NASA AEROSPACE SAFETY ADVISORY PANEL
National Aeronautics and Space Administration
Washington, DC 20546
VADM Joseph W. Dyer USN (Ret.), Chair

February 5, 2014

Mr. Charles F. Bolden, Jr.
Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Mr. Bolden:

The Aerospace Safety Advisory Panel (ASAP) held its 2014 First Quarterly Meeting at Johnson Space Center, Houston, Texas, on January 21-23, 2014. We greatly appreciate the participation and support that was received from the subject matter experts and support staff.

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

Sincerely,

VADM Joseph W. Dyer, USN (Ret.)
Chair

Enclosure

AEROSPACE SAFETY ADVISORY PANEL
Public Meeting
January 23, 2014
Johnson Space Center (JSC)
Houston, TX

2014 First Quarterly Meeting Report

Aerospace Safety Advisory Panel (ASAP) Attendees
VADM (Ret.) Joseph Dyer (Chair)
Dr. Patricia Sanders
The Hon. Claude Bolton
CAPT Robert Conway
Mr. John Frost
Mr. Bryan O'Connor (via telecon)
Dr. George Nield
Dr. Donald McErlean

ASAP Staff and Support Personnel Attendees
Ms. Harmony Myers, ASAP Executive Director
Ms. Marian Norris, ASAP Administrative Officer
Ms. Paula Burnett Frankel, Technical Writer/Editor

NASA Attendees:

Gina Davenport	NASA OIG
Steve Elsner	NASA/JSC CCP
Scott Johnson	NASA/JSC SMA
John Kennedy	NASA/JSC SMA
Bill McArthur	NASA/JSC SMA

Other Attendees:

Kim Gidlow	FAA Houston/JSC
Don Nelson	*[self – NASA retired]*

Attendees via Telecon:

Katia Ahmed	Unified School District
Michael Beavin	DOC
Mark Carreau	Aviation Week
Stephen Clark	Spaceflight Now
Irene Klotz	Reuters
Tom Dipaolo	NATCA
Jeff Foust	Space Review
Allison Hays	House Science Committee
Mike Hembree	UTC Aerospace
Nicole Kessler	University of Minnesota
Andrew Myers	*[self]*
Wasem Naqui	Raytheon
Diane Rausch	NASA
Kevin Sageden	NASA
Darren Samplatsky	United Technologies Aerospace Systems
Marcia Smith	spacepolicyonline.com
Jared Stout	US Health Representative
Terry Wilcutt	NASA
Daniel Woodard	Florida Institute of Technology

OPENING REMARKS

VADM Joseph Dyer, Chair of the ASAP, called the ASAP's First Quarterly Public Meeting of 2014 to order at 1:00 pm. He noted that the Panel members were very warmly welcomed and hosted by Dr. Ellen Ochoa, JSC Center Director. She and her staff were most hospitable.

The ASAP has just published its Annual Report for 2013 and has briefed the Administrator, Mr. Charles Bolden, and visited with staff from both the House of Representatives and Senate. One of the topics addressed in the Annual Report was the budget and the difference between the President's Budget Request and the appropriation. During the Hill discussions, there was proper dialogue regarding the question: Is NASA trying to do too much with too little? VADM Dyer noted that this will be an important topic going forward.

The Commercial Crew Program (CCP) is always a keen topic of interest. VADM Dyer highlighted the importance of competition. The CCP is a fixed-price contract and, by the budget request standards, underfunded; however, it is proceeding despite a number of constraints, including the "force-fitting" of money available into the contract. One of the last and critically important aspects of CCP is maintaining and sustaining competition among potential providers as deeply as possible into the program.

Another topic in the Annual Report was risk management. The ASAP noted that it may well be time to accept more risk, and the Panel is not opposed to that provided there is balanced reward and transparency and openness with regard to the additional risk that is being embraced. The Annual Report is available on the NASA ASAP website: http://oiir.hq.nasa.gov/asap/index.html .

The ASAP made a number of recommendations in the report and is looking forward to NASA's response. Given the interrelationship among the recommendations, the Panel suggested that NASA address those recommendations as an integrated package rather than one at a time.

There were a number of topics discussed at this meeting, including knowledge capture, the upcoming decision regarding contracting for more Soyuz flights to the International Space Station (ISS) vis-à-vis placing all reliance on the CCP, and the Exploration Systems Development (ESD) Program and the transition to implementation phase. Two other topics related to ESD were the first crewed mission and the scope of that first crewed mission along with its associated risk and safety aspects. Radiation risk on a mission to Mars is coming into better focus and is a topic of great interest.

