NASA ADVISORY COUNCIL (NAC)

Science Committee

NASA Headquarters
October 31-November 1, 2011

Wesley T. Huntress, Jr.
Chair

T. Jens Feeley
Executive Secretary

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November 11, 2011

Dr. Huntress convened the NAC Science Committee session of Monday, October 31, 2011 at 8:30 a.m.

OPENING REMARKS:
Dr. Wesley T. Huntress, Jr., Chair
Dr. T. Jens Feeley, Executive Secretary

Dr. Huntress called the meeting to order at 8:30 a.m., thanking Dr. Tapley for having chaired the previous meeting in his absence. Huntress noted, with sadness, the recent death of Michael Drake, who, Dr. Huntress noted, having worked so hard to have his mission selected, he would now be unable to take part. Next, he noted the death of NAC Science Committee member Ron Greeley, whom Huntress termed a pioneer figure in the field of planetary geology, a significant participant in virtually every Mars mission since Pathfinder, and 'a gentleman, scholar and mentor.' Dr. Huntress also noted the recent death of Andrew Dantzler, former director of the Solar System Exploration Division, at age 49.

Dr. Huntress noted the retirement of Ed Weiler, after thirty-three years of "service to NASA science," including nine years as Associate Administrator of Science Mission Directorate (SMD). Huntress praised Weiler for 'his passion, his integrity, and his leadership in science.' Huntress noted that Chuck Gay was serving as Acting SMD Associate Administrator. He further observed that the terms of two other NAC Science Committee members, Roy Torbert and Michael Turner, had expired; replacements were being sought. A certificate was then read noting the accomplishments of Richard Fisher, who directed the Heliophysics Division from 2002 through 2011, and now retiring. The certificate was endorsed by all members of the NAC Science Committee.

Dr. Feeley then presented an updated organization chart, showing Chuck Gay in the position of Acting Associate Administrator and Colleen Hartman in the position of Assistant Associate Administrator. Dr. Tapley called attention to the forthcoming report on the Joint Agency Satellite Division, which, he said, has been in operation for eighteen months. Its task was to take responsibility for all the reimbursable activities that NASA did with other agencies. Dr. Tapley thought it would be good for this committee to hear more details about what that Division does; a presentation was on the agenda for that afternoon.

ASTROPHYSICS SUBCOMMITTEE SUMMARY
Mr. Geoff Yoder; Acting Director, Astrophysics Division
Dr. Alan Boss, Chair, Astrophysics Committee, Carnegie Institution

Mr. Yoder presented the Astrophysics Division organization chart and the Astrophysics mission timeline. He noted that a fair number of current projects had been through Senior Review; three more projects, including Hubble, would enter Senior Review in 2012.

Dr. Hinners asked if the Division was proceeding with a nominal or a fixed budget. Yoder responded that for the most part a nominal budget would be used, with a separate budget for Senior Review. Yoder reported on Stratospheric Observatory for Infrared Astronomy (SOFIA), saying that the second general instrument Announcement of Opportunity (AO) had been issued on July 8, 2011; all responses had been received by October 7, 2011. The Division was targeting later in 2012 for the next Explorer AO.

Mr. Yoder, reporting on NuSTAR, said vacuum testing has been completed on July 31, 2011, with no major problems. He noted that NuSTAR was on the test bed during the April earthquake. The project was on schedule for launch in March 2012.

On Astro-H, Yoder said performance testing at cryogenic temperatures had been completed; the Calorimeter Spectrometer Insert (CSI) was completed: this was the major deliverable to the Japanese Space Agency (JAXA). He added that the flight model mirror was in fabrication, as was the detector array.

Mr. Yoder identified recent advances on SOFIA. While still in development, SOFIA had permitted the successful observation of the Pluto occultation on June 23, 2011. This had required making a last-minute shift in position of approximately 150 miles; nonetheless, virtually all of the Pluto occultation had been observed. On September 2011, SOFIA made its first international deployment in Germany, where people had waited in line several hours for the tour. A second 'public appearance'

occurred in September at Andrews Air Force Base near Washington D.C. for the benefit of military families and their children. Turning to the balloon program, Mr. Yoder said the Division desired to take longer flights; the current longest flights were four to six weeks in Antarctica; the goal was flights of 100 days.

Mr. Yoder then provided the schedule for the 2012 Senior Review. He noted that in this review the review of Education and Public Outreach (EPO) would be conducted simultaneously. The report was to be delivered to the Division by March 30, 2012. Missions newly added to the Senior Review list were Hubble, Fermi and Kepler; he wanted to make sure that each had completed the requisite basic Level I requirements before moving into Senior Review. Dr. Boss noted that Kepler was having trouble with noise. The project had assumed that the Sun was the nominal quiet star; in fact, it happened that 'quiet stars' were fifty percent noisier than the Earth's Sun. The difference significantly affected the received background signal that needed to be overcome. Dr. McComas asked if by noise Boss meant randomness. Boss replied that there was non-systematic randomness in the noise.

Professor Hubbard noted that everyone in the space science community was concerned with budgets; when you reached a Senior Review with the number of missions under consideration, he said, it suggested that you would have a significantly smaller number of operating missions. Mr. Yoder said that was difficult to say; he did not wish to guess. At present, both the FY'12 and FY'13 budgets were unknown. He believed the Division was in a fairly good financial position; he would not say no cuts might occur.

Dr. Boss noted that the most recent Senior Review had involved more major cuts than anticipated. Mr. Yoder said that the Division took the comments of the Senior Review very seriously. Dr. Tapley asked whether it was possible to generate considerable savings in a mission without turning that mission off. Yoder noted that a recommendation to stop the Guest Investigator portion of a mission was an example of how costs could be reduced.

