NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C.

NASA ADVISORY COUNCIL

October 16, 2008

Hilton Cocoa Beach Oceanfront
Cocoa Beach, Florida

MEETING MINUTES

Marguerite Broadwell
_____
Marguerite Broadwell
Executive Director

_____
Kenneth Ford
Chair

NASA ADVISORY COUNCIL
Hilton Cocoa Beach Oceanfront
Cocoa Beach, Florida
October 16, 2008

MEETING REPORT
TABLE OF CONTENTS

Meeting Report Prepared by:
Sallie Birket Chafer

NASA ADVISORY COUNCIL
Hilton Cocoa Beach Oceanfront
Cocoa Beach, Florida
October 16, 2008

OPENING REMARKS

NASA Advisory Council (Council or NAC) Chair Harrison Schmitt opened the public session of the 2008 fourth quarterly meeting, held at Kennedy Space Center (KSC). He thanked the KSC Deputy Director, Ms. Janet Petro, and the entire KSC staff for their logistics assistance.

Senator Schmitt reminded the Council and the audience that this session is open to the public and is conducted in accordance with the Federal Advisory Committee Act. In addition, he noted that minutes from the Council's third quarterly meeting in July—as well as NASA responses to Council recommendations from the 2008 quarterly meetings in February and April—were available in hard copy.

Senator Schmitt reported that the next Council quarterly meeting is currently scheduled for February 3-5, 2009, at NASA Headquarters (HQ) in Washington, but a final decision on the venue will be made in January. The Council will post additional details on its Web site.

Senator Schmitt confirmed the Administrator's decision that, as of the end of this meeting, Dr. Ken Ford will succeed him as the Council chair, thanking the Council for "an unbelievably interesting and educational experience." In their reports, the committee chairs expressed their appreciation and gratitude for the Senator's unique insights, enthusiastic leadership, and persistent support.

AERONAUTICS COMMITTEE: REPORT AND DISCUSSION

General Les Lyles, Chair of the Council's Aeronautics Committee, presented its report, which focused on (1) previous recommendations and (2) initiatives that the Committee discussed with the Council and the NASA Aeronautics Research Mission Directorate (ARMD) over the last year.

General Lyles addressed interactions and leveraged activities between the Air Force Research Laboratory (AFRL) and ARMD, briefly summarizing the AFRL mission and noting its wide variety of discovery, research and development (R&D), and science and technology activities to support national security interests with technologies that focus on air, space, and cyberspace. AFRL has a robust set of development activities and a budget of about $4 billion a year in basic research, science and technology, and R&D.

General Lyles observed that AFRL supports warfighting and operational activities and numerous other customers, but NASA represents a major input to AFRL balance in its portfolio and in science and technology investment. The Aeronautics Committee focused specifically on AFRL collaboration, cooperation, and coordination with ARMD.

Citing a short compendium of some activities under way, General Lyles reported that the Committee reviewed a long list of agreements between AFRL and ARMD on specific programs, technologies, and research areas. Numerous informal cooperative activities also are ongoing, and additional formal agreements are in development. The Committee concluded that the lengthy AFRL-NASA relationship cuts across many tasks and technology areas of interest to ARMD.

In response to a question from Senator Schmitt about money transfers, General Lyles noted that AFRL performs some NASA-funded activities, conducts some work with NASA (sharing resources), and funds some activities that meet NASA requirements. There is no common approach for each type of work.

General Lyles reported that the Committee had one positive observation and one concern. The Committee observed that AFRL and NASA undertake numerous joint activities, sustain many dialogues, and attempt to leverage the expertise and experience of both agencies. However, the Committee is concerned that most collaborations and cooperative work arrangements are scientist-to-scientist activities. The Aeronautics Committee developed a recommendation specifically to encourage NASA and the Air Force to develop a strategic framework to support analysis of their gaps and needs and to ensure that programs fulfill the gaps and needs of one or both agencies. The Committee deferred its recommendation after the Associate Administrator (AA) for ARMD described his early-stage attempt to forge a strategic framework with the Air Force, including talking to the Chief Scientist of the Air Force, Dr. Werner J.A. Dahm, who came on board a few weeks ago. The Committee will revisit this issue and expects to have more information by the next Council quarterly meeting.

Senator Schmitt asked whether the Committee observation indicated that there is no central coordinating review system to identify the various research activities and their relationships to each agency. General Lyles responded that the agencies actually signed an agreement about working relationships, but did not include a strategic framework. The Committee concluded that working agreements and biannual meetings to review activities are valuable, but more must be done. ARMD agreed and is working that initiative with the Air Force.

The Committee held a teleconference with the new AFRL Chief Engineer, Dr. Ken Barker, to discuss technology transition and the rather robust process that the Air Force uses to monitor, track, and aggressively identify ways to transition technologies into operational capabilities. The Committee was impressed with that process and suggested that ARMD analyze it to identify and apply lessons learned. General Lyles reported that NASA work on technologies for the Next-Generation Air Transportation System (NextGen) program will be important because NASA is a major player.

General Lyles described the ongoing structured formal review of the goals and objectives of the new National Plan for Aeronautics R&D and Related Infrastructure, recently signed by the President, as well as the assessment (in conjunction with peer groups and national experts) of whether current or future R&D plans of NASA or other agencies will satisfy such goals and objectives. This review should be completed (and the report submitted to Congress) in December. The Committee will report on the results of this review at the next Council meeting.

Dr. Ray Colladay added that the Committee has talked about this type of R&D policy as a basis for aeronautics policy that has long been missing in the Government and in investment decisions. He observed that perhaps the most important characteristic of this gap analysis process, which includes the Office of Management and Budget (OMB), is that it addresses aeronautical R&D at all agencies, compares research to policy, and identifies the gaps. The review also rightly considers overlaps, some of which have the value of different perspectives, but Dr. Colladay noted that OMB focuses on what it views as unnecessary overlaps and redundancies. Nevertheless, he emphasized that an important follow-up to these policy documents is regularly performing that type of gap analysis and reviewing investments by all agencies. General Lyles reported that easy first-tier stoplight assessments can be misleading unless the details behind some of the goals and objectives are understood. The Committee hopes not only to provide recommendations on how to influence this process, but also to ensure that whoever uses this gap assessment will apply it properly.

Senator Schmitt asked whether the Committee detected a willingness at OMB to consider aeronautical research and technology development (versus actual development) as part of a Government function. General Lyles noted that all members are concerned, based on previous discussions with OMB, that there may be some reluctance in accepting the need for any aeronautical research. Following up, Senator Schmitt asked whether the Office of Science and Technology Policy (OSTP) was in communication with OMB and trying to influence its attitudes. General Lyles responded affirmatively. Dr. Colladay agreed that significant communication occurs; in fact, the OMB examiner and OSTP offices are colocated. He noted that OSTP is very careful not to be a program advocate, but really wants to ensure that relevant facts are in evidence and that OMB makes decisions based on reality.

The Council deliberated about its April recommendation that ARMD should plan and develop candidate high-priority systems-level research projects, which shifts the focus from individual project and program research to a higher-level, integrated systems capability (demonstrations, prototypes, or products that actually can fly to demonstrate new technologies). The Committee recognizes that systems-level research likely will require more funds in 2010 and beyond because it falls outside normal foundational research. The Committee and the AA for ARMD talked in great detail about current efforts and ARMD initiatives under development. General Lyles observed that ARMD has been very responsive to the Council recommendation. The Committee concludes that the proposed ARMD systems-level research initiative will set the tone for foundational research and also impact future aviation needs. The Committee is very comfortable with the ARMD approach, which builds on the foundational R&D that ARMD has undertaken recently.

For example, some ARMD systems-level research initiatives address national issues such as the NextGen system, specifically gearing toward development of advanced operational concepts for vehicles, vehicle systems, and vehicle protocols for new aircraft, new engine technologies, safety enhancements, and reductions in environmental concerns such as fuel use, noise, and emissions. General Lyles noted that technologies, protocols, and air traffic control can improve commercial aircraft operations (and accrue significant fuel savings) by allowing a continuous climb or descent, using direct routing and improved rerouting, or implementing air field procedures such as no-stop taxi operations. The overall goal for reducing fuel consumption, noise, and emissions is about 50 percent in the next 20 years, and 40 percent can be achieved by developing a hybrid wing body aircraft (in the next 5 to 10 years) and applying advances (e.g., engines and airframe technologies, laminar flow over wings). Operational airfield activities can gain something like 2 to 5 percent (a couple hundred million gallons of annual fuel savings).

Dr. John Sullivan commented that the Council's idea was to establish a finite-length (4-5 years) targeted project to perform systems-level experiments that simultaneously reduce fuel burn, noise, and emissions from future aircraft and to generate feedback to improve foundational research. ARMD decided to look at a multifunctional aircraft testbed that adapts to emerging technologies and tests individual components (e.g., engines, airframe, laminar flow control, boundary layer ingestion inlets). General Lyles described ARMD's proposed systems-level research program as a very strong collaboration with other agencies (the sort of "clean green" program that the Federal Aviation Administration is sponsoring), industry, the NextGen Joint Planning Development Office, the Department of Defense, and other stakeholders.

Senator Schmitt queried whether ARMD is building a case for broader audience understanding (e.g., at OMB) of systems-level research (versus basic R&D), including clear examples of past payoffs and some semiquantitative measure of the importance of such research. He suggested that the long history of the National Advisory Committee for Aeronautics—and NASA aeronautics in its heyday—must include examples of such research being conducted and paying off handsomely in the efficiency and safety of commercial aircraft. His question elicited a number of possible examples. First, General Lyles noted that ARMD is defining a systems-level green aircraft program and is trying to develop a lay definition. Second, Dr. Colladay posited that it is easier to describe systems-level research in terms of what it is

not—it is not a demonstration (i.e., a point design), but more of a testbed that enables changes in configuration, exploration of interactions among various components when testing the whole system, and reductions in fuel consumption, noise, and emissions. Third, Dr. Colladay suggested that the best examples lie in flight research at Dryden Flight Research Center. Fourth, Dr. Sullivan pointed decisively to some of the engine testing a decade ago, which eventually put components on an airplane as part of a sequence to determine whether the entire system worked. He reminded the Council that engineers often encounter previously unknown systems interactions that must be defined and incorporated as feedback into fundamental research to specify and resolve associated fundamental questions. Fifth, General Lyles cited previous NASA foundational research that led to commonplace advances such as small and large winglets (which modify the airflow and therefore the drag profile of the wing, producing greater efficiency in flight) for aircraft of all sizes. Sixth, General Lyles mentioned the Committee's discussion with the Air Force about its technology transition plans and approaches, which have been immensely useful to the Air Force in garnering congressional and warfighter support for technology programs.

Senator Schmitt then asked whether anyone is working on streamlining and ensuring quality in maintenance. General Lyles replied, and Dr. Colladay agreed, that sustainment and maintenance are not addressed specifically in the three focus areas of safety, aviation, and foundation. Senator Schmitt noted the inherent aviation industry incentives in this arena, which might be strong enough to eliminate the need for specific Government action. He also cited embedded diagnostics as one specific enabling technology that might be appropriate (e.g., Caterpillar is installing embedded diagnostics to monitor machine aging and other problems). General Lyles confirmed that engine diagnostics, airframe diagnostics, and health monitoring systems are being assessed.