PUBLIC COMMENTS

VADM Dyer noted that the Federal Register Notice of this public meeting invited members of the public to speak for five minutes and/or submit written statements. There were two speakers: Mr. Don Nelson, retired NASA aerospace engineer, and Dr. Daniel Woodard, who indicated that he is associated with the Florida Institute of Technology. Both speakers submitted written statements. Mr. Nelson addressed the Panel with concerns he had about the Space Launch System (SLS) and the Multi-Purpose Crew Vehicle (MPCV) design approaches. Via telecon, Dr. Woodard briefly discussed two reports that were published some years ago but that he felt were relevant to the ASAP's work today--"Space Launch Vehicle Reliability" by Dr. I-Shih Chan of the Aerospace Corporation and recommendations on the future of human space flight contained in the Columbia Accident Investigation Board report. VADM Dyer thanked Mr. Nelson and Dr. Woodard for their comments and expressed appreciation for their input.

HUMAN HEALTH AND PERFORMANCE RISKS, HEALTH AND MEDICAL TECHNICAL AUTHORITY, AND HUMAN RESEARCH PROGRAM

Mr. John Frost, former Chief Safety Officer for the Army Aviation and Missile Command and currently safety consultant for organizations around the world, addressed the topic of human health and performance and some specific aspects of Health and Medical Technical Authority. The Human Research Program (HRP) is focusing on what health issues need to be resolved before we can go forward with deep space exploration. During the fact-finding meeting, Dr. William Paloski, Manager of the HRP at JSC, discussed the Program, which is the formal, organized program that is identifying the shortfalls and gaps in our knowledge about the human health effects of long-term human space flight. Specific hazards have been identified and there is a plan in place to address these. This plan relies implicitly on the availability of the ISS. The recent decision by the President to extend its life is critical to collecting the necessary data.

Dr. David Francisco, JSC Program Integration Manager, discussed some specific hazards that are being worked. The hazards fall into four categories: microgravity effects, radiation effects, isolation effects, and effects associated with the closed-environment nature of the craft. Overall, they are looking at about 30 hazards. One problem in planning for the future is not knowing specifically what the future missions will be. To address this, the team has chosen to establish six Design Reference Missions (DRMs) and determine what the health problems and risks are for each: low-Earth orbit (LEO) for six months or a year (considered medium risk for the health issues), deep-space sortie of a month (also medium risk), lunar visits of about a year (medium risk), deep space journeys of a year, and planetary missions of three years. The latter two are considered high risk for health issues.

The Panel heard about two specific hazards that are subsets of the 30: vision modification, known as "spaceflight-induced vision alternations," which includes reshaping of the eyeball and increased cranial fluid pressure (experienced on a majority of the long duration missions on ISS); and radiation. NASA has a good program for addressing the vision hazard and is developing in-flight protocols. The second specific hazard—long-term radiation—is a more problematic issue. This can have a profound impact on mission choices beyond LEO. NASA Standard 3001 sets the acceptable radiation limits today. That standard allows an increase of three percent in the chance of fatal cancer above the baseline risk faced by the general public. Current assessments indicate that an astronaut can spend about 250 to 500 days in orbit without exceeding this risk, depending on solar activity at the time. Long term flights exceed this timeframe. The NASA team looked at all six DRMs and determined that there is a high risk on the latter two. Their estimate is that it is unlikely that NASA will be able to shield much more than what is being done now. They currently estimate that with what we know today, these long-term missions could increase the chance of fatal cancer anywhere from 5 to 21 percent above baseline. This number needs to be considered before a decision is made to go forward with these types of missions.

Mr. Frost proposed a formal recommendation: (1) NASA should continue its research to seek mitigations for the radiation risk, and (2) NASA should establish an appropriate decision milestone point by which it will judge the acceptability of this risk. This risk choice should be made before NASA decides on a future long-term mission. The conundrum we want to avoid is spending billions on a planetary mission and then concluding that a risk as high as a one in five risk of death from the single radiation hazard is unacceptable.

HUMANS TO ASTEROID

Dr. Donald McErlean, former Chief Engineer at the Naval Air Systems Command and currently Engineering Fellow at L-3 Communications, reported on what the ASAP learned about the mission operations aspects of a prospective asteroid mission. As capabilities for longer-duration space flight are developed, the issue over the last several years has been whether or not NASA can construct a mission that meets several criteria and allows it to exercise those capabilities between a LEO scenario (generally three hours to one day away from Earth return) and a Mars scenario (as much as six months away from Earth return). The questions are: Is there an intermediary mission that would allow operation of equipment, work on communications capabilities, and work such things as what one would carry in a medical kit for 15 days away versus 3 hours away? How would those things change? Many of these things are very difficult to do analytically. After considerable evaluation, the Agency has proposed what it calls an Asteroid Recovery Mission (ARM). This would be an asteroid that would be robotically towed into cis-lunar space and visited by a crewed spacecraft (most likely an Orion or a modified Orion). The astronauts would proceed to explore the asteroid or "mine" it to obtain further data. This mission would represent a "middle ground"—somewhere between 17 and 33 days away from Earth. It would be much further away than a LEO mission but not as far away as a planetary mission.