Mr. Yoder reported on the desire to increase the number of Explorer missions – fifteen APD missions capped at $200 million and eleven SALMON missions capped at $55 million. Mr. Yoder then reported on Programmatic Special Topics; these included the desire to get a communications plan with the right information targeted to the right people, internally and externally; the evolution of an Astrophysics website that would be the single-source for pertinent information; the initiation of new quarterly Program Office meetings to improve communication between the program offices, U.S. program expertise and building outreach. Yoder then noted that the ESA Astrophysics Working Group (AWG) had on September 19, 2011 Recommended that Solar Orbiter and Euclid be selected as the M1 and M2 missions; these recommendations were accepted by the AWG.

Mr. Yoder called attention to significant awards received by persons in the astrophysics field, including the three individuals who had shared the 2011 Noble Prize in Physics for the 'discovery of the accelerating expansion of the Universe through observations of distant supernovae.' Yoder than presented a list (slide #19) 'Top Ten + 1' science achievements of the year, including Fermi's discovery of the giant structure of the galaxy; Chandra's discovery of the youngest black hole; Kepler's discovery of its first rocky planet; and Fermi's recording of antimatter being hurled into space. He continued with a listing of FY2011 Science Highlights.

Dr. Hinners asked if a ninety-day balloon experiment required an increase in balloon technology. Yoder said that was a "yes and no" matter; when larger payloads were launched, more attention had to be paid to the strength of the seams. The same issue had arisen in Antarctica several years ago when several seams had pulled apart.

Relative to work with ESA, Dr. Boss read a portion of the Astrophysics Subcommittee's (APS) letter, stating:

> The APS encourages NASA to explore with ESA and possible way on enhancing the scientific yield of the Euclid missions through U.S. participation at a level allowable by ESA and consistent with NASA's available resources.

The highest financial figure quoted for U.S. participation was twenty percent of the total cost. Dr. Tapley asked whether that twenty percent involved infrared activities. Mr. Yoder said that possible NASA participation in the Euclid mission was still in an exploratory phase; various things had been considered

in terms of U.S. contribution. Attention had to be paid to determining what ESA could purchase directly or from the U.S. Any outcome, he said, would give NASA a 'seat at the table.' Dr. Huntress asked if there was a clear idea of what resources NASA had to contribute. Yoder said there was not. Dr. Boss said figures in the range of two to twenty percent had been discussed.

Professor Hubbard noted that Euclid was part of ESA's mandatory program; the undertaking was as definite as it could be. ESA was planning on letting contracts in summer 2012. The 'ESA clock was ticking – that's why they have to know what NASA's interest may be. Dr. Boss said there was a strong motivation for NASA to have some impact. Dr. Feeley noted that Euclid was part of the space science component of ESA; this made it mandatory.

Mr. Yoder then presented the APS letter on James Webb Space Telescope (JWST), affirming that JWST was one of the Administration's three top goals for NASA. In consequence, $156 million in additional funding was needed in FY12 to complete and launch the mission by 2018. While the apportionment remained under discussion, the APS letter said that additional funds for JWST were anticipated. The letter noted that the source of the additional $1.052 billion in additional funds was a matter of concern to other Divisions.

Mr. Yoder noted that in the forthcoming Senior Review, Hubble could absorb over half the funds available for all missions. He added that Kepler could become a bare bones budget. Next, he presented an APS letter on the De-orbiting of Hubble. This could be undertaken as a NASA activity; Hubble will de-orbit on its own in approximately 2025. A de-orbit mission was now estimated at $500 million, an estimate that could rise to the level of a Flagship Mission. Dr. Hinners asked if the de-orbiting would be human or robotic. Dr. Boss noted that the most recent Hubble servicing mission added a tow ring to the frame. Mr. Yoder noted that any money spent on Hubble meant funds not spent on science; perhaps some robotic technology mission could be contrived that would provide a science return. Dr. Hinners asked if the option of human intervention was being considered. Mr. Yoder said the Aerospace Corporation had been asked to do an independent assessment of alternatives. The need, he said, was to look at what was the cheapest and most effective way to bring this mission down.

Mr. Yoder then presented an APS letter on APD/SMD, stating it part the "wish to thank Ed Weiler for his three decades of dedicated service to NASA." The letter noted that search efforts were underway for a replacement and that Acting Director Mr. Yoder was 'continuing to move forward with APD agenda.'

Further conversation on Senior Review ensued. Professor Hubbard asked when a mission was invited in to the Senior Review process, did their operating budgets come with them or if decisions on each project were made from the aggregated pool of funds. Mr. Yoder said Senior Reviews occur every two years. There was no single pool of funds for everyone to fight over. .

Professor Hubbard asked if a mission lost dollars, did it go directly to the general pool. Mr. Yoder said no. An audience member commented that the Senior Review provided advice; all decisions on funding were then up to the Division administrators to make the financial decision. Dr. Huntress said the Hubble de-orbit looked a 'little frightening;' he wished to hear more from some appropriate source. Dr. Feeley said the important information might be embargoed; Huntress noted that, should that be the case, the committee could still pose questions.

PLANETARY SCIENCE SUBCOMMITTEE
James Bell, Arizona State University
(By speakerphone)

James Bell said 'a real giant in the field had been lost last week,' a reference to Ron Greeley, who died at age 72. Greeley, Bell said, was owed a debt of gratitude by many present. Bell described the missions in which Greeley had been involved; the researchers he had mentored and the services for the community he had performed. It was, Bell said, difficult to think of a Mars mission in which Greeley had not been significantly engaged. He noted that plans for a memorial service were pending.