Dr. Sullivan observed that NASA is expending significant effort on prognosis-diagnosis, the idea that monitoring structure enables reductions in normally built-in safety factors and their weight because the user organization only does inspections when needed. NASA also is working on human factors because maintenance entails human factors that constitute one of the biggest issues in aviation safety from the point of view of both pilots and mechanics. Designers of the new composite aircraft are considering built-in sensors to enable as-needed, rather than time-scheduled, maintenance. Senator Schmitt noted that one of the biggest unanticipated advantages of the switch from propeller-driven aircraft to jet aircraft was the ability to more effectively perform as-needed maintenance. General Lyles commented that the Committee should discuss with ARMD the concept that as personnel are conducting foundational research, they need to confirm that someone is analyzing maintenance and sustainment because such concerns might dictate changes in some technologies.

SCIENCE COMMITTEE: REPORT AND DISCUSSION

Dr. Jack Burns, the new Chair of the Council's Science Committee, presented its report, which focused on (1) recent astrophysics, planetary, and Earth sciences missions; (2) the Committee's special Earth sciences session; (3) the Mars Science Laboratory (MSL); and (4) recommendations on near-term access to space and the Lunar Exploration Analysis Group (LEAG) lunar goals roadmap. Dr. Burns confirmed that this really in many ways is a golden age for NASA science, and it only gets better every year.

Dr. Burns reviewed initial results from the Gamma-Ray Large Area Space Telescope (GLAST), now renamed the Fermi Gamma-Ray Space Telescope. He showed the first all-sky survey in gamma rays, including the plane of the Milky Way galaxy and several pulsars. By luck, a blazar (a relatively distant galaxy with a jet that beams gamma ray and other wavelength emissions, nearly along the line of sight) went off during this integration, prompting many observations and analyses.

Dr. Burns described the Swift spacecraft, which also operates in the gamma ray wavelength, but looks for gamma ray bursts and very recently found the most distant burst ever detected. The universe is now

estimated to be 13.7 billion years old, and this gamma ray burst originated in a galaxy that is 12.8 billion light-years away, so the emission left the galaxy when the universe was less than a billion years old, that is, in its infancy. This burst was so bright that it was even visible to the naked eye for a few seconds.

Dr. Burns reported that the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) satellite is only the second spacecraft to visit Mercury, after Mariner 10 in the 1970s, because Mercury is so close to the Sun—and the gravitational pull of the Sun is so strong—that sending a spacecraft to the planet is very difficult. MESSENGER will be the first spacecraft to actually orbit Mercury, making multiple passes of the planet to slow down and eventually go into orbit, scheduled for March 18, 2011. It completed a second pass just 10 days ago. Dr. Burns marveled that Mariner 10 mapped only 45 percent of the surface, so, at this late stage in the space program, MESSENGER will generate the first complete picture of one of the major planets in the inner solar system, using multispectral cameras to produce an exquisite level of detail.

Dr. Mark Robinson, a member of the MESSENGER science team, discussed one of the most significant geologic discoveries so far, confirmation of extensive volcanic deposits, which had been debated (based on exosphere and magnetic field data) until the first flyby. MESSENGER also verified that the planet has a magnetic field, a significant finding because older calculations suggested that the planet should have lost all of its heat and no longer have a liquid outer core. In response to a query from Senator Schmitt about extremely large basins such as Caloris, Dr. Robinson responded that the spacecraft did detect one 700 km basin not on the terminator, but much of the territory was imaged at high sun, when ancient degraded basins are very difficult to see. Scientists thus are waiting for orbital laser altimeter observations, heeding lessons of the 1994 Clementine Moon mission, which identified eight previously unknown old basins.

Dr. Burns discussed imaging the dynamics of Saturn's atmosphere and its satellites and showed a brief video of views captured by the Cassini-Huygens spacecraft, which has been flying by or orbiting Saturn and Titan, the largest moon, since 2004.

Dr. Burns observed that this also is the golden age of science for Mars, with a robust set of missions in place and planned for the next decade. Two rovers are still functioning well beyond their original lifetimes; Mars Odyssey is still orbiting the planet; and the Phoenix spacecraft landed near one of the poles, but its survival during the harsh winter is in question. The Phoenix mission was all about the ice and water on Mars, and it has been very successful—including directly sampling and analyzing ice and most recently experiencing snow virga, the first evidence of snow on Mars. Dr. Don Fraser asked whether any of the Martian plans use an aerial vehicle (presumably long-endurance) to explore more territory. Dr. Burns and Dr. Robinson confirmed that there have been some proposals in Europe and the United States (e.g., scout proposals for gliders, balloons, and airplanes), but current planned missions do not incorporate aerial components.

Dr. Burns showed a short movie of spectacular solar images captured by the Japanese Hinode spacecraft, which includes several NASA-funded detectors and imagers and is one of a new generation of very-high-resolution spacecraft operating at high energies in the x-ray part of the spectrum. Despite the Sun's current relatively inactive phase, flaring activity continues. The Hinode image shows a boiling, churning cauldron of solar activity. As Dr. Burns observed, the study of solar activity, particle acceleration, and cosmic rays is interesting physics, but also important for warning of radiation events affecting future astronauts working on the Moon's surface and on long-duration missions above low-Earth orbit (LEO). Despite decades of solar studies from the ground and in space, the Sun is still not well understood.

Dr. Gerald Kulcinski asked about the status of the 2017 outer planets flyby mission, which requires 25 kg of plutonium for the radioisotope thermoelectric generator (RTG). One of two outer planet flagship

missions (to Titan or Europa) will be selected soon, but either will require a new generation of RTGs and considerable plutonium, even if the more efficient Sterling heat conversion engine is used. Dr. Kulcinski worried that the plutonium must be acquired primarily from the Russians (according to the latest estimate, 5 kg each in 2009, 2010, and 2011), must be on deck some 5 years before the mission (so time is short), and might require dipping into U.S. plutonium reserves. Dr. Burns later reported that NASA does have access to sufficient Pu-238 through the Department of Energy contract with Russia. He verified the requirement (24.5 kg) for the more traditional multimission RTG, but the currently baselined, more efficient Sterling engine would reduce that requirement to 6.2 kg. When Dr. Kulcinski cautioned against assuming that the Russians will deliver the promised 15 kg of Pu-238, Senator Schmitt agreed that a contingency plan would be in order for this mission.

The Council held a lengthy discussion on sea ice levels. Dr. Burns described new developments, displaying an image from the National Snow and Ice Data Center in Boulder, using NASA data, that shows a dramatic drop in Arctic sea ice coverage, which is at its lowest level for the year and second lowest level since the dawn of the satellite era (the lowest was 2007). Nonetheless, the image now shows, for the first time in modern history, a clear new Northwest Passage from the Atlantic to the Pacific, opening interesting and to some extent troubling possibilities, including national conflicts over oil exploration in the Arctic. Russia has been very aggressive in pursuing that option, so claims of oil rights will accelerate. The decline in sea ice and this new passage pose interesting political problems that must be addressed by the international community.

Senator Schmitt wondered whether anyone is actively investigating historical sea ice surrogates, particularly in the medieval "warm period" of the 1300s in Europe and Greenland, which were warmer than even today (hence the Norse colonies in Greenland and Newfoundland), implying that the Northwest Passage probably existed then, too. Dr. Byron Tapley was not aware of anyone actually trying to make the case that the Northwest Passage was open in that region, although researchers clearly are reviewing ancient climate records elsewhere. Senator Schmitt stressed the importance of such studies because the diminution of sea ice is cited in a variety of technical and political contexts, although Arctic ice might have totally disappeared in other periods of time. Dr. Tapley explained that sea ice is ebullient (i.e., if it melts, the sea level does not change), but the sea level record suggests that mass has been added to the ocean recently; ocean water both is warmer and includes additional mass because the rise in sea level is not only steady, but also increasing more rapidly in recent years. He noted a possible explanation in the melting of glaciers on land and in the movement of tectonic plates. Over the long haul, the bigger concern is the melting of glaciers on Greenland and in Alaska and associated warming of the permafrost. Dr. Charles Kennel reported that the Intergovernmental Panel on Climate Change documented the retreat of land ice during the last interglacial maximum, using ice coring and other land ice evidence. However, he knew of no investigation of the history of sea ice, which Dr. Burns thought would be harder to document.

Dr. Burns reviewed Science Mission Directorate (SMD) missions from 2007 through 2016, including Earth science, remote sensing, and planetary missions. Scientists are excited by the wedge of missions after 2009 and by the prospects of data from missions such as the Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS), a joint Exploration Systems Mission Directorate (ESMD)-SMD lunar mission; the Glory mission; MSL; possibly the Wide-Field Infrared Survey Explorer (WISE), a near-infrared telescope; Kepler, which for the first time will attempt to detect Earth-like planets around other star systems; the Stratospheric Observatory for Infrared Astronomy (SOFIA) aircraft; the final Hubble Space Telescope servicing mission; and Herschel and Planck, which will be launched on a single spacecraft (Planck will investigate cosmic microwave background during the first moments of the very early universe, while Herschel will observe the far infrared). A number of missions are in various stages of planning and execution for 2010 and beyond, beginning to fill a gap in 2010-2011 that the Council was significantly concerned about, primarily in terms of personnel retention,

as recently as a year ago. SMD added missions such as NuSTAR and the Lunar Atmosphere and Dust Environment Explorer (LADEE), creating a much more robust set of flights.

Dr. Burns explained that one of his intentions as the new Chair of the Committee is to review operations of, and communications among, the Committee and its five subcommittees (Earth science, astrophysics, heliophysics, planetary protection, and planetary science), a unique organizational structure among NAC panels. He listed several strategies for improving communications, including (1) his participation in subcommittee meetings last month, (2) invitations to subcommittee chairs to participate in Science Committee meetings, (3) invitations to division directors from each of the four discipline areas to participate in the Science Committee meeting, which generated not only tremendous interest, but also actual participation by all invitees in a robust set of informative and in-depth fact-finding sessions, and (4) participation in this meeting, and a commitment to attend future meetings, by the new SMD AA, who also instructed his division directors to attend.

As a new approach, at each quarterly meeting, the Committee will emphasize a specific discipline, spending a couple of hours drilling down into that field; at this meeting, the Committee focused on Earth science. Senator Schmitt inquired whether the Committee sees this first review generating actual substantive recommendations for the Administrator. Dr. Tapley declared that the format has incredible potential as a vehicle to focus the Committee on issues and associated recommendations, even though this review did not generate specific recommendations. Dr. Burns agreed, citing the Committee's requests for additional information to underpin possible future recommendations. Senator Schmitt cautioned against losing the benefit of this remarkable effort on Earth science as the Committee moves to the next in-depth review.

Dr. Tapley identified the key Earth science issue for the Committee: NASA's response to the January 2007 Earth science decadal survey. The survey report recommended an integrated slate of 15 new NASA missions to continue the suite of observations begun by the Earth Observing System (EOS), taking 24 basic Earth measurements that serve the Earth sciences, potential societal applications, and a wide range of disciplines (e.g., land use, ecosystems, biodiversity, weather and climate change, water resources, human health and security, solid Earth resources).

NASA data requirements run the gamut from long-term measurements to separate climate changes and thus entail high-precision, calibrated, and validated data; global and synoptic data; and an element of simultaneity inherent in the EOS program that now drives future system requirements. The decadal survey report divided the 15 recommended NASA missions into four tiers, spreading them over time and specifying four missions in the 2013-2014 time frame. However, NASA Earth science program funding has been in decline since 2000, and available resources have enabled NASA to initiate only two of those four missions. Dr. Tapley concluded that NASA and the scientific community—which is concerned about and discussing this NASA response—need to analyze strategies to address the current disconnect between decadal survey recommendations and NASA plans and capabilities.