NASA felt that this mission must satisfy four compelling objectives: (1) meet the Administration's policy, (2) fit within the Global Exploration Roadmap and be aligned with the interest of NASA's international partners (missions in the lunar vicinity), (3) take advantage of existing capabilities being developed within the Agency, and (4) be affordable and sustainable within the anticipated budget levels. NASA has determined that the ARM meets these criteria and that the Agency will continue to pursue the cis-lunar asteroid exploration mission. This mission does several things: it allows NASA to utilize its systems and components beyond LEO, it will provide a technology demonstration for a very important piece of technology—solar electric propulsion (SEP), and it will enhance detection and observation of near-Earth objects. This would be the first step toward demonstration of proof-of-

concept for planetary defense. NASA intends to build a demonstrator for SEP, and capturing the asteroid and moving it into a pre-determined orbit would be an interesting and feasible demonstration for this technology.

There are three phases to the program: (1) identify a suitable asteroid (occurring now with support from ground observation sites and a large number of "amateur" astronomers); (2) around the 2018-2019 timeframe, launch a robotic mission using SEP and capture an asteroid or "carve off" a piece of one and tow it into cis-lunar space; and (3) approach the captured asteroid with a crewed mission on Orion to perform the exploration. A number of issues must be addressed if Orion is to be used and space walks conducted from it, including what tools will be required and what communications between the capsule and the outside astronauts are needed. In fact, just equipping Orion for spacewalks (since it has no airlock) will require the design of a completely new space suit as well as a process for entry and exit from the capsule. Since the current ISS (airlock) type suit would be much too cumbersome to both store and don/doff inside Orion, the life support group is working on some imaginative suit technology, e.g., a typical flight suit with an outer protective cover that could be donned inside the capsule over the normal flight suit. The protective cover would provide Micro-Meteoroid and Orbital Debris (MMOD) protection, enabling the opportunity for use of the flight suit during a spacewalk. Most of this is in the preliminary concept stage. During discussion of the ARM, Dr. McErlean noted that a number of centers are now involved, and it is very gratifying to see the various centers coalescing around the mission and beginning to formulate what they would do to support it by utilizing their core capabilities and technologies.

MICRO METEOROID AND ORBITAL DEBRIS

CAPT Robert Conway, formerly the Director of the Naval Aviation Safety School in Pensacola, Florida, and currently the Manager of Quality Assurance and Safety at Disney, reported on the next two topics. These two smaller briefing involved things that hit spacecraft and aircraft and cause severe damage—MMOD and bird strikes on NASA aircraft.

The briefing by Dr. Mark Matney was on NASA and DoD cooperation on orbital debris characterization—what NASA is doing with DoD to identify and shield from orbital debris in LEO. The approach is very good and the presentation was very informative. International leadership is being provided by NASA, and DoD policy directs NASA and DOD to work together. DOD has the lead for tracking large objects (greater than 10 cm); NASA leads the small debris population and assesses collision risk. The activity started to evolve in 1995, when an interagency report directed that NASA and DoD define guidelines for future spacecraft. In 2001, the government orbital debris mitigation standards were adopted. Those are basically the "rules of the road" on how to fly in space and how to track orbital debris.

As far as tracking goes, things greater than 10 cm are tracked; things less than 5 mm are shielded against. For the gap between these two sizes, Dr. Matney described the processes that are being used: in situ sensors called "dragons," a meter-class autonomous telescope, and space surveillance telescopes. Not only are they looking for orbital debris in orbit, they are looking for it as efforts branch out towards the deep space missions (asteroid and Mars). Impact testing is being performed. This reveals how current technology and engineering processes and designs break up in space. The interest is in how the new designs break up and how equipment and spacecraft can be designed for minimal dispersal.

Unfortunately, there is no "silver bullet" for active debris removal, but this issue is still being pursued. The Panel was pleased with the insight and rigor of the MMOD programs in understanding the problem and the tracking that is being done.

FLIGHT OPERATIONS - BIRD STRIKES AT ELLINGTON FIELD

In aviation, bird strikes are a big problem. Over the last eight years, JSC has averaged six strikes per year and $122,000 average per year in damage. It was interesting to note that NASA's first astronaut fatality occurred at Ellington Field due to a bird strike. Over the last eight years, the increase in damage costs was due to birds getting bigger. The question is: Why? After an incident in 2011, the investigations became more intense. It was discovered that bird size was related to the Houston Airport Authority (HAA) growing hay on the property to help offset the

airport operations cost. An FAA circular advised against this type of activity, but it was not regulatory in nature and was essentially ignored. NASA mitigation efforts included negotiating with the airport officials and working with the Air National Guard, which also had a similar problem. Finally, JSC Air Operations involved the leadership at the Center and a letter was sent to FAA. At that point, things started to happen. HAA is now working on a Wildlife Hazard Management Program and they have cut the grass. While the number of strikes has remained consistent, the dollar value of the damage has diminished.