Dr. Bell said his presentation on the status of the Planetary Science Subcommittee had been largely prepared by Greeley and Jim Green. He, as Acting PSS Chair, would deliver the report that would include 'science nuggets', present major PSS Discussion Issues and Concerns, and report out the Assessment of the PSD *'Mission-Enabling Activities.'* On 'science nuggets,' Bell reported that Mars

Exploration Rover (MER) (slide #6) had completed a three-year 20-kilometer journey to the Endeavor crater, providing 'new vistas, new rocks and new science.' The rover was in very good shape; it was analyzing the materials on Endeavor's rim, where clay and silicate were located. Bell reported on the forthcoming summer workshop on lunar volatiles; the Lunar Exploration Analysis Group (LEAG) had reported evidence of lunar water [???]. This, he said, was becoming a hot topic again. He reported that Messenger, orbiting around Mercury, had supplied data for a major paper on fluid volcanism; he noted that smooth planes on Mercury, which comprise about six percent of the planet's surface, have been posited as volcanic; flow activity can be seen.

Regarding the Small Bodies Assessment Group (SBAG), Dr. Bell said the Wide-field Infrared Survey Explorer (WISE) was turning into 'a wonderful' planetary science discovery mission; it had discovered the first Earth Trojan satellite.

The Cassini Solstice Mission, Dr. Bell reported, detected strong radio emissions indicating a major thunderstorm; this raised the question of whether there were similar spring storms on Uranus and Neptune. Venus Express, he noted, had engaged in the continued detection of 'whistlers,' which were a proxy for lightning and electrical activity. James Bell added a report on CAPTEM and the recovery of a small (150 micrometer) rocky particle from near-earth asteroid 25143 by the Japanese spacecraft Hayabusa; approximately 1500 dust-sized particles had been returned by Hayabusa, confirming that the asteroid was comprised of very primitive solar system material.

Discussing Planetary Science Subcommittee status, Bell said the primary issue was how senior management would implement the recommendations of the 'decadal review' in the continuing 'grim' budgetary environment. The overarching goal of the division, he said, was to maintain a balanced portfolio. Bell noted that Flagship missions were not possible in the current budget environment, though he saw a slender possibility of such missions being undertaken through international partnerships. Bell noted that the Decadal Survey's highest priority was the Mars Sample Return, followed by a mission to an outer planet. Mars Sample Return involved missions in 2016 and 2018, with the latter involving a sample-cache; subsequent missions would be required to return samples. MSR could possibly be a NASA/ESA collaborative effort. Regarding the Outer Planet Flagship mission, Bell said, the goal was to get the project underway in the 2013-2022 decade. He noted that the community was strongly behind the joint effort both programmatically and financially.

Bell reported on the outer planet Flagship study. He said the Europa-Jupiter system mission was 'not in the cards financially.' He added that the concept was being reassessed: a joint APL/JPL and community Science Definition Team (SDT) were 'descoping' the Europa mission. The effort's notion was to outline a slimmed down mission that eliminated the non-Europa science from the overall mission objectives. He noted that only one Flagship mission could be provided in the next decade – JUpiter Icy moon Explorer (JUICE) was currently in a review as one of the three possible L-class missions. The others were International X-Ray Observatory (IXO) and Laser Interferometer Space Antenna (LISA).

Bell presented the report on Planetary Science Subcommittee status: His report assessed mission enabling activities, including basic research; targets of focused research; mission data analysis; technology development; recruiting and training of the next generation of researchers and supporting infrastructure. The report was issued during summer 2011; the key results were that the Planetary Science Division was generally conducting the efforts needed to meet the appropriate goals. Three recommendations were put forward, these being: first, focus on improving portfolio management; second, better definition of objective evaluation criteria; and, third, ensuring that funding was made consistent with the decadal survey.

Looking to the future, Bell identified the following as issues: first; the continued monitoring of status of possible Mars or Europa missions with ESA; second, determine the appropriate position on the possible impact of specific threats to the budget; third, remain updated on implementation of the Decadal Survey recommendations; fourth, react to PSD responses to the recent PSS report on 'mission enabling activities'; and, fifth, assess the top concerns of community members.

James Bell made reference to a final email received from Ron Greeley, which noted that the Division faced both pluses and minuses: the pluses were the successful launches of Jupiter Uranus Neptune Outreach (JUNO) and Gravity Recovery & Interior Laboratory (GRAIL); the minuses included budgetary uncertainly. Bell closed by commenting, 'Ron, we will soldier on.'

Jim Green
Director, Planetary Science

Jim Green noted that a year ago he outlined mission-related milestones; he was pleased to report the Division had been enormously successful in meeting those targets. He provided details, which included:

- Lunar Reconnaissance Orbiter (LRO) in science mode
- Mercury Surface, Space ENvironment, GEochemsitry and Ranging Mission (MESSENGER) orbit insertion at Mercury
- Selection of next New Frontier mission, Origins, Spectral Interpretation, Resource Identification, Security – Regolith Explorer (OSIRIS-Rex)
- JUNO launched to Jupiter
- GRAIL launched to Moon
- Mars Science Laboratory (MSL) launched to Mars
- Curiosity Rover landing site selection

And others.

Dr. Green noted that the NASA Administrator had challenged him to produce a crowd of 10,000 for the launching of Juno and GRAIL. The Juno '10K Challenge' had drawn 12,300 individuals at five sites. The Grail launch, though it had been delayed a day, drew 5,000. An additional 30,000 people had viewed the launch over the lives-stream activity.

Dr. Green noted that MSL "Curiosity" Rover was in final testing; MSL, he said, was in ready-to-launch status. The next launch window opened on November 25, 2011; if launched on that date, Mars landing would occur on August 6. 2012.