In addition, Dr. Tapley addressed long-term continuity in Earth observation measurements, which constitutes a national issue, a NASA problem, and a core ongoing concern of the Committee. In the early plan for the National Polar-Orbiting Operational Environmental Satellite System (NPOESS), the first step was implementing a set of five key measurements on the satellite; however, a fallback program dropped those measurements. When planning the decadal survey, the National Academies expected those five measurements from NPOESS, so part of the overall decadal strategy was adversely affected. The NASA Earth Science Division (ESD) rebaselined two measurements by flying them on the NPOESS Preparatory Project (NPP), and NASA is working with the French on a bilateral program to extend altimeter measurements over the short haul. Dr. Tapley asserted that a coherent plan for the transition of important

measurements (not just to the NASA science programs, but other Federal agencies) must be established to preserve a forward-looking EOS.

Dr. Tapley reviewed the flagship EOS program missions, including Aura, Terra, and Aqua, noting that a suite of midclass missions and a suite of lower-class missions are doing a reasonably good job of acquiring the 24 primary measurements (and a few new metrics). The need to take numerous measurements simultaneously, which drove the large size of previous EOS platforms, is now being realized by satellites flying in formation. For example, Cloudsat, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), Aura, Aqua, and the French Parasol all fly in a time-frame orbit separated by about 18-20 minutes, and two additional satellites (the Orbiting Carbon Observatory and Glory) will be launched in 2009, creating a cluster of seven satellites flying in formation and fulfilling the simultaneity requirement. This idea could be used in the future, controlling satellites and combining their capabilities to obtain required measurements. In addition, although the suite is healthy now, SMD must address the replacement time frame and strategies for preserving information content.

Dr. Tapley revisited an earlier discussion on cost trades among various mission classes (e.g., Earth science, space science), indicating that the Committee reviewed first-cut results from an ongoing study and will report on its findings at a future meeting. The Council then discussed cost estimates in greater depth. Dr. Burns observed that realistic cost estimates depend on the specific mission because some (particularly smaller) missions led by principal investigators clearly contain costs as a regular task. However, problems are plaguing bigger missions such as the MSL, which offers many hard lessons learned, and the James Webb Space Telescope (JWST), which suffered from early cost underestimates and had to be rescoped and rebudgeted. After Senator Schmitt refocused the discussion on realistic costs for decadal survey missions, Dr. Tapley acknowledged the ongoing challenge, but NASA has rescrubbed all of the numbers and compared them to those of the National Academies. In most cases, the new NASA numbers are higher, but the firmer foundation has generated a fair amount of confidence in cost estimates for the first two missions in the first suite, and the other two missions are undergoing the same sort of scrutiny. In response to a question from Senator Schmitt about truly independent external reviews of those numbers, Dr. Burns reported that the two decadal surveys now starting (astronomy and astrophysics; planetary science) are using external groups in developing cost estimates and are applying greater rigor and objectivity than before. However, the relative quality of the resulting cost estimates is still unknown; these predominantly one-of-a-kind missions with unique high technologies confront inherent hurdles in properly estimating costs. Senator Schmitt recommended involving the professional communities because of their vast experience, which enables them to assess the relative complexity and sensibility of projected costs, and noted the Committee's role in reviewing NASA mission cost estimates.

As a personal point, Senator Schmitt worried that the space community and scientists in general are not taking full advantage of synergistic information, known and unknown, as well as the numerous direct and indirect (and historical and prehistorical) surrogates for climate, from the records of the British Admiralty to caves. He asked the Committee to consider, perhaps in a future workshop, encouraging the scientific community, NASA, and others to tie the two-decade trends in satellite data with historical and prehistorical trends in archaeology, anthropology, and geology, creating a continuum between past and present that will be very important to building a true model of Earth's climate over time and understanding satellite data. For example, he noted that a previously unknown ozone surrogate might be available to supplement the less than two decades of satellite ozone data that are being used to make all sorts of conclusions about natural ozone levels, despite the lack of knowledge about trends during various solar cycles. Dr. Brad Jolliff added that the National Science Foundation (NSF) operates the Paleo Perspectives on Climate Change program, which might sponsor research to connect past geologic records with climate change and satellite data.

Dr. Burns summarized the Committee's discussion on MSL, which is the size of a small bus and will roam around Mars for some time. It is designed as a true science laboratory, with very sophisticated tools that have never flown (or landed on another body) before. Despite recent developments, he reiterated the April Council recommendation, "NASA should continue to make every effort toward MSL mission success with a launch in 2009."

Dr. Burns noted the FY09 MSL budget addition, management optimism about a 2009 launch, and retirement of many major technological hurdles operative a year or even 6 months ago. The Jet Propulsion Laboratory has identified goals and metrics for remaining technological issues, including key hardware deliveries and acceptance tests, and must pass a major review in January or postpone the launch until 2011, despite considerable cost savings in the earlier launch. Dr. Burns stressed that the MSL mission is extraordinarily complex and that many lessons can be learned by examining technological hurdles, reserves, and project mistakes. Senator Schmitt suggested that the Committee consider a full review of the MSL mission at the next meeting.

Senator Schmitt observed that the Exploration Committee might be interested because MSL is at the limit of Mars entry, descent, and landing technology and testing capabilities and illustrates the extreme difficulty of landing payloads larger than MSL—including human crew payloads an order of magnitude larger—on Mars. Dr. Burns agreed that MSL is an important cross-cutting mission—for the science and also for future programs—because it will test on a small scale the key technologies (e.g., aerobraking techniques, aeroshells, landing parachutes) necessary for human missions to Mars.

Dr. Burns reported on a central Committee concern, near-term access to space and the shortfall of medium-class payload launches due to uncertainties in the future and cost of the Delta II launches. The Committee observed exciting commercial developments, such as the recently launched Falcon 1 and the follow-on medium launch capability of Falcon 9 (years away). For now, SMD identified Minotaur (mostly 4 and 5) launch vehicle opportunities to possibly fill the gap in medium-class launch vehicles. NASA will launch LADEE on a Minotaur 5 from Wallops Island in 2011, marking the first Minotaur space science mission. Dr. Burns emphasized that this approach (1) fills the gap between the current generation of medium launch vehicles and the new generation of commercial vehicles, (2) initiates Wallops as a space science launch site to supplement KSC launch opportunities, and (3) reduces launch and mission costs to a modest level.

Recommendation

The Committee made the following recommendation, which the Council unanimously approved:

> **NASA should work with the Office of Science and Technology Policy and the Department of Defense to obtain a limited number of Minotaur launch vehicles to launch science missions. This capability would fill the gap until new commercial vehicles are available to provide launch services on a reliable, routine basis.**

SMD informed the Committee that relevant discussions are progressing and that NASA might potentially acquire even more Minotaurs, creating additional modest-cost launch opportunities.

Dr. Burns then explained that the Lunar Exploration Analysis Group (LEAG) represents a considerable cross-section of the science community and has been developing a lunar goals roadmap for several years. The LEAG now is led by Dr. Clive Neal, a member of the Planetary Science Subcommittee. The LEAG also solicited community input to this roadmap at a well-attended July workshop. The LEAG roadmap integrates science and exploration, defining related themes, goals, objectives, investigations, and priorities. As Dr. Burns and Dr. Jolliff noted, the LEAG has been addressing fundamental questions

(including the solar system, the universe, and the place of humans in them) by focusing on the type of observations that can be made from the platform of the Moon, looking back at Earth, out to the universe, and at the Moon and the solar system processes that it records. Dr. Burns described the two goals incorporated in the roadmap, the feed-forward theme (using the Moon to prepare for future missions to Mars and other destinations, including asteroids) and the sustainability theme (extending human presence to the Moon for long-term exploration, space science observations, and commercial activities).

Dr. Burns noted that communications between the LEAG and the NASA Optimizing Science and Exploration Working Group (OSEWG) have begun recently, but a more formal communication process is needed to enhance those communications (which should improve interactions between SMD and ESMD as planning proceeds).

The Science Committee discussed the LEAG and OSEWG jointly sponsoring a workshop in mid-2009 as a follow-on to the NAC-sponsored Tempe workshop 2 years ago. The LEAG and OSEWG are discussing sponsorship terms and location for an open meeting that would address lunar exploration architecture, surface science scenarios, and responses to the previous Council recommendations from the Tempe workshop. The Committee contends that the LEAG is the best group to organize this workshop given its outreach during the last few years and given its enthusiasm as a participant. Dr. Jolliff emphasized opportune timing given the lunar capabilities concept review held earlier this year and the surface science scenario review in mid-2010. A mid-2009 workshop could review the Council's Tempe recommendations and other suggestions consistent with the National Research Council report on science associated with further exploration of the Moon. Because many of these recommendations are directly related to the surface scenarios and to surface exploration and science, a mid-2009 workshop could affect the Constellation 2010 program review.

Recommendation

The Science Committee made the following two-part recommendation, which the Council approved without objection, but with an amendment to the second part to emphasize the *implementation* of responses to previous NAC recommendations:

> **A formal mechanism should be established to enhance communication between the Optimizing Science and Exploration Working Group (OSEWG) and the lunar science community through coordinated interaction with the Lunar Exploration Analysis Group (LEAG).**
>
> **The LEAG and OSEWG should coordinate a workshop in conjunction with a regular meeting of the LEAG or other appropriate conference to review NASA's ongoing implementation of the lunar exploration architecture, including the development of surface science scenarios and implementation of NASA responses to previous recommendations of the Council.**

EXPLORATION COMMITTEE AND AD HOC BIOMEDICAL COMMITTEE: REPORT AND DISCUSSION

Lieutenant General James Abrahamson, Chair of the Council's Exploration Committee, presented its report, which incorporates the report of the Ad Hoc Biomedical Committee. [The Ad Hoc Biomedical Committee is composed of representatives from both the Exploration Committee and the Space Operations Committee, meets periodically as needed, and reports to the Exploration Committee.] This report focused on (1) the current status of the International Space Station (ISS) as a national laboratory, (2) an update on the status of the Human Research Program (HRP), highlighting two or three major accomplishments in FY08, and (3) comments and proposed recommendations on lunar radiation risks.

General Abrahamson stressed the superb cooperation between the Exploration Committee and the Space Operations Committee, which results in frequent cross-references between the reports of the two committees. For example, the Exploration Committee's fact-finding included a full progress update by the Space Operations Mission Directorate (SOMD) and also joint work with the Space Operations Committee on the launch vehicle gap (i.e., the period between Shuttle retirement and the advent of the new Ares vehicle and other space transportation options to LEO and the Moon). Both committees are closely evaluating this critical gap and associated issues. General Abrahamson noted a recent breakthrough, congressional approval for a continuing exception to the Iran, North Korea, Syria Nonproliferation Act (INKSNA) that will enable NASA access to Russian Soyuz flights during the gap. He observed that this approval was in no small part due to NASA officials, who articulately explained that such flights have always been part of the exploration plan and are critical to working within budget and exploring space.