CAPT Conway encouraged them to continue with the Wildlife Hazard Management Program and mitigation plans. He indicated that he would follow up with the Inter-Center Aircraft Operations Panel (IAOP) and benchmark how the other centers are dealing with this problem. He encouraged Air Operations at JSC to do the same.

JSC SAFETY AND MISSION ASSURANCE (SMA)

The Hon. Claude Bolton, retired Major General in the USAF and former senior acquisition officer for the Army, discussed the JSC SMA topic. Mr. Bill McArthur, Director of the JSC SMA, provided the Panel with an update and status report. His briefing covered: JSC workforce safety, the competing priorities for the SMA workforce in FY14, the counterfeit part control process, and Technical Authority (TA) implementation. Mr. McArthur reported that the JSC total case incident rate from FY07 to September 30, 2013, had fallen in many areas. For example, the JSC civil servant rate is 75 percent below the federal government rate. The JSC team rate is 74 percent below the private industry rate. Mr. McArthur further reported that the JSC safety and health program is strong despite challenges. Injury severity is down 75 percent, the damage mishap rate is down 30 percent, and inadvertent fire alarms continue to decline due mainly to increased system reliability and process improvements. The majority of JSC civil servant mishaps are office-related, including touch-labor exposure of cuts, punctures, and strains. Challenges for JSC SMA include the possible overlapping of CCP and ISS milestones in FY14. Should this occur, the SMA resources could be significantly strained. Overlapping milestones could exceed directorate resources, and the reduced scope could impact cost, schedule, and safety. Mr. McArthur and his staff are working mitigation strategies for the milestone overlap possibility. Some of the mitigation efforts include prioritization of all ISS, MPCV, and CCP SMA efforts and coordination with KSC, MSFC, and JSC SMA offices and SMA TA to ensure consolidated SMA planning for CCP risk assessments.

Mr. McArthur also reported on the JSC SMA TA status. SMA TA at JSC is implemented by the Chief Safety Officer (CSO) for each program/project located at JSC. CSOs are assigned for ISS, CCP, Orion, ESD, and the Advanced Engineering Systems programs. The ASAP posed the question it has asked a number of times over the past several years: Must an employee need a "level of courage" to express a dissenting opinion? Very candidly, Mr. McArthur responded affirmatively, and asked: How do we create an environment to facilitate this behavior? He indicated that the following things are being done: CSOs are selected specifically for their moral courage as well as technical skills, CSOs brief the Center Director independently of the programs they support, management in all organizations encourages all employees to voice alternate/dissenting opinions, and dissenting opinions are routinely solicited in major milestone and flight readiness reviews.

The final area covered by Mr. McArthur was JSC's counterfeit control philosophy. Ms. Cheryl Corbin, a member of Mr. McArthur's staff, provided a good briefing on this topic. Ms. Corbin stated that the counterfeit control philosophy at JSC consists of three main elements: prevention, detection, and knowledge. She provided examples in each area. JSC's product authentication and counterfeit investigation process consists of four primary stages: procurement, screening, investigation, and notification. To improve this process, Ms. Corbin formed a LEAN/Six Sigma team, and performed a Kaizan on the process, which helped improve it. With regards to challenges, Ms. Corbin told the ASAP that there is a real need at NASA to develop universal language and procedures for NASA advisories, audit data/procurement data as well as supplier evaluations, and a wider dissemination of information inside and outside NASA. Such development and process improvements will improve the usefulness of the database.

Questions from the ASAP highlighted a concern that the ASAP had commented upon in its 2012 JSC quarterly meeting. This was the concern regarding how funding is allocated to the JSC SMA office. At that meeting, the Panel specifically noted that the Office of Safety and Mission Assurance (OSMA) and the Office of the Chief Engineer

(OCE), as well as the Office of the Chief Health and Medical Officer (OCHMO), are in a line-item called "cross-agency support and construction." That budget line-item is managed at NASA Headquarters by a Cost Account Manager (CAM) who is in the Mission Support Directorate. The ASAP observed that this CAM does not have program responsibility for safety, nor do those two offices (OSMA and OCE) report to the Mission Support Directorate. The ASAP questioned how well that CAM understands the implications of the budget cuts that have to be made. At that meeting, the ASAP put forward a recommendation that NASA review and determine the appropriateness of having OSMA and OCE in a non-safety-aligned budget line item and office.