Speaking to the future of Planetary Science, Dr. Green noted that the Division was simultaneously in the midst of the decadal survey release and in the middle of a major revolution on understanding the origins and evolution of the solar system and life beyond Mars. Planetary Science, he added, had a major connection with human exploration in that it provided knowledge of the hazards that human explorers would face. He noted that President Obama had stated the goal of circling an asteroid by 2025 and circling Mars by 2030. Green noted that NASA space policy stressed international cooperation; the Division was working quite hard with the ESA Mars program: ESA's portion was about $1.2 billion; NASA's portion was about $1.4 billion. Rhetorically, Dr. Green asked how everything suggested could be done. The decadal survey contained a modified figure; it had been created with the President's FY'11 budget, plus inflation. Then the FY'12 budget had been produced. Scott Hubbard asked what the difference between the two figures was. Dr. Green said about $900 million. Dr. Green also presented a slide that summarized the decadal survey recommendations on flagship missions under three budget scenarios:

Recommended program: Mars Astrobiology Explorer (descoped); Jupiter Europa Orbiter (de-scoped); Uranus Orbiter and Probe; Enceladus Orbiter and Venus Climate Mission;
Cost Constrained Program: Mars Astrobiology Explorer (de-scoped); Uranus Orbiter and Probe
"Less favorable" budget: Descope or delayed flagship mission

Dr. Green then described the constraints on the Mars budget; the difference was more than half of that related to FY'06 budget. This point led to discussion of the future NASA/ESA partnership with Mars. Dr. Green noted that efforts to merge NASA and ESA Mars programs began in January 2009, due to mutual budget limits. When, he noted, MSL missed its launch window and ESA did not acquire full funding on its Exo-Mars program, a series of bilateral missions followed. The two-opportunity mission was jointly identified as the best way to proceed. In November 2009 NASA Administrator and ESA Director General signed a Statement of Intent, a plan that was always subject to the availability of funds. Two technical teams were working on the architecture; the Division's hope was to leverage as much of the existing Mars program as possible. Dr. Huntress asked Green if, based on what the latter knew now, the agreement was in jeopardy. Green said that was a good question: the Obama Administration's view

was that due to budgetary uncertainty it could not commit to the Mars 2016/2018 efforts. He noted that NASA's strategy for the future was to continue to pursue of the Joint Mars Exploration Program with ESA as the cost-effective approach to fulfilling the Decadal Survey. Huntress sad ESA cannot just 'twiddle its thumbs' while it waited for the U.S. He believed NASA had been 'a poor partner in the past' and there was evidence that ESA was looking to the East (i.e. Russia) and might be unwilling to wait for NASA. Green said a firmer statement of U.S. intent was unlikely before the first of the year; that timing, he noted, did not mesh well with what ESA wanted or with the planetary launch window. Green said he thought ESA was incredibly frustrated; he hoped they would react not with anger but with vision. Professor Hubbard said he had heard that this program was a rogue operation whose existence was unknown to the Office of Science and Technology Policy (OTSP) or to the Office of Management and Budget (OMB), and that this assertion was simply untrue. Green affirmed this was the case. Second, Hubbard said, a statement had been 'spawned' that the 2018 Mars mission was not moving ahead and that OMB has not made this information public. Green said he had received no official notification that the 2016/2018 Mars' missions have been cancelled, or that NASA was to stop its work with ESA on these missions. Hubbard reported that, having been on the steering committee that planned the decadal survey, he was troubled by the 'cherry picking' of the priorities of the document. He held that a descoped Mars mission remained the first priority; it was, he added, a project for which ESA had put $1 billion on the table. Dr. Hinners commented that OMB did not feel NASA should commit to ESA's sequence of Mars events. The comment was made that the National Academy had reviewed the human component of the Mars program and had concluded that sample return from Mars must be achieved first to lead the way for human exploration.

Dr. Bell commented that the community was confused by the Administration's messages. He believed the decadal survey statements were quite clear, and that what the survey was advocating constituted a first step. Dr. Hinners said something 'just does not compute': he did not see the NASA Administrator taking steps to clarify the circumstance; personally, he said, he was baffled. Chuck Gay said he believed NASA Administrator Charles Bolden had been clear in signing the statement (slide #17) with the ESA Secretary General. He believed Administrator Bolden had been working with the ESA leadership to create a path forward. He was aware there was budget concern and uncertainty over what the future may hold. The current desire, he believed, was to get through the next several months to see where things stood. Dr. Huntress said that given that time was slipping away from the Europeans, it seemed absurd to throw away the $1.2 billion ESA has prepared to commit to the venture; he said that if he was ESA, 'I would be pretty angry right now.' James Bell commented that Mars was among the most successful exploration programs NASA had ever had; he believed a number of milestones had been achieved in the past year and that the landing of MSL in the next year be a further notable success.

RED DRAGON
The Feasibility of a Dragon-derived Mars lander for scientific and human-precursor investigation
John Karcz
Ames Research Center

John Karcz said the starting point for his group's work had been the recognition that it might be possible to take advantage of the commercial spacecraft now in development to be able to do more with a Discovery class budget. The SpaceX capsule, he said, would be used to take people to low-earth orbit; SpaceX would have most of the capabilities needed to put material on Mars. He reported that SpaceX developers had been thinking along these lines. He believed that a substantially unmodified version of the crewed capsule intended for the International Space Station (ISS) could be used for payload transport to Mars. Currently, he said, the 'Icebreaker' concept was a drilling mission that would penetrate a meter or more into the Martian regolith. He noted that Dragon was a dense spacecraft; that is, it had a high ballistic coefficient. He believed Dragon could be used to deliver payloads of one ton or more to the Martian surface. He added that drag must slow the capsule sufficiently for the remainder of descent to be within the propulsion system capabilities.

Scott Hubbard said he thought propulsive entry into the Martian atmosphere was very difficult; all Martian missions to date had used a parachute to slow the rate of descent. John Karcz said the primary

technical question was whether Dragon could perform all the necessary EDL functions. He believed a retro-propulsive descent would be possible as the basic approach.