General Abrahamson observed the long NASA history and tradition in biosciences, particularly working with crews to optimize safety and performance. During early Shuttle operations, biosciences moved into very basic research areas with individually exciting experiments (e.g., the electrophoresis experiment) that, however, did not produce systematic bioscience breakthroughs to benefit the people of Earth, as hoped—nothing comparable to the potential of ISS as a national biotechnology laboratory. Senator Schmitt offered historical perspective, citing the at least 50-year roots of the idea; the diary of T. Keith Glennan, the first NASA Administrator, makes it clear that a relationship between NASA and the National Institutes of Health (NIH) is important for the long-term future of spaceflight. Senator Schmitt noted his own attempts, and those of others, in succeeding decades to start that relationship, despite the difficulty of the task, concluding that the essential ingredient was willing Administrators at both NIH and NASA.

Exploration Committee member Dr. David Longnecker summarized recent developments, beginning with the congressional directive 3 to 4 years ago that NASA should promote use of the ISS as a national laboratory. He noted that Council members, specifically Dr. Longnecker and Dr. Stephen Katz, who heads the NIH National Institute of Arthritis and Musculoskeletal and Skin Diseases, were significantly involved in fostering that approach and a subsequent interagency meeting in December 2006 attended by numerous NIH leaders and representatives of a number of Government agencies, including the Food and Drug Administration, NSF, and U.S. Department of Agriculture (USDA). This meeting was the spark that led to subsequent national laboratory activities and generated other significant organizational cooperation, including many links between NASA and various public and private organizations.

Dr. Longnecker gave many examples of interagency agreements (memoranda of understanding), such as those that NASA signed with NIH and USDA. He cited and briefly summarized three commercial agreements that produced experiments flying on STS-126 (and remaining on board the ISS for a few months). These agreements include proprietary information and have a fairly common theme, cell and vaccine development, because there is something fundamentally different and not yet understood about cell mitosis (i.e., cell division) and cell development in microgravity. First, Bioserve Space Technologies (University of Colorado) has developed proof-of-concept experiments for vaccine and cell development in space. Second, Zero Gravity, Inc., and the USDA have signed a cooperative R&D agreement (CRADA) and are conducting work in plant and animal cell development. Third, Spacehab, Inc., and the Veterans Administration have signed a CRADA for vaccine development, specifically for salmonella.

Dr. Longnecker also described the Biotechnology Space Research Alliance, a spontaneously assembled southern California group that represents a relationship among at least four organizations, specifically (1) Biocom, the industry trade association of more than 500 biotechnology companies and members, (2) the University of California at San Diego, (3) the Howard Hughes Medical Foundation, a highly influential and very important medical research group, and (4) the San Diego Regional Economic

Development Corporation. Collectively, their stated organizational goal is to become the global leader in space-based biotechnology research.

Dr. Longnecker summarized the two most significant human research areas. First, the HRP integrated research plan involves significant developments, including a newly clarified concept of moving from health standards to deliverables. He explained that health standards in general are analogous to engineering requirements (e.g., the extent of allowable bone loss or acceptable radiation exposure over a period of time). Defining these standards more clearly informs both operations and development work (e.g., for Orion and lunar surface operations). He concluded that the HRP integrated plan now relates much more closely the engineering and human factors sides of the NASA organization. Associated activities include a risk mitigation assessment tool for a quantitative assessment of risks. Second, last year, HRP issued both research announcements and awards for ground-based and flight-based research in areas such as musculoskeletal, immunological, and cardiovascular research. Both NASA and the national Space Biological Research Institute have solicited proposals and made awards for specific projects and research protocols.

The Council held a lengthy discussion about hazards versus risks. Senator Schmitt revisited his underlying decades-long concern that NASA has not assembled or implemented a comprehensive plan to identify hazards that create risks. He noted that hazards and risks are different; the hazard must be known before the risk can be assessed. He lamented the absence of a scientifically credible protocol for determining individual or statistical distribution of hazards—whether bone loss, fluid loss, or long-term and short-term issues—by systematically flying and reflying astronauts and gathering data before, during, and after flights. He cited the exception of Skylab and recommended flying those astronauts again to obtain additional data points. Dr. Longnecker agreed in general, noting that NASA has analyzed some individual hazards (e.g., those associated with solar proton events). Observer Dr. Neal Pellis, a senior scientist at the Johnson Space Center (JSC), called to mind a NASA presentation that described the integrated research plan and the standards-to-deliverables approach (i.e., hazards are identified and then experienced for a time frame that poses a risk, and the hazard is the actual effect of that probability). Senator Schmitt observed that most of NASA's biomedical information is anecdotal or near-anecdotal individual data, not systematically and repetitively gathered data on many individuals so that NASA can understand the hazard. Dr. Pellis cited a current example in the ISS Medical Program (i.e., collecting urine specimens before, during, and after flight on all personnel and archiving them in flight for subsequent Earth-side analysis of exposures to microgravity and radiation and associated potential hazards), but he agreed that expanding this approach to other systems is warranted.

Dr. Longnecker reported that principal lunar spaceflight hazards, which differ from those for LEO missions, include two additional major hazards, solar particle events and galactic cosmic radiation (heavy particles that can damage tissue, which exhibits greater cellular, nuclear, and cytoplasmic damage than is normal with x-rays and similar exposures). The cellular and organ damage can be acute, such as central nervous system deterioration, or chronic, such as cancer.

A National Research Council report issued in the summer of 2008 concluded that the physics of such hazards was reasonably well understood, while the Achilles heel in future space exploration planning was biological: "The committee finds that the lack of knowledge about the biological effects of and responses to space radiation is the single most important factor limiting the prediction of radiation risk associated with human space exploration."

Recalling four briefings at Glenn Research Center and informal input from members of the scientific community who are enthusiastic about addressing these issues, Dr. Longnecker cited the NIH role in proton therapy, an expensive (at least $150 million per unit) new cancer cure available from six or seven

centers across the nation, which is leading to expanded resources for biomedical scientists interested in areas relevant to NASA space exploration and spaceflight.

Recommendation

Recognizing that NASA has an active and robust radiation program, the Biomedical Committee made the following recommendation, which the Council approved without objection (after the discussion summarized below):

> **NASA should sponsor a NASA Advisory Council–convened workshop to assess both current knowledge and the research plan to address the health risks associated with human spaceflight beyond low-Earth orbit. Such review must be timely (well prior to the Orion Preliminary Design Review) in order to inform both vehicle and operational requirements for future space exploration.**

Dr. Longnecker explained that upcoming preliminary design reviews (PDRs) and critical design reviews (CDRs) should be informed as much as possible by current knowledge in the radiation field, as are NASA operational plans. For example, NASA described the use of small pressurized rovers (SPRs) for extensive extravehicular activities (EVAs) on the Moon. The Biomedical Committee concluded that these efforts would be enhanced by assembling a group—smaller than the Tempe conference, more like the lunar biomedical workshop held in the summer of 2007—to review these factors, leveraging expertise to assist NASA. Senator Schmitt declared that NASA cannot afford to be wrong on this; confidence is not nearly as high in the outside community as within NASA; and design parameters for Orion, Altair, and future lunar facilities and roving vehicles must be based on best available information. The Council discussed the time-critical nature of this workshop recommendation, which would be helpful in preparing for Constellation CDR and PDR activities. Dr. Longnecker observed that current plans call for eight to nine NAC meetings before the Orion CDR in 2010, but that delay in addressing the radiation issue poses problems, so the Biomedical Committee intends to accelerate the process. Dr. Fraser suggested changing the recommendation language to include "well prior to Orion PDR" to emphasize the Council's concern about providing timely input to NASA and the Council agreed.

Colonel Eileen Collins noted that the four radiation briefings at the last Council meeting still left the impression that much is not known about the effect of space radiation versus radiation on the Earth. When asked, the astronauts cite this as the number one hazard, mainly because of the unknowns. She observed that designers with plans to protect astronauts from radiation can interfere with the operational ability to conduct the mission (e.g., because of bulky, heavy spacesuits). General Abrahamson concurred, citing the example of current lunar rover concepts, which use water as radiation protection, but 2 cm versus 6 cm of water is a big decision because of the huge weight difference, so additional information will be important to the Constellation Program. Senator Schmitt emphasized that an absence of information drives more conservative decisions and higher costs.

Dr. Lucy Fortson asked whether aeronautics data from high-altitude, long-duration flights could be useful for NASA studies of non-LEO missions and the proposed workshop. Dr. Longnecker confirmed that he has seen data for some radiation effects (e.g., cataracts) that show dose-response relationships when comparing radiation exposures for commercial pilots versus the general population versus NASA astronauts. General Lyles cited the rich Air Force School of Aerospace Medicine database on SR-71 and U-2 pilots, including rigorous retention of information for U-2 pilots who are still flying. General Abrahamson suggested that workshop organizers should look broadly across various data sources.

Observation

General Abrahamson summarized the Committee's evaluation of the overall status of the Ares program and its relation to lunar and space transportation planning and architectures. He reported that NASA has examined, exercised, and reviewed more than 1,000 different launch vehicle and operational concepts in terms of cost, schedule, and risk. The Exploration Committee has confidence in the current plan, which is well structured given constraints of budget, schedule, and achievable technology and production. Although alternative approaches will always be suggested, the Exploration Committee concluded that the importance of making this information available and using it in continuing planning warrants the following observation, which the Council approved without objection (after the discussion summarized below):

> **Given the quality of NASA's analysis and the project's momentum, it is imperative to maintain stability and continuing progress on execution of the current plan. The Ares project is well under way with an established baseline and provides a solid foundation for the Constellation Program. The current Exploration Program has strong and accelerating international support and participation.**

General Abrahamson explained the Committee's decision that it is indeed imperative to maintain stability in the current plan, which is relied on not only inside NASA, but also in the international and commercial communities that must provide support. Even well-meaning changes can impact the feasibility of additional international and commercial support for, and involvement in, the program. The Committee concluded that new alternatives can entail cost penalties that can lengthen the gap. Senator Schmitt clarified (and General Abrahamson confirmed) that the Committee has not identified any alternatives to the current architecture that make technical and budgetary sense and that the current architecture represents the most feasible approach to implementing the Constellation Program.

HUMAN CAPITAL COMMITTEE: REPORT AND DISCUSSION

Dr. Gerald Kulcinski, Chair of the Council's Human Capital Committee, presented its report, which focused on (1) the Committee response to the NASA response to a previous Council NASA TV recommendation, (2) status and future of NASA TV, and (3) NASA Education Program update.

Dr. Kulcinski reminded the Council of the July 2008 Council recommendation, "An outside organization should be contracted to do an evaluation of the current effectiveness and viewership of NASA TV and to recommend a clear rationale and set themes for its continuance. This outside entity should take into account the NASA internal 2007 review of NASA TV." He briefly summarized the major reasons for this recommendation, specifically (1) the original NASA TV objective of supporting the Shuttle program, scheduled for retirement in 2010, makes a reassessment reasonable; and (2) numerous decisions are being made that affect NASA TV, so a third-party evaluation (compared to an internal review) is important.

Dr. Kulcinski cited several excerpts from the rather lengthy NASA response. First, the Strategic Communications/Public Affairs Office (PAO) contends that the 2007 analysis of NASA TV was sufficient, so further outside evaluation is not needed. Second, *after* the PAO presentation to the Committee on July 9, NASA developed a comprehensive plan to produce and improve NASA TV content and programming and the NASA Web site. Third, the PAO recommended conducting any outside evaluation of effectiveness and viewership after the new Agency plan is in place.