The ASAP noted that the current JSC SMA budget is lower than the FY14 budget request. It appears that the allocation of the current SMA budget was done at NASA Headquarters through a process that the ASAP questioned previously. The ASAP re-asserts its previous recommendation—that NASA review and determine the appropriateness of having OSMA and OCE in a non-safety-aligned budget line item and office. It is important to ensure that SMA is appropriately resourced to accomplish the mission it has been tasked to perform.

Mr. Bolton noted that the ASAP is impressed with the professionalism and dedication of the JSC SMA staff and its processes. However, the Panel remains concerned regarding the increasing challenges that tight and shrinking budgets will present the JSC SMA. The ASAP suggests that the SMA budget and organizational alignment be reviewed and appropriate actions taken to ensure that SMA budget decisions are appropriately informed by accountable leadership.

JSC ENGINEERING DIRECTORATE – PROGRAM OVERSIGHT/INSIGHT ROLES

Dr. Patricia Sanders, former Executive Director of the Missile Defense Agency, reported on the ASAP's discussions with Ms. Laurie Hansen, JSC's Chief Engineer. She described the role of the Engineering Technical Authority (ETA) at JSC, how it is adapting to support the varying programmatic models, and the challenges it faces. In general, the ASAP was impressed with the professionalism and approach of the engineering team as she represented them. Overall, appropriate processes and policies are being employed and emphasized and were made more effective--but were not dependent upon--the relationships Ms. Hansen has established with program management and the technical respect and credibility she and her team have earned.

The Engineering Directorate seems to be reasonably resourced, although it has required supplements for surge periods. Though the engineering staff is experienced and dedicated, there is some challenge to sustain the requisite skill balance across the engineering disciplines. This will be a "watch" item for the Panel.

The ASAP noted the adaptability being exercised by the ETAs with regard to ISS, Orion, and Commercial Crew, as different program situations exist in each case. ISS is a mature program and the ETA engagement with that program is fairly traditional and benefits from well-established processes and long-standing relationships. With the Orion program, the engineering staff has more of an in-line role, so the ETA role takes a hybrid approach that balances insight and independence. There is also a challenge presented by the absence of an overall System Engineering and Integration (SE&I) for ESD. The CCP brings an entirely new and different program model, and the Panel appreciates that the ETA is evolving its approach to meet its responsibilities in that environment. The Panel sees this as a work in progress and will be interested in following how it takes form over time. Professional efforts are being applied by Ms. Hansen and the Engineering Directorate in seeking the best way to deal with what is intended to be a more streamlined and affordable business model without sacrificing safety and sound engineering practice.

Ms. Hansen gave the Panel a measure of confidence in the Engineering Directorate's and TA's ability to effectively address engineering problems. Their more significant challenge at times may be in recognizing when a problem exists.

The ASAP strongly recommends a continuous and formal effort in knowledge capture and lessons learned. Modern tools exist to facilitate this, and NASA should avail itself of them. Rigor in this area is particularly critical as the experience in specific skills dissipates over time and as engineering talent is stretched across programs.

COMMERCIAL CREW UPDATE

Commercial crew was one of the major topics in the ASAP's Annual Report. Dr. George Nield, Associate Administrator for Commercial Space Transportation at the FAA, discussed the updates the Panel received on commercial crew. There were three speakers who provided updates on CCP—Mr. Phil McAlister, Ms. Kathy Leuders, and Mr. Nathan Vassberg. Mr. McAlister, Director of Commercial Spaceflight Development at NASA Headquarters, noted some recent important events. The first was the decision by the Administration to extend the ISS to at least 2024. This is important to the CCP for a number of reasons: it gives providers almost seven years of operations, it takes some of the schedule pressure off with regard to utilization of the vehicles that are being developed, and it helps the providers close their business cases. Orbital Sciences' spacecraft Cygnus docked with the ISS on January 12. This was the fifth time a commercial vehicle has flown to the ISS. The 2014 Omnibus Appropriations Bill, passed by Congress and signed by the President, provided $696 M for the CCP—not as much as requested, but significantly more than in previous years.

Considerable progress has been made by the providers under Space Act Agreements (SAAs) for Commercial Crew Integrated Capability (CCiCap). Boeing has completed 15 of its milestones, Sierra Nevada Corporation has completed 8, and SpaceX has completed 12. Each provider has five milestones remaining. This year will be a big year for commercial crew. A number of critical CCiCap milestones are coming up: critical design reviews, in-flight abort and other pre-flight tests, completion of Certification Products Contract (CPC) round 2 products, and contracts awarded under the Commercial Crew Transportation Capability (CCtCap) in the August/September timeframe.