Regarding costs, Dr. Karcz said that SpaceX estimates a cost of $150 million to $190 million for a launch vehicle and lander. The Dragon already has most of the necessary capabilities: sufficient lifetime and resources for a Mars transfer trajectory; atmospheric entry systems capable of guided lifting and highly capable retro-propulsion thruster. Falcon Heavy, he noted, could throw Dragon to Mars. He also noted that Dragon offers a large interior volume. He believed the EDL technology was scalable to large cargo and human landers. Assuming launch by Falcon Heavy, he said, the trunk would separate nears Mars; the capsule would decelerate through retro-propulsive action. The version under discussion would land on its legs.

Larry Lemke, Ames Research Center, said what was foreseen was both similar to and different from other landings. Ballistic coefficient and lift-to-drag determine the change in speed during the dissipative portion of entry. Basically, he said, Dragon's entry characteristics were in the middle of the spectrum of 'where we have been and where we wish to go'—between previous landers and future human-scale landers. Dr. Tapley asked what proportion of the deceleration would be performed retro-propulsively. Lemke said that retro-propulsion would start at supersonic speeds. This approach, he stated, should make it possible to land the capsule at much higher Martian elevations than could be done if a parachute was used. Professor Hubbard asked what sites were being considered; Dr. Karcz said all contemplated sites were in the northern hemisphere. He noted that retro-propulsion had been studied by NASA for human landings.

Addressing current results (slide #12), Dr. Karcz said that a few point cases for EDL had been examined and that they had explored various alternatives around the nominal cases, and that the group was very comfortable that it could put down more than a ton of payload on the selected landing site. He reported that the EDL 'looked okay' at least for the missions under consideration. Other work was continuing: for example, on how to integrate the payload to Dragon.

Dr. Huntress said it was a very interesting concept to pursue, particularly as a human precursor and even as a Discovery concept. He asked if any notion had been developed as to how this could address the decadal recommendations for Mars. Karcz said his group had engaged in preliminary discussion, but had not examined the possibilities carefully. A second team member said that if one considered sample return missions, he doubted a Dragon capsule could do everything one would want. Huntress asked if the group had 'pitched this approach to the human side' of the house. Karcz said the approach addressed a number of matters that the human effort would need to address. Conversation returned to the method of descent. Karcz said the angle of attack in landing would not be controllable; however, the length of the flight path could be altered by rolling and banking. Extending the 'flight path' of descent would in effect, compensate for adjustments in speed. Professor Hubbard asked how the payload would be moved from inside to outside the capsule. This drew the comment that the vehicle had 'a big hatch.' It was noted that the presentation had made reference to a 2006 analysis by Braun and Manning; in response to a question, John Karcz said he had not spoken directly to the authors.

DISCUSSION WITH ACTING ASSOCIATE ADMINISTRATOR CHARLES GAY

Dr. Huntress noted that $1 billion had been removed from the Planetary Science division in recent years; this, he said, made it very difficult for NASA to meet its mission commitments. He thought that the Science Mission Directorate (SMD) was healthy, but that well-being reflected the legacy of five years ago. The budget situation also made it difficult to meet international obligations. He asked Charles Gay for his reaction. Gay said the absence of an FY'12 budget placed matters in an even more awkward position; there was not a sufficient basis for undertaking planning. However unfortunate finances might be, he said, it was not surprising given the state of the national economy.

Dr. Boss raised the subject of the JWST budget and where the additional money would come from. He had the feeling from discussions with colleagues that other divisions would be chipping in. He noted that while from the astrophysics perspective this was wonderful, it was not so for others. Gay stated that it had not yet been determined where these funds would be obtained. Dr. Huntress said he did not want to see cuts 'spread out like peanut butter,' but rather consist of targeted program cancellations and significant reductions. Gay said that view had been expressed; those involved were trying to do what

made the most sense. Dr. Huntress said this was a big matter: at issue was $1 billion spread over five years taken from three Divisions.

An audience member said the additional funds to be committed to JWST were $1.2 billion – half from mission budgets. One could not, he added, get that kind of money out of a flight mission; rather, it would come from across the board of those three Divisions. Dr. McComas said there was a longstanding effort to keep funds of individual Divisions as separate as possible; he believed the science community as a whole has benefited enormously from this. If, he said, an era is being initiated in which there was taxation across those boundaries, he believed problems would ensue. Gay said this was a good point: traditionally, he added, funds have stayed within science areas. He pointed out that there had been some 'straying' in the past; for example, some Hubble expenses had been met elsewhere. Sometimes, he said, a problem is so large that one cannot avoid crossing boundaries one would rather keep. Without foretelling the future, he believed JWST would constitute an exception. Dr. Boss said that if the amount to be cut exceeded some level, he anticipated that the Science Committee's advice should be sought. Charles Gay said the advice of the Science Committee were valued.

Dr. Hinners said the whole question of Flagship missions had come to the fore again. Were people failing to understand soon enough what undertaking a Flagship mission entailed? His feeling, he said, that the way these projects were undertaken caused things to be missed. Charles Gay said costs needed to be better understood earlier on; certainly by confirmation review. Further, the plan itself needed to be executed better. Flagship missions typically had the largest problems in both areas. He noted that GRAIL and Juno had both launched in summer 2011 on schedule and within budget. He added that he often thought that JWST was 'just really hard.' There was no easy way to figure out its costs. Still, cost calculations were something that was owed to both internal and external stakeholders. He believed there was too strong a tendency to think about things optimistically; a better appreciation for what could go wrong was needed. Dr. Huntress said affordability was also an issue with small and medium missions; often, he said, what began as a Class D mission migrated to C+. In aggregate, he noted, such missions constituted the major element of the SMD portfolio. In general, he said, they were becoming decreasingly affordable: mission caps were rising; launch vehicles were more expensive. He noted that if one built a Volkswagen to Masarati requirements it became unaffordable. He believed NASA policy 7120 was, at heart, an approach to building Flagship missions. Using that policy to build smaller missions meant that one would spend a great deal more than was needed. Charles Gay said 7120 was intended to accommodate everything. What was needed, he believed, was the ability to think in 'Class D-like' ventures. This, he said, had implications on mission assurance; parts programs, and other matters. He believed there needed to be comfort with taking a little more risk; this, he said, related to institutional culture and would take some time to happen. He added that in general things went fairly well with Principal Investigator (PI)-led missions. Compared to Flagship missions, there were real differences in how PI missions were conceptualized and how they matured. Commonly, he noted, a given PI had had several proposals rejected prior to the one that was approved; this allowed a long period of refinement and critique of the proposal.