Dr. Kulcinski provided an overview of NASA's proposed three-step tactical plan. The first step is recognizing NASA TV and NASA.gov as powerful communication and outreach tools and changing the culture of HQ-specific multimedia staffing and funding as well as an apparent lack of coordination

between HQ and the NASA Centers, which fund individual programs. The second step is keeping the lights on; the $2.1 million 2008 budget fell to roughly $1.8 million this year, a going-out-of-business trend. Dr. Kulcinski noted that OMB seems to be penalizing NASA TV for outreach activities, which it views as inappropriate marketing. The goal is to restore the $2.1 million budget, enabling NASA TV to survive and supporting the Web site with one Web editor (but no new development). The third step is to upgrade multimedia ($600,000 a year), make the transition to high-definition television (HDTV) (one-time $2.5 million investment), and possibly offer on-demand capabilities ($85,000 a year).

Dr. Kulcinski described the Committee's reaction to NASA's response. First, NASA is now fully aware of the problem and addressing it, although no solution is yet in place. Second, the technical quality problem can be resolved in part by moving to HDTV, a relatively small investment compared to other NASA line items. Third, the infrastructure problem demands program coordination personnel and on-demand technology, and the new leadership is fighting for the funding necessary by requesting a return to the $2.1 million budget.

The Committee made two observations, coincident with NASA's views. First, content planning should be centralized across NASA to overcome lack of coordination and poor communication between HQ and the NASA Centers. The Committee supported the PAO plan to strengthen interagency coordination. Second, it is too soon to know whether the new plan will be successful, particularly given the 3-month tenure of the new director. Consequently, the Committee consensus was to monitor the status of NASA TV for the next 6 months, emphasizing the quality of content and presentation. The Committee was not entirely happy with the NASA response, but nonetheless agreed to postpone the external review pending the outcome of the implementation of current NASA initiatives. Admitting that the NASA TV budget is extraordinarily small compared to other NASA expenditures, Captain Rick Hauck agreed that the Committee should continue closely watching this program.

Dr. Burns expressed his disappointment in the NASA response, noting that NASA TV offers a huge opportunity to draw the public into the Ares and Constellation programs and the return to the Moon, but is nowhere close to realizing its modern potential and deserves a much higher priority at NASA. He specified that the problem in general is not technology, but rather content. Dr. Fortson agreed that content creation is key, but not as simple as technological issues and much more expensive. Dr. Jim Milgram observed that NASA TV has more dead time than active time, is totally unedited, and cannot even be a good advertisement for NASA. Dr. Kulcinski remarked that NASA TV simply cannot afford to undertake content development.

Colonel Collins asked about the NASA TV demographic. Neither Dr. Fortson nor Dr. Kulcinski had seen a complete audience assessment, despite Dr. Fortson's observation that such information is the foundation for effective content, programming, and packaging.

The Council discussed OMB objections to NASA TV and its budget. Dr. Ford wondered whether the production of slick, expensive professional content would smack more of advertising than education and outreach, so focusing on specifically educational aspects of missions such as Cassini might overcome OMB resistance. Senator Schmitt contended that OMB objects to the very existence of NASA TV as advertising, despite long-standing National Aeronautics and Space Act policy calling for the dissemination of NASA results to the public. Recognizing chronically insufficient funding for public affairs, much less NASA TV, the Senator admitted that the needed culture change in OMB and, indeed, in Congress would be difficult after 50 years of inadequate emphasis on fulfilling the requirements of the Space Act.

General Abrahamson urged consideration of several alternatives, such as incorporating education funds project by project (particularly for science projects), allowing scientists who know the most about the

mission (and its relevance to other science) to devise the message. Dr. Kulcinski responded that each NASA directorate has education funds, but not for NASA TV, and that centralized funding is better than dependence on numerous small variable allocations. General Abrahamson agreed that a centralized approach is better, but acknowledged that the problem with OMB probably is not solvable without a currently unforeseen dramatic development. He also advanced the possibility of NASA forming a joint venture with a professional television editing company that would sell the resulting services to universities, science projects, and the like.

Dr. Ford urged strategic thinking because once NASA TV is eliminated in its current suboptimal form, reapproval of any version will be hard. Dr. Fortson said that the current NASA plan is geared toward using NASA TV as an internal communication tool and upgrading it later—a plan that might help NASA TV avoid elimination by serving internal audiences until public requirements are better understood and assessed (and program strategies and funding are in place).

Dr. Fortson emphasized that television is merging with Internet-based resources such as podcasts, creating real future opportunities that might evaporate if NASA TV is eliminated. Dr. Burns agreed that the frontier is on the Internet; its increasingly high-quality, inexpensive content led him to conclude that the current NASA content development approach might be unnecessarily expensive and that television might not be the best option when the target young audience might respond more effectively to Web sites and simple Web technologies. Senator Schmitt suggested that the Committee review at the next meeting the trade-offs between concentrating available resources on the Web versus continuing television content development when resources probably will not be adequate for substantive improvements. Dr. Kulcinski agreed. Senator Schmitt observed that the consensus of the Council is probably that sufficient resources will never be available in current or anticipated environments to make NASA TV a useful implementation of the Space Act mandate—whereas available resources might support significant Web activities.

Dr. Kulcinski then summarized the role of the NASA Education Program, as manifested in the traditional triangle that emphasizes inspiring, engaging, educating, and ultimately employing students. He observed that several Federal reports and this Committee have been requesting for some time that NASA Education devise high-quality, well-defined metrics to measure its success, rather than relying solely on turnstile data (e.g., number of participants). He reported that NASA began to move in that direction about a year ago and just completed its first full assessment.

Dr. Kulcinski summarized the three program outcomes, specifically (1) for higher education, contributing to development of the science, technology, engineering, and mathematics (STEM) work force; (2) for elementary and secondary (E&S) education, recruiting and especially retaining students in STEM disciplines; and (3) for informal education, forging partnerships between STEM formal and informal providers. He then described objectives for each of these outcomes. For higher education, objectives are faculty and research support, student support, higher education student involvement, course development, and targeted institution research and academic infrastructure. For E&S education, objectives are short-term and long-term educator professional development, curriculum support, and student involvement (the best time to reach students is K-12). For informal education, objectives are support for educational resources, professional development, and informal education opportunities with private organizations.

Dr. Kulcinski explained that the Education Program portfolio review uses thematic questions for each outcome to generate a much more meaningful set of data. For graduate and university education, thematic questions include the source of NASA interns, student majors and alignment with NASA core competencies, and later employment at NASA or other aerospace organizations. For K-12, measuring whether NASA projects are creating a pipeline is not easy, but produces important information for STEM disciplines. Another key metric is the level of NASA content and current mission data in local K-12 projects. For informal education, the key issue is a cluster analysis of NASA education investments that

specifies key investments, identifies targeted and missing audiences, and recommends possible evaluation techniques.

Dr. Kulcinski presented illustrative FY08 data on the 450 funded projects, which do not include any aeronautics projects, but are relatively well distributed across other areas and across directorates, centers, and HQ. He broke down the $191 million Education Program budget, noting that about 58 percent is allocated to higher education, 28 percent to K-12, 11 percent to informal education, and 3 percent to cross-cutting work. The organizational breakdown shows about 75 percent of education funding at HQ, 17 percent at the mission directorates (SMD at about 12 percent), and 6 percent at the centers. After a discussion, General Abrahamson, Dr. Kulcinski, and Senator Schmitt concluded that the $191 million line item includes more education activities at the centers than just 6 percent as well as a large proportion of earmarked funds.

Dr. Kulcinski gave examples of previous turnstile numbers—such as number of underrepresented students, students who receive significant support, and students served through Space Grant projects—which did not offer insights into the quality of, and the impact on students in, the NASA programs. (Each state has a Space Grant program, which drills in on the state education system.) He then summarized the type of data currently collected. After 1 year of participation, 45 percent of higher education students were employed by NASA, its aerospace contractors, or universities or other educational institutions, and another 43 percent went into STEM disciplines. He concluded that 9 out of 10 students involved in NASA projects continue in a STEM-related area, and roughly half of those are employed directly or indirectly by NASA. Roughly 30 percent of undergraduates are pursuing advanced education. In response to a question from Dr. Burns, Dr. Kulcinski pointed out that this is the first year for these data, so no trends are identifiable.

For K-12, Dr. Kulcinski reported that 62 percent of the educators who participated employ NASA resources in classrooms. In addition, 50 percent of the science, engineering, mathematics, and aerospace academy (SEMAA) students, the cream of the crop, plan to work in STEM careers. In terms of national reach, in 2007, about 400,000 K-12 students participated in NASA activities (a turnstile number), and some 200,000 students, teachers, and parents participated in Space Grant precollege activities. In addition, the Education Web site received more than 45 million hits.

Addressing informal education, Dr. Kulcinski observed that 350 museums and science centers are actively engaged in major NASA events. NASA confirms that about 1,750 informal education providers (a number that requires additional explanation) use NASA resources. More than 200,000 individuals participated in Space Grant projects and activities.

In response to a question from Dr. Robinson about the STEM numbers, Dr. Milgram acknowledged that such data currently are very self-selecting, but this is the first attempt to collect the information (a learning curve in progress) and represents a dramatic improvement over previous measures of success. Dr. Kulcinski agreed that the Committee viewed such data positively. Dr. Fortson observed that NASA hired an external evaluator to perform outcome studies, which entail measurements that are difficult to assess and evaluate and pose challenges to researchers who must appropriately elicit motivation data. She agreed that the identification of the most meaningful and relevant outcome questions is ongoing.

Mr. Michael Montelongo focused on return on investment (ROI) for the $191 million budget, suggesting a strategy that enables ROI measurements, beginning with the end goal (e.g., encouraging greater participation by young people in activities that lead to a connection with NASA) and investing in programs that best support that goal. Dr. Kulcinski noted that NASA is contributing to the national goal of attracting people into STEM careers, whether NASA-related or not.

In response to a question from Senator Schmitt, Dr. Ioannis Miaoulis responded that museums have obtained quite a bit of material from NASA and are partnering with universities that have NASA grants (e.g., for the little traveling exhibit on frontiers events), suggesting that NASA and the museums could collaborate on traveling exhibits that museum visitors would love. He concluded that the initiative for such projects is a push-pull relationship between the museums and NASA.

Dr. Fortson reported that in the last 5 years, SMD established the Museum Alliance, which now serves small and large museums (and communities) alike. She observed that NASA is replicating this push-pull model Agency-wide, enabling museums to obtain the same embargoed information distributed to the press and then to prepare visuals and presentations before missions. She explained that this initiative represents a significant difference and substantial progress for museums (overriding previous concerns about obtaining NASA information) and establishes data points of contact for museum personnel. Dr. Miaoulis added that museums are an educational opportunity that NASA has not fully exploited; visitors to the top 20 museums and science centers total tens of millions. Dr. Robinson cited the example of the Adler Planetarium, which will receive Lunar Reconnaissance Orbiter Camera (LROC) data in near real time for an exhibit designed to encourage citizen science initiatives (building on projects such as Stardust at Home) and will share scalable versions of the exhibit with other museums.

AUDIT AND FINANCE COMMITTEE: REPORT AND DISCUSSION

Mr. Robert Hanisee, Chair of the Council's Audit and Finance Committee, presented its report, which focused on (1) KSC finances, (2) unfunded environmental liabilities, (3) Earned Value Management (EVM) accounting, (4) NASA's status on the Government Accountability Office (GAO) high-risk list, (5) FY08 financial statement audit update, (6) transition to the NASA Shared Services Center (NSSC), (7) Continuous Monitoring Program (CMP), (8) Shuttle transition, and (9) several ongoing issues. Mr. Hanisee expressed the Committee's appreciation for the complete access and cooperation of the NASA financial staff at HQ and at every NASA Center as the Committee tries to untangle the Agency's financial Gordian knot.

