foust	*Space News*
Jessica Lande	Boeing
Joey Roulette	Reuters News
Josh Finch	NASA
Kyle Henry	*Let's Talk Space News*
Linda Karanian	Karanian Areospace Consulting
Loren Grush	*The Verge*
Marcia Dunn	Associated Press
Marcia Smith	spacepolicyonline.com
Marina Koren	*The Atlantic*

Mark Carreau	*Aviation Week and Space Technology Magazine* Publication
Maryanne Chevalier	NASA
Marybeth Davis	Boeing
Michael Lapidus	SpaceX
Patricia Filibee	Boeing
Philip Sloss	nasaspaceflight.com
Randy Cruz	NASA HQ
Richard Williams	NASA ASAP Member
Samantha Masunaga	*Los Angeles Times*
Stephen	*Space Flight Now*
Steven	US Citizen
Steven Young	*Space Flight Now*
Theodore Cronmiller	Law Office
Tom Culligan	Boeing
Tommy Sanford	Commercial Space Flight Federation

+ 6 additional registrants with incomplete information