Dr. Green commented that efforts were underway to pull together the lessons learned from Mars Science Laboratory (MSL). He stated that these lessons would definitely be made available to others. Dr. Huntress asked, as activity ramped down, how the workforce was affected. These, he said, are the people upon whom reliance is made to make things work. Green noted that 'several batches' of 250 people have been let go; some were in critical core competencies and would be working elsewhere in the Agency. Charles Gay said he was particularly concerned with the expertise at Goddard and JPL.

Dr. McComas introduced a new topic: he noted that at the previous Science Committee meeting, a finding had been made that greater effort should be undertaken to raise the SMD public profile in the post-Shuttle era: Was this happening? Charles Gay said it was. He called attention to the large number of people present for the Juno launch; he said he was noticing considerably more newspaper articles. Jim Green said he saw considerably more publicity. Gay added that A/PO was frequently engaged in working to learn about pending activities.

* * *

NOTE: The meeting took a 90-minute break so that committee members could attend the retirement event being given for Dr. Richard Fisher.

JOINT AGENCY SATELLITE PROGRAMS
Marcus Watkins
JASP Director

Marcus Watkins reported that in April 2010 NASA created within SMD a new division named the Joint Agency Satellite Division (JASD) to handle all reimbursable work done by NASA on satellites and instrument development. JASD was created to focus immediately on the transition from the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program to the new Joint Polar Satellite System (JPSS) program. Watkins then presented an SMD organization chart, showing JASD's place within in. He also presented a chart of the JASD organization, which included a National Oceanic and Atmospheric Administration (NOAA) deputy to ensure continued communication. Marcus Watkins said JASD used the same 7120.5 NASA processes to ensure it would work closely with customers to support a variety of products. JASD's primary tasks, Watkins said, was to ensure adequate management on behalf of customer agencies; oversee center executive; and do a good job of representing the partners.

Dr. Tapley asked if there was any fleshing out of what JASD relied on from the other science divisions to represent any NASA science requirements for reimbursable missions through existing inter-agency forums. Marcus Watkins noted that a weekly meeting occurred that included science requirements among its topics. The customer, he said, retained final decision authority and responsibility for strategic planning and legislative and executive branch coordination.

Marcus Watkins explained the evolution of polar satellite programs. He noted that NASA/JPSS would operate NPP for NOAA after the satellite was handed off by the Earth Science Division at the 90-day point, with hand off to NOAA occurring nine to fifteen months following launch. Watkins identified the five NPP/JPSS-1 sensors, giving the characteristics of each. Watkins noted that NPP remained a NASA mission. The current plan for JPSS was for two spacecraft to be built with a seven-year operation expectation. Changes were expected from a safety perspective. He reported that during the previous year there had been considerable success in tying contracts to instruments; NASA, he added, has management for all the instruments. Watkins added that DoD plans for DWSS spacecraft were under development. Watkins then presented the NPP/JPSS-1 sensor characteristics and the details of the JPSS Common Ground System. This, he note, could handle five satellites at one time, with command and control from Suitland, Maryland.

Marcus Watkins reported that NASA procures and manages development of four sets of spacecraft and instruments for the NOAA-managed Geostationary Operational Environmental Satellite – R-Series (GOES-R) program; that program was the next generation of geostationary weather satellites and had completed Preliminary Design Review (PDR). Watkins then presented the continuity of the GOES mission through 2036.

Marcus Watkins then discussed the reimbursable projects program, noting that a small office had been established at Goddard Space Flight Center (GSFC) to manage the smaller reimbursable projects – Ocean Surface Tomography Mission/Jason 3; Landsat-9; Meteorological Operational Satellite Program (MetOp) and Deep Space Climate Observatory (DSCOVR). Dr. McComas noted that on Jason 3 the launch vehicle selection was on hold: what was intended? Watkins responded that the matter was under study: launch could definitely occur from a Delta, or possibly from a Minotaur. McComas asked if Jason 3 was open to multiple launchers, what outcome was likely. Watkins said original consideration had been directed at Taurus; now, further consideration has been requested. He added that there might be only two possible solutions or many solutions. Dr. Tapley asked if the Jet Propulsion Laboratory was building the altimeter; Watkins said he did not know, but would find out and report back.

Marcus Watkins reported on last week's successful launch of NPP. At present, he said, everything was checking out wonderfully well. He added that the development of JPSS-1 was moving very well; scheduled to be launched at end of 2016.

Dr. McComas asked about the sequence whereby funds from other agencies came to NASA for work to be done for that agency. Taking NOAA as an example, Watkins said NOAA received funds from Congress; then passed the money to NASA for the work in question. NASA identified in its own budget

that it would be implementing the program. He noted that the general budget situation was highly uncertain: differing amounts had been identified for appropriation in the President's budget, the House version and the Senate version. It would be ideal, he added, to know what the budgetary reality for the rest of the year.