Ms. Leuders, CCP Acting Program Manager, provided more specifics about CCP progress and plans. She discussed the theme of laying the groundwork now to execute the CCtCap contract. They have a plan of attack to deal with the risks and execution. This includes things such as getting mature decisions under the CCiCap preparatory effort, refinements and understanding of the contractors' approaches under the CPC, assessment of the contractors' maturity and compliance, and planning for program execution. NASA has parallel contract efforts: the CPCs (designed to get early NASA disposition of certification products, such as alternate standards, hazard reports, verification and validation plans and variances, and the certification plans) and the CCtCap contracts. Initial proposals were due on Jan 22; final proposals are due later in the year. The second round of the CPC effort will also occur this year. The goal there is to identify who "owns" the open work and the cost risk associated with it.

Some of the other progress in the program includes: the Program Management Plan draft, which is under final review for approval; and the Memorandum of Understanding (MOU) with the Launch Services Program (LSP), which is in work. The program is in a good position now. NASA is confident that it will receive some good proposals, launch vehicles are flying, launch pads have been built and are being operated, and the spacecraft are under extensive review and analysis. Still, there are a number of challenges. The primary one is budget—specifically, whether or not NASA will have the budget to maintain competition. NASA is looking at contingencies on what it would do under various circumstances. In its final report, the ASAP recommended that NASA maintain competition in the CCP until there is confidence that an acceptable level of safety will be achieved.

Finally, Nathan Vassberg, who works for Ms. Lueders in the program office, provided some additional comments on the safety aspects of the program. The key item that he mentioned was the establishment of a Safety Technical Review Board (STRB) to focus safety review on the hazard reports. This should help the program get a good handle on what the risks are and their disposition. This process is based on the Process Requirements and Review approach that the ISS safety program has used successfully in the past.

The ASAP has seen a lot of progress in the program since its last meeting. There are still challenges, but they are being addressed in very professional and appropriate way. This will be an important year for the program.

VADM Dyer broached the subject that was part of its fact-finding session earlier: the issue of contracting with the Russians for additional Soyuz transportation to the ISS vis-à-vis placing all reliance on the successful initial operating capability of the commercial providers.

Dr. Nield noted that the ASAP was told that within a few months, NASA needs to made a decision on whether or not the U.S. should extend the contract with the Russians for additional seats on the Soyuz, because there is a three-year lead-time with regard to long-lead parts for that program. There are some difficult options. Will commercial providers be ready by 2017? Providing some margin may seem like a good thing to do, but that would take focus, incentive, attention, and business away from the commercial providers. There is even the question whether it would be possible to buy long-lead items from the Russians. If NASA needs to go back to Congress and request more funding for Soyuz seats (not currently in the plan), perhaps it could ask instead for additional funds that would help to increase the probability of the commercial providers being ready on time. These are things that NASA must think about in the months ahead.

Mr. Frost noted that there are a number of risks involved in that question. One is having access to ISS. Another is that if a hard deadline of 2017 is placed upon the commercial providers, such a limitation can have safety implications. What NASA will have will be a fixed-price contract with a fixed deadline. History has shown that those constraints can lead to shortcuts that affect safety. This will be an important decision.

EXPLORATION SYSTEMS DEVELOPMENT AND ESD RISK ACCEPTANCE

VADM Dyer discussed the briefing the Panel received from Mr. Daniel Dumbacher, Associate Administrator for ESD. The ESD Program is composed of three pieces: a MPCV, otherwise know as Orion (Lockheed Martin is the contractor); the Space Launch System (SLS), which is the rocket (Boeing is the contractor) plus solid boosters from the Shuttle Program; and the Ground System. Mr. Dumbacher was with ASAP for most of the afternoon. There are some important aspects of ESD that differ from the classic program. It is an incrementally-developed program. Its specific mission is currently undefined, although there are Loss of Crew (LOC) requirements for ascent and descent—specifically, 1 in 400 for ascent and 1 in 650 for descent. The ASAP would like to see more mission focus and goals and thresholds for LOC for ascent and descent. FY 2013 has been a very active year for the ESD programs. The SLS and core stage completed Preliminary Design Review (PDR). The core stage is on the critical path. Exploration Flight Test (EFT)-1 is only seven months away (the end of FY14). FY14 also saw Critical Design Review (CDRs) for the booster and core. SLS CDR will be in the middle of FY15. The first uncrewed exploration mission (EM-1) is in the first quarter of FY16. Accomplishments over the last several years that the ASAP has been tracking closely include: the February 2013 heat shield structure testing, the successful completion of nine parachute tests, and the power-up of Orion at end of November. The ESD Program carries five "red" risk items, which include three budget-related risks with regard to architecture, schedule, and mass reduction. The other two address EM-2 and issues to be worked out with the European Space Agency (ESA) and its Service Module.