Mr. Hanisee noted one of KSC's biggest tasks, managing the complex work force as the Shuttle, the largest sustaining NASA program to date, winds down while the Constellation Program ramps up simultaneously. Such a transition can lead to talent and personnel mismatches, but he reported that KSC is handling it with aplomb up to now. In fact, KSC employment figures are essentially the same as those from a year ago, 2,227 civil servants and 13,000 contractors/tenants onsite, including 119 full-time equivalents (FTEs) and 28 contractors in the Office of the Chief Financial Officer (OCFO).

The transition of all center accounts payable to the NSSC entailed a little buildup among contractors; the KSC OCFO lost a few people, but replaced them with contractor personnel to monitor the transition process (an easier metric to reduce later). The KSC budget is now about $1.5 billion, and the OCFO's repeatedly emphasized strategic plan is "making dollars make sense." To ensure cost-effective use of funds, KSC has undertaken 18 different initiatives in functional areas (finance, systems and processes, customers, and team culture) and is making significant progress. The Ernst and Young (E&Y) audit field work found no reportable deficiencies.

Mr. Hanisee explained the status of NASA unfunded environmental liabilities, which respond to an accounting requirement that the future cost of environmental closure of known contaminated sites and facilities must be booked as a liability. Noted some years ago as a significant deficiency, environmental liabilities were removed from the audit report list, but every year E&Y complains that NASA has not secured independent verification and validation of the Integrated Data Evaluation and Analysis Library (IDEAL) software that the Agency obtained from the U.S. Navy and currently uses.

In FY08, NASA booked $943 million in unfunded future environmental liability for 134 different projects at 15 NASA sites, ranging in cost from $12,000 to $168 million. As Mr. Hanisee reported, two projects require more than 100 years to remediate, and the White Sands Test Facility cleanup (probably related to Apollo engine tests) accounts for 39 percent of the $943 million and will require 50 years to complete at the current rate. He declared that such numbers are highly hypothetical and not real, merely the best possible estimates using the IDEAL software parametric methodologies. Nonetheless, E&Y is not satisfied with NASA's handling of this issue because the software does not create an adequate audit trail; NASA's parametric model methodology includes numerous assumptions, and changing any one breaks the audit trail. Concerned that E&Y might again report unfunded environmental liability as a significant deficiency or a material weakness, the OCFO has completed an internal software assurance self-assessment, is preparing a configuration management plan by this December, and is calibrating the parametric model used in the IDEAL software.

Mr. Hanisee emphasized that no environmental safety law or Government regulation requires surveys of individual sites to estimate future environmental liability, yet E&Y is urging NASA to do precisely that (at a cost of $5-10 million) for asbestos remediation at NASA facilities (not included in the $943 million). NASA argued that it is aware of and has remediated such plants, knows associated costs, and should use the parametric estimating tool to calculate an average (mean) liability for each plant and total those numbers—but E&Y objects. The Committee consulted with Dr. Milgram about other possibly more mathematically certain options, and he suggested probability estimating techniques, which are highly accurate when the sample size is sufficiently large. The NASA Chief Financial Officer (CFO) will investigate the viability of this solution, and Dr. Milgram volunteered to contact Stanford statisticians about generating a rough calculation. Mr. Hanisee assured the Council that the Committee would have additional reports at future meetings.

Mr. Ted McPherson addressed NASA's 18 years on the GAO high-risk list, noting that the list is comparable to a below-investment-grade rating by Standard and Poor or Moody's in terms of standard and customary management competencies and delivery of results on time and within budget. He cited the disproportionately negative perception of the list; in January, before budget hearings, a major media event in the halls of Congress identifies agencies on the list as well as those that have been removed. Mr. McPherson reiterated GAO concerns about NASA performance on post-contract-award administration, financial management, program and project management, cost estimating, and analysis.

To illustrate the potential for removal from the GAO high-risk list, Mr. McPherson cited his personal involvement in working with the GAO to remove two agencies that were on the list for 15 to 16 years—the USDA's U.S. Forest Service, with 32,000 employees, and the Department of Education's Federal Student Aid Office, which manages $400 billion of student loans, grants, and guarantees for 22 million customers. He suggested that OMB, GAO, and NASA must agree on evidence of success; for example, major development projects with a life-cycle cost of $250 million or more would be delivered in the future within 110 percent of the baseline cost estimate, within 110 percent of the schedule, and with success requirements met for 90 percent of the missions. A body of evidence or portfolio of results can be built by adding other factors such as a GAO assessment of the quality and depth of management and a clean audit. Mr. McPherson stressed that such an undertaking would have been premature before now.

Mr. McPherson described unobligated funds carryovers; in each fiscal year from 2003 through 2007, NASA had $1.5 billion to $2.1 billion in unobligated funds, basically uninvested funds. The NASA CFO implemented a phasing planning and reporting process to enable NASA managers in all missions to invest appropriated funds more effectively, with a goal of halving unobligated funds. In fact, NASA reduced unobligated funds from $2.1 billion in FY07 to just over $500 million in FY08, a 75 percent reduction. This outcome enhances investment by providing insights about the timing of financial resource deployment and better aligning the formulation of the budget with the execution of the budget to achieve

a meaningful result. A specific example was the reprogramming of $31 million of facility 2-year funds into another current-year purpose, which the Agency otherwise most likely would not have done.

Mr. McPherson concluded that NASA has made reasonably good progress in management reporting that displays the investment portfolio by centers, projects, programs, themes, and missions. The next step is making these techniques more integrated and routine in decision-making and mission reviews. Mr. Montelongo added that from a financial point of view, NASA has confronted and continues to face some significant challenges, but the Agency is installing robust processes that inject rigorous financial discipline. Mr. Hanisee agreed, but explained that the challenge is to institutionalize these processes so that work continues across administrations.

Mr. Montelongo described NASA's CMP, the program initiated to assess, coordinate, and address internal controls and compliance with Generally Accepted Accounting Principles. Since February, the Agency has monitored performance each month, by center, for accounting control activities (e.g., fund balance, accounts receivable, accounts payable, inventory, status of funds). Trends show exceptions (deficiencies) decreasing; the May 2008 exception rate was 17 percent, compared to 9 percent in September 2008.

Mr. Montelongo identified two remaining concerns, soft spots that trigger many errors and corrections. First, the status of funds (i.e., synchronization of budgetary and proprietary accounting) now requires some manual intervention because of limitations in SAP, the NASA accounting system. Second, the Government-wide issue of intra-agency and interagency transactions (i.e., transactions among NASA organizational units or between NASA and other Federal agencies) entails an unnecessarily complex process at NASA. Senator Schmitt asked about any residual impact on the Treasury imbalance, and Mr. McPherson responded that none was in evidence, but a lot of work, error, correction, and rework was required to keep the Treasury balance in synch.

Mr. Montelongo described the NASA Earned Value Management (EVM) process, which ranks as a corporate management imperative—and an OMB and NASA imperative—to control projects and manage performance against plans. NASA is taking a bottom-up approach to this enterprise solution and associated culture change. First, NASA began last year to build EVM competency through voluntary training courses, serving 665 people in FY08 and a projected 1,000 individuals in FY09. Second, NASA is developing an Agency-wide EVM platform by piggybacking on the Constellation Program EVM development process, which will be validated by the Defense Contract Management Agency and then offered to other missions and centers.

Mr. Montelongo reported that this attempt to prevent each mission directorate and center from developing a custom methodology is at risk because EVM tools already are beginning to proliferate at the centers, and senior managers to date have not directed the centers and project managers to employ a central set of tools. General Lyles itemized two common problems in implementing EVM, specifically (1) maintaining consistency across organizational units and (2) involving contractors in the same training program.

The Council and the Audit and Finance Committee discussed the advisability of a recommendation that NASA take steps to prevent the proliferation of conflicting EVM approaches within the Agency. When Senator Schmitt asked, Mr. Hanisee confirmed that none of the Committee members has discussed this issue with NASA because it just came to their attention. Senator Schmitt suggested that the Committee compose a very general recommendation and discuss it with the Associate Administrator in February to confirm that he understands the issue, which falls under his authority and not that of the CFO, and Mr. Hanisee agreed to follow up on that idea.

Mr. Montelongo briefly addressed the Shuttle transition, describing the two categories for selling such materials: property sales, which send sale proceeds to the Treasury, and exchange sales, which allow the Agency to retain 90 percent of the proceeds. NASA intends to use the latter, applying accounting procedures that treat such sale income as refunds. Dr. Kulcinski asked about the magnitude of these upcoming transactions, and Mr. Hanisee admitted that NASA has no idea of the salvage value of what probably amounts to more than 300,000 individual items.

Mr. McPherson updated the status of the 2008 financial audit, observing that the topics discussed by the Committee over the last 3 years are reflected in audit opinions on the financial statements. The goal was not to secure a clean audit opinion, but to implement a solid foundation and perform work that would merit an improved audit opinion. Mr. McPherson summarized the essentially year-round process, which begins with audit planning early in the year, moves to sampling and testing at the centers in the spring and summer, and progresses to preparation of the full-year financial statements (submitted on October 17) and substantive testing of the statements (to be completed by early November). The Agency thus should have an indication of the audit opinion by early November. Mr. McPherson reviewed results (of varying importance) to date, centering on internal control activities; interagency transactions/eliminations; environmental liabilities; property issues; single-grant accounting; closeouts of grants, contracts, and purchase orders; and remaining material weaknesses and reportable conditions from the last 5 years, which now—thanks in part to the work of the Audit and Finance Committee—focus primarily on general accounting (financial systems analysis and oversight) and the property issue.

Mr. McPherson observed that merely progressing to being auditable has required years of fine work by career NASA professionals, led by Terry Bowie, the NASA Deputy CFO, whom the Committee repeatedly acknowledged as laboring in the trenches. Mr. McPherson was pleased to report that Mr. Bowie received the very prestigious Presidential Rank Award, given every year to fewer than 100 career Senior Executive Service civil servants, and the Council offered its congratulations.

Mr. Hanisee reported that the property, plant, and equipment (PP&E) item is still a huge hurdle to overcome because E&Y apprised NASA that it would never receive a clean audit opinion until the PP&E issue is resolved, which requires massive work to redocument all ISS and Shuttle expenses. However, the Office of the Inspector General (OIG) has determined that the required level of nonproductive expenditures is unacceptable. The NASA CFO and Deputy CFO devised a strategy for approaching the Financial Accounting Standards Board, the OIG, and E&Y with a proposal to change the ISS from a capitalizable asset to an R&D facility, an approach already used to write off satellites and other legacy assets. If successful, the Agency could reduce the PP&E item to an arguably immaterial sum given the size of the NASA budget. Mr. McPherson also noted that NASA smoothly implemented the new Integrated Asset Management tool, an SAP module, last May and is applying it to Constellation asset accounting.

Mr. McPherson revisited the HQ OCFO authorized personnel roster of 103 people. OCFO currently has 93 employees and 3 new hires, a shortfall of 7 people. The current hiring freeze will prevent filling those positions, but the CFO reported that the shortfall is spread across four to five functional areas and is not really critical.