EARTH SCIENCE DIVISION
Peg Luce
Deputy Director, Earth Science
Jack A. Kaye
Associate Director of Research

Jack Kaye opened by presenting recent 'highlights' from the research community. These included the new global elevation model based on ASTER data and recently released, work by NASA-funded scientists to develop the first complete map of Antarctic ice motion, and the observation of a chemical ozone loss never previously observed in the Arctic and similar to that in the Antarctic. Regarding the ozone question, Kaye said there had been a general tendency to resist saying there was an Arctic ozone hole, but it certainly appeared to be the case. The final science highlight cited was the effort by the NASA Aqua satellite to analyze and map Earth surface temperatures; this effort, he said, referenced years of data in determining what the maximum land temperatures were in this period. Kaye also reported on the Aquarius Commissioning and SSS Measurements, which showed the relatively saltiness of the world's oceans. He noted that the requisite data had been gathered in 2.5 weeks; he thought it an amazing achievement to get something that looked that good so quickly.

Dr. Kaye then reported (slide #5) on the NASA NPP mission, which was providing critical data continuity for earth science research and risk reduction for JPSS instruments, algorithms, ground systems and archives. He noted that from NOAA point of view, the latter agency wished to get experience with the new instruments that were central to its future. He noted that NPP was designed to support both climate and weather research and to provide a test for the new instruments. He believed that 'everything suggests the post-launch is going quite well.'

Peg Luce introduced flight program milestones: Landsat Data Continuity Mission (LDCM) was making process toward its December 2012 launch readiness date (LRD); the Operational Land Imager (OLI) had been delivered to Optical Sciences Corporation and was integrated on the spacecraft; and the Thermal Infrared Sensor (TIRS) instrument from Goddard had been progressing 'phenomenally' and was now in environmental testing. Further, she noted that Orbiting Carbon Observatory-2 (OCO-2)) might need to change launch vehicles; this, if it happened, would occasion delay. She reported that the Global Precipitation Measurement instrument had been delivered, but that facilities needed for further work in Japan had been damaged by the earthquake and tsunami. This had delayed matters – a February delivery date was now foreseen. She noted that all of the Division's satellites were now operating beyond their original lifetimes: Cloudsat, she said, now had only ten percent of its battery capacity. Operations teams had been working at keeping the satellite operating; at present, it was capable of full operations in the light, with reduced operation in the dark. Reporting on Earth Venture, five selected suborbital campaigns had all passed their confirmation reviews. She noted that these missions had all been developed by Principal Investigators (PIs). On EV-2, she said, proposals had been received and demonstrated what can be undertaken with a $150 million budget. The EV-Instrument draft had been released for public comment.

Jack Kaye reported on suborbital progress and milestones – among other things, the first round of DISCOVER-AQ flights had been completed in the Baltimore/Washington area; the Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) had carried out partial payload test flights over Alaska; HS3 instruments had been loaded onto Global Hawk; and Airborne Tropical Tropopause Experiment (ATTREX) had carried out test flight near the Dryden Flight Research Center. Kaye identified a series of pending missions: one would involve deploying aircraft to undertake ice thickness measurement; a second would be a major multi-aircraft campaign in Southeast Asia to study atmospheric composition that should

provide valuable information on process knowledge and satellite capability; and a third will study changes in salinity the following from the decreasing sea ice coverage, which allows more solar energy to reach the water surface.

Summer 2011, Kaye said, witnessed the third annual Student Airborne Research Campaign (SARP), which had involved thirty students, mostly undergraduates, from around the country. Students had had the opportunity to work with NASA PIs; to go into the field to secure data, and other activities. He believed the group had bonded strongly and was maintaining contact through Facebook and other means.

Dr. Byron Tapley
Chair, Earth Science Subcommittee

Dr. Tapley reported on the status of the Earth Science Subcommittee (ESS); he noted that the ESS had not met since the last NAC Science Committee session. The ESS had planned to meet in connection with Agency-related budget meetings, but these meeting had not happened. The group, he noted, had held a telecom whose primary item was to conduct the annual assessment of the Earth Science Division program as called for under the Government Performance and Results Act (GPRA). The telecom had also allowed for an update on program and budget status and a report on the pending NPP launch.

Dr. Tapley identified topics of concern within the Division. These included possible budget impacts, modeling and data assimilation activities, and Tier 1 mission status. On this last, the concern was on what might be saved from the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) project. He noted that the National Academy had issued a report identifying major problems with geodetic network decay; he was interested in learning what formal response to this finding would be made. This question, he stated, tied to NPOESS, in that the latter supplied approximately thirty data records that were important to climate studies. He was aware that a recommendation had been made as to how these would interact, but he was not certain how this would play out. He believed it was appropriate that a briefing on this subject be presented at the next NAC Science committee meeting.

Tapley called attention to possible difficulties with the European science community in connection with the forthcoming decadal survey. In the United States, he said, things were clarified by the role of the National Academy; it was not clear that the European community had any analogous structure.

Dr. Boss commented that it appeared collaboration was good between NASA and NOAA.
Dr. Tapley stated that the central question the two agencies needed to address was the importance of continuity of measurement to climate research; the best way to do this was through a satellite. He noted that people who do weather forecasting are often comfortable with a lower level of precision. NPP, he said, will put sensors into orbit that will serve both the science and weather needs. Maintaining continuity of measurements over multiple decades was an important issue. He added that clarity was still lacking over how these requirements should be defined: there had been a very lengthy set of requirements attached to NPOESS, but it was not established which of these remained in effect.

Dr. Huntress adjourned the NAC Science Committee session of October 31, 2011 at 4 p.m.

* * *

Dr. Huntress convened the NAC Science Commission session of November 1, 2011, at 8:30 a.m.

REPORT ON HELIOPHYSICS
David McComas
Southwest Research Institute

Dr. McComas reported that the Heliophysics Subcommittee (HPS) has not met since the last NAC Science Committee session. This was because the HPS met three times a year; the Science Committee met four times a year. Dr. McComas noted that Dr. Roy Torbert was no longer HPS Chair; Dr. Robert McPherron was acting Chair. Dr. Barbara Giles was recently appointed as the Director of the Heliophysics Division, having previously served as the HPS Executive Secretary.