A topic of energetic discussion and interest was the December 2017 EM-1 mission and the EM-2 crewed mission, targeted for August 2021. EM-1 is an uncrewed, full-system launch and extended duration flight, but it may launch without a working Environmental Control and Life Support System (ECLSS). The first crewed mission (EM-2 in August 2021) would be the first flight of the full-up ECLSS, and it is being examined in terms of options. The baseline is a high lunar orbit (HLO), but there are discussions about stretching that mission to send two crew members on an asteroid sample return mission. The Panel's concern is: Should we take on that aggressive an approach on the first crewed mission on a new system?

Dr. McErlean commented that there are a number of missions that are being considered in addition to the two that VADM Dyer mentioned. There are some intermediary missions, one of which involves several orbits around the Earth to do ECLSS check-out before doing a HLO. None of these have been selected, but they are being considered. The issue of whether EM-1 should have an operating ECLSS is an item still under discussion.

VADM noted that the incremental aspect of SLS and ESD is interesting. It is easy to see where it comes from. When under budget pressure and attempting to do a lot with limited resources, NASA has elected to go down the "indecision-is-the-key-to-flexibility" path. The design intent misses the focus that is part of a classic program, but is in keeping with an approach to be more flexible and to build a capability that will be utilized in the future. In its Annual Report, the ASAP expressed some concern that not unlike CCP, ESD system development is proceeding ahead of requirements. This is not the most efficient approach and there is some concern whether it is the safest one.

There is a different SE&I organizational structure in the ESD Program. Mr. Bryan O'Connor (via telecon) discussed the "old ways" versus the ESD approach. He noted that the ASAP is always interested in how NASA is dealing with lessons learned. Sometimes the most important part of the discussion is making sure that if people are doing something that is countering some lesson that was learned some time ago, they have thought it through, understand the implications, and have mitigated the shortcomings. ESD's cross-program systems integration (CPSI) is one of those areas that is an experiment in some ways. There have been some previous attempts at things like this that didn't work out very well. For example, in the early 1990's, the Space Station was redesigned—both the system and program. Before that time, the Space Station had been a loose confederation of programs that had an integration function that was not at an engineering center—it was in Reston, Virgina, and was attached to NASA Headquarters. It was difficult for the Program Manager to integrate that program the way that it was set up. This loose confederation model goes against good, solid systems engineering and integration and accountability for the Program Manager. NASA changed this—it put the SE&I at JSC and made progress in getting the projects more closely coupled and integrated. Shortly after the Challenger accident in the late 1980s, NASA decided that the SE&I for Shuttle would be in Washington. This approach became unsustainable and was abandoned after a couple of years. The Agency ultimately went back to an engineering center to integrate that program. The question is: Why does NASA have to keep learning this lesson? Tightly coupled programs need to have good oversight and integration over the projects. This also came out of the Columbia accident review.

Mr. O'Connor noted that when the ASAP looks at CPSI, it seems consistent with non-tightly-coupled programs. It seems consistent with capability-development rather than mission-development, and it also benefits from better communications today than in the past. The system safety team under Mr. Paul McConnaughey is doing a great job in getting the right people to work on SE&I issues. However, there are some things they are doing to keep the level of work under control, such as delegating some of what used to be done at the top level down to what was formerly was called projects, but are now called "programs." When the ASAP sees this difference, it will continue to ask about the lessons learned on strong SE&I. It will be a continuing topic for the ASAP as it visits the centers involved with human space flight.

Dr. Nield made a few comments regarding how the program is being put together and the EM-2 goal. This is an example of NASA at its best and not-so-best. They have highly-motivated, "can-do" people. However, at this point in the planning process, deviating from baseline procedures and generally accepted practices in order to make things work may not be the most prudent approach.

INTERNATIONAL SPACE STATION

Dr. McErlean reported on the ISS briefing. The ISS is a mature, ongoing program. It has had some recent incidents, but they have been well-handled by the team, and they have a process by which they deal with them. This will be a busy time for ISS over the May-June timeframe. There will be five or six visiting vehicles to the Station, which will be a heavy workload for the crew. On the positive side, the Russians have recently updated a software program that allows for a more rapid cycling and firing of the maneuvering engines, which gives them much greater maneuverability with less expenditure of fuel. This improvement in capability illustrates how the ISS is being continually upgraded. Dr. McErlean discussed the ammonia cooling-loop pump failure. It was an interesting failure and the ISS team fully admits that it was a lesson learned. Internal to the pump is a flow control valve that is loaded on the ground with firmware. That valve failed to property control the flow, and they had no way to reboot it. They reacted to the problem very well, got a handle on it quickly, and knew they had to do a spacewalk. There was a continuing concern about the spacesuits, and it was a classic risk/benefit balance. They went through an exceptional process. The team put some fixes into the spacesuit system and decided to do the spacewalk and replace the pump. They readily admit that this was an unexpected failure. In their prior failure analysis, they always felt that pump failure would mean not pumping; in this case the pump failed while still pumping but in an uncontrolled fashion. This gave rise to another type hazard chain that was new and thus drove more innovative corrective actions. They stated that because of this demonstrated failure mode, they would not design the pump with its flow control internal and inaccessible if they approached the design today. The root cause of the controller failure is still under investigation.