Mr. McPherson summarized the NSSC transition update, noting that NSSC has transferred accounts payable from the remaining centers, has integrated these processes, and is basically running smoothly. A passing grade for transaction processing requires paying 98 percent of all processed invoices on time, and the NSSC was at 96 percent in the most recent month and 97 percent the month before. The passing grade for interest payments to contractors because of late invoice payments (essentially wasted money) is $200 in interest payments per million dollars; the NSSC consistently runs at $40 to $50 and now reports $41. Mr. McPherson observed that the NSSC workload has increased to 45,000 transactions per month,

but its technology is beginning to squeak, so additional capital spending will be required. The NSSC is working with the contracting community to encourage electronic invoice submission, which would be a big improvement because the NSSC currently must process invoices that go directly to the centers, starting the invoice payment clock and essentially preventing on-time payment.

Mr. McPherson reminded the Council that the Agency is moving to grant-by-grant accounting, is currently loading the appropriate SAP module, and expects to turn it on by January 2009. Most grants historically have been run though Goddard Space Flight Center (GSFC), and NASA plans to leave all existing grants at GSFC for closeout. The Department of Health and Human Services will continue to issue grant payments while NSSC processes the paperwork, thereby minimizing grant payment disruptions. Mr. McPherson cited one of the advantages of the new system, which will automatically close out a grant after the last payment, solving some of the problems associated with grants that remain open for years although no work is being performed and the final payment has been made.

SPACE OPERATIONS COMMITTEE: REPORT AND DISCUSSION

Colonel Eileen Collins, Chair of the Council's Space Operations Committee, presented its report, which focused on (1) the SOMD update, (2) FY09 Shuttle and ISS program plans, (3) ISS access, (4) ISS as a national laboratory, (5) Commercial Orbital Transportation Services (COTS) activities, (6) the Space Communications and Navigation (SCaN) program, and (7) Orion crew display development. She noted that the Committee had held teleconferences on the Soyuz TMA, which had problems with ballistic reentries on Soyuz TMA 10 and 11, and was pleased with Russian-NASA cooperation to clear the current Soyuz flight.

Colonel Collins highlighted the updated SOMD status, observing that the budget is sufficient to undertake Shuttle, ISS, and other planned activities under the continuing resolution (CR) that expires on March 6, 2009, and even under an additional CR extension to the end of the year, because the SOMD FY09 budget is similar to the FY08 budget.

The recently signed NASA Authorization Act of 2008 (succeeding the previously approved NASA Authorization Act of 2004) includes key provisions. First, the Act specifies Utilization Logistics Flights 4 and 5 (ULF-4 and ULF-5) as the last two ISS missions on the Shuttle baseline flight manifest; they will deliver critical spares, support logistics during the flight gap, and return critical equipment to Earth. Second, it adds a mission (possibly the last Shuttle flight, but order might change) to deliver the Alpha Magnetic Spectrometer, designed to study dark matter, to the ISS. Third, as discussed by the Audit and Finance Committee, NASA must inform Congress about its plan for disposition of Shuttle orbiters and hardware (ground and flight) within 90 days of passage of the Act. Fourth, before April 30, 2009, NASA must terminate or suspend any activity that precludes continued safe operation of the Shuttle beyond 2010, thereby preserving the next Administration's option to delay retirement. Fifth, within 120 days of passage of the Act, NASA must report to Congress on options, impacts, and costs associated with Shuttle operations after 2010. A soon-to-be-released study, stimulated in part by the Council, focuses on two options: extending the life of the Shuttle by 1 to 2 years (and flying 1, 2, or 3 additional missions per year) or by 3 to 6 years, until 2015 (and flying an additional 1, 2, or maybe 3 missions per year). Colonel Collins expects more details by the next NAC meeting. Sixth, NASA must take all necessary steps to ensure ISS operation through at least 2020. Although the ISS is funded through 2016 (and has a budget of zero thereafter), it is not showing signs of aging so rapidly that it must retire, so Congress is assessing extending operations through 2020.

Colonel Collins highlighted the Space Shuttle Program Plan, including the primary directive to retire the Shuttle no later than 2010 after five flights in FY09 and five flights in FY10. She noted that the delay in the final Hubble Space Telescope servicing mission means only a 4-6 week slip, pushing the last Shuttle

flight to May 2010 rather than April 2010, a feasible change. The plan supports the Ares I-X test flight; incorporates severance and retention costs through the last flight, such as contractor work force retention initiatives, employee incentives, and support for employee skill conversion classes, including funding; and covers transition and retirement costs through 2010.

Colonel Collins reviewed the ISS Program Plan, observing that NASA is on course to build out the ISS by adding international partner elements (e.g., the European Columbus laboratory and part of the Japanese component). She summarized the next Shuttle flight, which will support six-person operations (starting next spring) by delivering key systems such as a water processing facility (to be checked out before more astronauts arrive), an advanced resistance exercise device, and sleep stations. She commended NASA on its plan for rotating crew members in the out-years (two or three Russians, two or three Americans, and one international crew member). Citing ISS funding for commercial cargo transportation (which also helps firms raise private funds), Colonel Collins noted that one of the challenges in the current tight budget is funding COTS launches because costs are a little higher than originally thought, not a surprise in the space business.

Congress last month approved an extension of the INKSNA waiver through 2016, so NASA can continue to develop contracts for planned Soyuz flights through September 2014. Colonel Collins deemed the waiver very good news; despite reliance on the Russians, astronauts can be transported to the ISS during the gap. Starting next spring, Russia will launch four Soyuz vehicles each year, and they already have lists of prime and backup cosmonauts and astronauts for each flight as well as required training.

Because of the currently scheduled decommissioning of the ISS in 2016, NASA confronts the challenge of securing additional funding if ISS operations are extended to 2020. Colonel Collins showed the Council a timeline of ISS development milestones, including Node 3, the last major U.S. element, launching in 2010; the regenerative Environmental Control and Life Support System, launching next month (and key to staffing the ISS with six crew members); habitability modules; water collection system; crew quarters and galley; carbon dioxide removal system; exercise equipment; ExPRESS Logistics Carrier, which allows spares to be stored on the outside of the ISS; and Station-to-Shuttle Power Transfer System, now installed on two orbiters (Endeavour and Discovery), which is performing well and enables the Shuttle to stay in orbit longer. She described the recent operational problem with the starboard Solar Alpha Rotary Joint (SARJ) that limited the power available to build and to fully engage international participation. NASA found the root cause, so the next Shuttle mission (ULF-2) will be able to restore full power during an EVA to repair the starboard SARJ.

Colonel Collins focused on the operational perspective of ISS as a national laboratory, noting that Dr. Longnecker already discussed this topic in depth in the Exploration Committee report. This perspective is driven by the need to access and fully exploit the ISS facility (i.e., the COTS program, acceleration of the Constellation Program, and possible extension of the Shuttle timetable are all a response to the need to access the ISS). She displayed the ISS National Laboratory End-User Network diagram, which depicts the academic, industrial, and government organizations that negotiate agreements with NASA to use the ISS national laboratory facilities.

Noting that Congress designated the U.S. component of the ISS as a national laboratory in 2005, Colonel Collins emphasized the importance of the science that can be conducted on the ISS until 2016 (or 2020) by astronauts who sometimes merely turn the experiment on and off and other times address more extensive work requirements and specific milestones. She cited several examples. First, the 2008 NASA Space Act Agreement (SAA) with Spacehab studies the salmonella bacteria in space, where cells behave differently, especially if left on the ISS for 3 to 6 months (rather than flying 1 or 2 weeks on the Shuttle). For instance, in microgravity, gene expression within cells is dissimilar; some cells (such as salmonella) grow more rapidly; mass transfer at the cellular level is different; and fewer bacteria appear to be required

to create an infection. Second, the 2008 Zero Gravity, Inc., SAA entails a plant and animal genesis experiment that employs cell division to create new cell lines. Third, the Ad Astra SAA is still under development, as are mission profile specifics, but will offer an opportunity to test the company's new electric propulsion engine, the Variable Specific Impulse Magnetoplasma Rocket (VASIMR), by turning it on for 10 minutes in space and testing its performance.

Colonel Collins updated other SOMD programmatic elements, including the Launch Services Program Plan, which underpins the nine NASA FY09 payloads; Crew Health and Safety Program Plan; and Rocket Propulsion Test Program, which SOMD supports by furnishing fire protection, communications, and documentation services.

Colonel Collins then highlighted recent SpaceX activities, including a successful Falcon 1 launch (no payload) from Quajaline last September. The flight goals were to enter orbit and restart the engine to circularize the orbit, which SpaceX accomplished by placing the Falcon 1 in a roughly circular orbit at 600 km, with an inclination of 9 degrees. SpaceX also successfully completed a Falcon 9 engine test firing at its static test facility in McGregor, Texas. Future goals include three more Falcon 1 launches through 2009 and a Falcon 9 test launch in June (again, orbital insertion only). General Lyles asked when SpaceX would conduct a test flight with a payload on board, observing that the firm should work very closely with the Department of Defense Space Test Program because it has a consistently long list of experiments waiting for a ride and because the experiment owners would recognize and accept the high risk of a test flight, enabling SpaceX to integrate a Falcon payload.

Colonel Collins summarized the visit of Admiral Ben Montoya to Pad 40 on the Cape side to tour the SpaceX facilities. She noted that the Admiral met highly motivated personnel diligently performing work on structural, mechanical, and electrical components. The Committee plans to visit the SpaceX factory in California soon.

The Science Committee and the Space Operations Committee arranged a joint briefing on the Space Communications and Navigation (SCaN) program to assess NASA's plan to deliver sufficient bandwidth to relay dense data streams to Earth from the steadily increasing number of science missions and human exploration missions—not just to the ISS, but to the Moon and one day to Mars. She expressed the concerns of both committees about the current SCaN requirements, which were very general, included no numbers at all, and incorporated very little schedule or budget information. Senator Schmitt observed that requirements for various activities over the next 20 years have been seriously underestimated, and the resulting data streams are *huge*. He asserted that the three mission directorates must have some idea of their data transmission requirements for missions and for continued and enhanced ISS operations, but that information has not reached the SCaN team for integration into a strategic plan. Mr. Jay Greene observed that the Constellation team has a command and control plan scaled to its own program, but might not communicate with SCaN personnel. Dr. Jolliff reframed the issue more specifically, noting that choice of transmission technology—optical communication systems, lasers, Ka band—has a critical influence on other elements, such as type of receivers in the Deep Space Network and other networks (where aging 70-meter antennas must be replaced with 34-meter arrays or another option). Senator Schmitt added that inserting Earth into the data processing loop for Mars demands serious consideration of optical technologies, which might argue for briefings from NASA and external experts to quantitatively evaluate the SCaN approach and possible elements of a strategic plan. Dr. Ford noted that regardless of the technology employed, protocol issues, which are the same for robotic and human missions, must be rolled into the Council's ongoing discussions on network security.

Declaring that SCaN is begging for a recommendation to quantify requirements, devise metrics, and develop a schedule and budget, Colonel Collins reported that the two committees will revisit the critical SCaN issue and develop a recommendation at the next meeting. Because ESMD did not participate in

this briefing and the SCaN architecture is much less developed than relevant mission and vehicle architectures, Senator Schmitt suggested that three committees (Space Operations, Science, and Exploration) should follow up with discussions to better define data transmission requirements and strategic plan topics and thus produce a more substantive recommendation. In response to a question from Senator Schmitt, Mr. Greene concluded that he would expect SCaN to be further along at this stage of Constellation development and that SCaN needs more robust leadership.