On the spacesuit side, the ASAP received an excellent briefing on the suit failure, toured the suit lab, and got an in-depth explanation of what they are doing about it. Some mineral deposits plating out of the cooling water were blocking very small holes that are important for the cooling-water air-loop separation. The fan didn't stop the flow, and water got into the air side of the loop and plated out on the inner helmet. This was a unique failure not seen before. They are working the issue. The new suit design completely eliminates the problem—it goes to a different concept for re-circulating the coolant. The situation is in hand at this point, but they are still looking at where contaminants are getting into the system and how they are plating out. There is still an active engineering investigation.

The Panel has been active in talking to the program about end-of-life (EOL) planning. It is inevitable that the Station will eventually come down. The question is under what circumstance it will come down and how it will be controlled. NASA reported that the EOL plan was taken up by the Multilateral Control Board and accepted. Individual partners have agreed to share cost and liability and will bring the Station up to where it needs to be for controlled reentry. The ASAP will continue to monitor progress on this level.

Mr. Bolton noted that ISS is the only platform in the U.S. to look at long-duration exposure to space. If there is an asteroid or Mars mission, there must be a way to prove technology. This is a good reason to keep ISS going. Last year, the ASAP talked about each partner's ability to extend the Station. At that time, the Panel was told that the partners' liabilities would be limited according to mass. The question is: Where is the body of law that governs the liabilities? Although the ASAP received an answer, Mr. Bolton indicated that he was not completely comfortable with it, and he would pursue this question with the people in the U.S. who are trying to build that body of law.

CAPT Conway added that the accidental discoveries or collateral benefits of all of this activity is immeasurable. The important thing is to capture this knowledge. The ASAP should continue to evaluate the Knowledge Management Office and its effectiveness. VADM Dyer agreed that the ASAP will focus more on knowledge management and transfer in the coming year. Exaggerating to make a point, he noted that knowledge management and transfer within NASA has some aspects of "story-telling around the campfire" instead of modern, digitally-accessible and retrievable information. When one looks at what has been lost or difficult to regain from Apollo, one can see the importance of capturing the wisdom of those who have gone before.

VADM Dyer adjourned the meeting at 2:35 pm. Before the Panel departed, Ms. Harmony Myers announced that the next Panel activity is an insight visit on February 18 to the White Sands Test Facility. The next quarterly meeting will be April 21-23 at the Kennedy Space Center.

ASAP RECOMMENDATIONS, FIRST QUARTER 2014

2014-01-01 **Radiation Risk Decision on Deep Space Mission** [contact: John Frost]

Finding: Deep space journeys of a year and planetary missions of three years are considered high risk for health issues. Long-term radiation is a problematic issue. The current NASA standard allows an increase of three percent in the chance of fatal cancer above the baseline risk faced by the general public. Current assessments indicate that an astronaut can spend about 250 to 500 days in orbit without exceeding this risk, depending on solar activity at the time. Long term flights exceed this timeframe. The NASA team estimate is that it is unlikely that NASA will be able to radiation shield much more than what is being done now. They currently estimate that with what we know today, long-term missions could increase the chance of fatal cancer anywhere from 5 to 21 percent above baseline.

Recommendation: The ASAP recommends that (1) NASA continue to seek mitigations for the radiation risk and (2) establish an appropriate decision milestone point by which to determine acceptability for this risk to inform the decision about a deep space mission. This risk choice should be made before NASA decides to go forward with the investment in a future long-term mission.

Rationale: This risk can have a profound impact on mission choices beyond LEO. The conundrum we want to avoid is spending billions on a planetary mission and then concluding that a risk as high as a one in five risk of death from the single radiation hazard is unacceptable.

2014-01-02 **Knowledge Capture and Lessons Learned** [contact: Pat Sanders]

Finding: Knowledge management and transfer within NASA has some aspects of “story-telling around the campfire” instead of modern, digitally-accessible and retrievable information. Lessons learned, accidental discoveries, and collateral benefits from all of NASA’s human space flight activity is immeasurable.

Recommendation: The ASAP strongly recommends a continuous and formal effort in knowledge capture and lessons learned. Modern tools exist to facilitate this and NASA should avail itself of them. Rigor in this area is particularly critical as the experience in specific skills dissipates over time and as engineering talent is stretched across programs.

Rationale: When one looks at what has been lost or difficult to regain from Apollo, one can see the importance of capturing the wisdom of those who have gone before.