Colonel Collins reported that the Committee visited JSC in July to consult with the Orion Crew Exploration Vehicle rapid prototyping team. The team goal is to design prototype displays and crew interfaces. Colonel Collins described the current prototype, which has three screens, each divided into two displays. The crew interfaces with the displays by using (1) the bezel buttons around the screen, similar to those in aircraft, (2) the control stick, and (3) the little keyboard, now only at the test facility. She concluded that the displays are both traditional (with functions such as guidance and navigation, flight control displays, attitude, and performance) and nontraditional (with the capability to display procedures on screen, rather than in a paper checklist, thereby enabling pilots to interact with the procedures, for example, by choosing the line and executing tasks such as opening and closing valves and operating circuit breakers, similar to ISS operations). Although the windows look small, the view during rendezvous is enhanced by displaying docking on the screens. The team has produced only three to four prototypes to date; however, Colonel Collins reported that they seem to have thought of everything, including soliciting evaluations from crew members and external experts and applying some off-the-shelf aircraft display development software.

Senator Schmitt asked whether the rapid prototyping team intends to eliminate paper in the cockpit so that the only single point of failure is the display itself. Colonel Collins responded that the Aerospace Safety Advisory Panel (ASAP) is examining the level of redundancy not only in systems, but in Orion overall. Moreover, she did ask about redundancy if one or all of the displays failed. The current strategy includes developing a system with backup flight hardware (similar to the Shuttle approach) and carrying paper copies of critical emergency procedures, such as those for rebooting displays after an electrical failure. However, the team is attempting to minimize both the number of switches and the need for hard copies.

Senator Schmitt inquired whether the team anticipates a different set of displays for lunar missions compared to ISS rendezvous operations. Colonel Collins indicated that the team has not started work on lunar displays, instead focusing on launch and reentry; systems displays; launch and reentry guidance, navigation, and control; and rendezvous profiles. She noted that the current Constellation acceleration study might address this issue as part of the option to drop lunar components now, but reinsert them in the future as appropriate.

Mr. Greene objected to leaving avionics and software decisions to individual project managers rather than a central software office, so Altair computers could differ from those in Orion. Senator Schmitt commented that such stovepiping is one of the Administrator's concerns. When Mr. Greene reminded the Senator that the Lunar Excursion Module (LEM) and the Command Service Module (CSM) both used the same verbs and nouns, Senator Schmitt recalled that even he could operate the CSM after learning to fly the LEM. Dr. Ford extended the issue to concerns about the unclear locus of authority and responsibility across the Constellation Program for computing functions. Dr. Ford declared that some organization somewhere must integrate such functions in a coherent whole. Mr. Greene suggested establishing a Level 2 software and avionics office.

Colonel Collins reported that despite NASA's response, the Space Operations Committee believes that lunar surface mobility lies at the heart of daily crew operations and thus contends that its recommendation last summer is still valid: "It is the opinion of the Space Operations Committee that the United States should take the lead in developing lunar surface mobility."

APPENDIX A

NASA ADVISORY COUNCIL
Hilton Cocoa Beach Oceanfront
Sea Oats Room
Cocoa Beach, Florida
October 16, 2008

MEETING AGENDA

8:00 a.m. – 8:15 a.m.	Opening Remarks	Hon. Harrison Schmitt
8:15 a.m. – 9:15 a.m.	Aeronautics Committee	Gen. Lester Lyles
9:15 a.m. – 10:15 a.m.	Science Committee	Dr. Jack Burns
10:15 a.m. – 10:30 a.m.	*Break*	
10:30 a.m. – 11:30 a.m.	Exploration Committee	Gen. James Abrahamson
11:30 a.m. – 12:30 p.m.	*Lunch (Council Only)*	
12:30 p.m. – 1:30 p.m.	Human Capital Committee	Dr. Gerald Kulcinski
1:30 p.m. – 2:30 p.m.	Audit and Finance Committee	Mr. Bob Hanisee
2:30 p.m. – 2:45 p.m.	*Break*	
2:45 p.m. – 3:45 p.m.	Space Operations Committee	Col. Eileen Collins
3:45 p.m.	Adjourn	

APPENDIX B

NASA ADVISORY COUNCIL
Members and Committees
October 16, 2008

Role/Group	Members
Chair	• **Hon. Harrison H. Schmitt**, Apollo 17 Astronaut and Scientist
Aeronautics Committee	• ***Chair***: **General Lester L. Lyles**, Consultant, The Lyles Group • **Dr. Eugene E. Covert**, T. Wilson Professor of Aeronautics (Emeritus), Department of Aeronautics and Astronautics, Massachusetts Institute of Technology • **Dr. John Sullivan**, Professor, Aeronautics and Astronautics, and Director, Center for Advanced Manufacturing, Purdue University
Audit and Finance Committee	• ***Chair***: **Mr. Robert M. Hanisee**, CFA; Managing Director, Trust Company of the West • **Hon. Edward R. "Ted" McPherson**, Chief Executive Officer, InterSolve Group, Inc. • **Hon. Michael Montelongo**, Senior Vice President, Strategic Marketing, Sodexho, Inc.
Exploration Committee	• ***Chair***: **Lieutenant General James A. Abrahamson**, USAF (Ret.) • **Dr. Kenneth Ford**, Founder and Director, Florida Institute for Human and Machine Cognition • **Dr. Donald C. Fraser**, Member of the Board, DRS Technologies • **Captain Frederick H. "Rick" Hauck**, USN (Ret.); NASA Astronaut (Ret.) • **Dr. David Longnecker**, Chair, Committee on Aerospace Medicine and the Medicine of Extreme Environments, Institute of Medicine, National Academies
Human Capital Committee	• ***Chair***: **Dr. Gerald L. Kulcinski**, Associate Dean for Research, College of Engineering, University of Wisconsin-Madison • **Dr. Lucy F. Fortson**, Vice President for Research, Adler Planetarium and Astronomy Museum (Chicago) • **Dr. Ioannis Miaoulis**, President and Director, Museum of Science (Boston) • **Dr. R. James Milgram**, Professor, Department of Mathematics, Stanford University
Science Committee	• ***Chair***: **Dr. Jack O. Burns**, Professor, Department of Astrophysical and Planetary Sciences, University of Colorado; Vice President (Emeritus), Academic Affairs and Research, University of Colorado System • **Dr. Bradley L. Jolliff**, Research Associate Professor, Department of Earth and Planetary Sciences, Washington University (St. Louis) • **Dr. Mark S. Robinson**, Professor, School of Earth and Space Exploration, Arizona State University • **Dr. Byron D. Tapley**, Director, Center for Space Research, and Professor, Aerospace Engineering, University of Texas at Austin
Space Operations Committee	• ***Chair***: **Colonel Eileen M. Collins**, Astronaut (Ret.) • **Dr. Pat Condon**, Vice President, Strategy and Executive Consulting Services, Shipley Associates • **Mr. Jay H. Greene**, Consultant, Aerospace Engineer • **Dr. Thomas D. Jones**, USAF (Ret.); NASA Astronaut (Ret.) • **Rear Admiral Benjamin F. Montoya**, CEO, Smart Systems Technologies, Inc.
Ex Officio	• **Dr. Raymond S. Colladay**, Chair, Aeronautics and Space Engineering Board, National Academies • **Dr. Charles F. Kennel**, Chair, Space Studies Board, National Academies

Role/Group	Members
Not in Attendance	• **Dr. Owen K. Garriott**, Adjunct Professor, Department of Biological Sciences, University of Alabama in Huntsville; NASA Skylab and Spacelab Astronaut (Ret.) • **Dr. Stephen I. Katz**, M.D., Ph.D.; Director, National Institute of Arthritis and Musculoskeletal and Skin Diseases • **Dr. Ilan Kroo**, Professor, Aeronautics and Astronautics, Stanford University • **Dr. John M. Logsdon**, Charles A. Lindbergh Chair in Aerospace History, National Air and Space Museum, Smithsonian Institution • **Mr. Howard J. Stanislawski**, Partner, Sidley Austin Brown & Wood, LLP

APPENDIX C

NASA ADVISORY COUNCIL
Hilton Cocoa Beach Oceanfront, Cocoa Beach, Florida
October 16, 2008

ATTENDEES

Council Members	NASA Attendees		Other Attendees	
Abrahamson, James A.	Cooke, Doug	HQ	Block, Bobby	Orlando Sentinel
Burns, Jack	Green, Thomas	HQ, OCFO	Brandow, Heidi	ITT Corporation
Colladay, Raymond S.	Halsema, John T.	KSC	Chafer, Sallie Birket	NASA consultant, meeting recorder
Collins, Eileen	Iademarco, Paul	HQ	Dermody, Jim	Optronic Laboratories, Orlando
Condon, Pat	Keaton, Jacob	HQ	Ellegood, Edward	Embry-Riddle Aeronautical Univ.
Covert, Eugene	King, Marla	HQ	Faulconer, Walt	Applied Physics Laboratory
Ford, Kenneth	Mango, Ed	KSC	Halvorsen, Todd	Florida Today
Fortson, Lucy	Parham, Jane	HQ	Heard, Marsh	EDC
Fraser, Donald C.	Pellis, Neal	JSC	Ketcham, Dale	SRTI/Univ. of Central Florida
Greene, Jay	Riesco, Melissa	HQ	Luney, Percy	Space Florida
Hanisee, Robert M.	Wetmore, Michael	KSC	Nicholas, Lisa	Office of State Rep. Ralph Poppell
Hauck, Rick	Wolfe, Jean	HQ	Nuckles, David	SAIC
Jolliff, Bradley L.			Parsons, Kevin	Northrop Grumman
Jones, Thomas			Rein, Michael	United Launch Alliance
Kennel, Charles F.			Rye, Jessica	Alliant Techsystems (ATK)
Kulcinski, Gerald L.			Sasso, Tony	State Representative, District 32
Longnecker, David			Shaulis, Steven	Pratt & Whitney Rocketdyne
Lyles, Lester L.			Solid, Lee	EDC
McPherson, Edward R.			Spicer, Deb	Space Florida
Miaoulis, Ioannis			Sprague, Rebecca	KSC Spaceport News
Milgram, R. James			Yates, Tracy	United Space Alliance
Montelongo, Michael				
Montoya, Benjamin				
Robinson, Mark S.				
Schmitt, Harrison H.				
Sullivan, John				
Tapley, Byron				

APPENDIX D

NASA ADVISORY COUNCIL
Hilton Cocoa Beach Oceanfront
Cocoa Beach, Florida
October 16, 2008

MEETING PRESENTATION MATERIALS

List of Committee Presentation Materials*

1. Aeronautics Committee Report to the NASA Advisory Council [Lyles]
2. Science Committee Presentation to NAC Plenary [Burns]
3. Exploration Committee and Ad Hoc Biomedical Committee Report [Abrahamson]
4. Human Capital Committee Report [Kulcinski]
5. Report of Audit and Finance Committee [Hanisee]
6. Space Operations Committee Report [Collins]

Other Materials Distributed at the Meeting

1. NASA Advisory Council, Meeting Minutes, July 10, 2008
2. NASA Responses to NASA Advisory Council 2008 Recommendations (to date)

***** Presentations and other materials distributed at the quarterly NAC meeting are available (1) online at http://www.hq.nasa.gov/office/oer/nac/minutes.htm and (2) on file at NASA Headquarters, OER/ACMD, 300 E Street SW, Washington, DC 20546.