Dr. McComas said he would provide an overview of the Heliophysics work plan, which included launch capabilities for small, medium and large missions. Further, he would discuss how the upcoming decadal survey might be implemented; describe recent technical and scientific advances; and review those lessons learned. Sometimes, he noted, the same mistake was made more than once. Smart people, he commented, learned from their mistakes; very smart people learn from the mistakes of others. In addition, Dr. McComas said, the presentation would provide advice on interagency planning for the new solar wind monitoring, and would discuss investigation of methods for leveraging scientific discovery and learning inherent in the System Observatory and the developing cyber-infrastructure to make progress on the 'grand challenge' questions in Heliophysics.

Dr. Giles discussed plans for the next Heliophysics meeting, December 1-2, 2011. Much time, she said, would be spent on the decadal survey: time was short; a roadmap was expected by 2012. Her hope was that the results emerging from the decadal survey would be largely actionable as they emerged. Dr. McComas noted the occurrence of a prolonged (11-year) solar minimum; the heliosphere has as a whole been shrinking. It was possible, he said, that science was viewing a different sort of minimum – something he found fascinating. At the same time, the number of sunspots remained significantly lower than predicted. He rejected the 'dynamo theory' as a cause of this.

Barbara Giles
Director, Heliophysics Division

As the Division's newly-appointed director, Barbara Giles noted that she had begun with NASA as an undergraduate coop student; had enjoyed working at various levels of the organization; and had come to NASA HQ in 2004. She was pleased to inherit from Richard Fisher a division in such well-running order. Heliophysics, she noted, explored the Sun's connection with and affect on the Solar System; a better understanding of the Earth and Sun was provided by an integrated approach.

Dr. Giles described three flight programs:

First, Solar Terrestrial Probes (slide #2) -- These probes looked for those processes that turn magnetic energy into heat energy. She noted that this mission, while at had not exceeded the external financial commitment, had had $35 million added to the management baseline. She regarded the mission as challenging – not technically, but in terms of the number of instruments needed. Dr. Huntress asked how the Heliophysics Division defined a Flagship mission. Giles said it was any mission budgeted at over $1 billion. Giles further noted that major structural elements of the unit's Observatory #2 were in assembly at GSFC. To accommodate the project, a new clean room had been constructed due to conflicts with other undertakings. Huntress asked how was it fitted into a faring. Giles said they were stacked. She noted that the next mission (STP#5) was in pre-formulation activities. She then provided a color chart (slide #5) of STP program.

Second, Living with a Star. This, Dr. Giles said, consisted of three projects,

First, Radiation Belt Storm Probes (RBSP)/Balloon Array for RBSP Relativistic Electron Losses (BARREL)/ (slide #6). The former will provide insight into dynamics of particle acceleration with radiation belts; the latter consists of two campaigns of long-duration balloons to measure the effects of relativistic electron participation and estimate electron loss. BARREL has conducted its second test campaign; RBSP has accommodated slips in the Atlas launch queue. Current launch date is August 2013.

Second, Solar Orbiter Collaboration (SOC) (slide #8), Giles noted, had been selected by ESA as its first M-class mission. NASA will be providing two instruments and a launch vehicle. She noted that a draft NASA-ESA-MOU had been completed in summer 2011. About the same time, launch vehicle cost increases required the descoping of some U.S.-supplied instruments. Giles said she would supply the vendor list. Dr. Huntress asked whether it was unusual for Europeans to buy American instruments rather than build them themselves. Giles said it could be that the venture was far enough along that it was less expensive to purchase something than to manufacture it from scratch.

Third, Solar Probe Plus (SPP) (slide #9), Giles said, was also ranked as a Flagship mission. Dr. Huntress asked why the word 'plus' was included. The explanation was that Solar Probe was originally intended to go around Jupiter; this had proven too expensive. Subsequent re-study identified a mission that would use the gravitational pull of Venus to slow the satellite's orbit; this would not bring the satellite as close to the Sun, but would place it near the Sun for a much longer time. It was a better missions for less money; hence, the 'plus.'

On program status, Giles reported that all instruments had been delivered for RBSP, except for the MagEIS. On BARREL, the first of twenty payloads had been integrated and tested. On Solar Probe Plus, Andrew Driesman was now project manager; Major Design Review (MDR) was scheduled for November 1-3, 2011; and Cargo Mission Contract (CMC) review was scheduled for November 14, 2011. Finally, she said, SOC had been approved for ESA's Cosmic Vision program with a 2017 launch date.

Dr. Giles then discussed the program status of the Explorer missions (slide #12): Those missions included:

Interface Region Imaging Spectrograph (IRIS). Dr. Giles said that understanding the interface between the photosphere and corona was a fundamental challenge in heliophysics. She noted that on this mission cost reserves were fully liened. A detailed cost and schedule review was due in the near future. She noted that construction was being undertaken by Lockheed-Martin, which was facing challenges due to the compressed schedule. Problems always arose, she said, whenever there was an effort to do things more rapidly. Dr. Huntress said this supported his argument that processes designed for larger missions caused problems for smaller ones. Dr. Hinners said that unless one started with an organization that was used to doing things small and fast, one was 'behind the 8-ball' from the beginning. Dr. Huntress commented that what one needed to create was a 'skunkworks.'

Dr. Giles said the Division had recently made a Step 1 selection for its next Explorer mission. The absence of a launch vehicle prevented this mission from being a large one. Three full missions had been selected for concept study, with a downselect to one. The general circumstance was that the Heliophysics Division could undertake either one full mission or one Mission of Opportunity, but not both. The Astrophysics Division now had the budget to select one of each. Heliophysics would choose between the options. Dr. Giles identified (slide #15) three Explorer Mission Selections; each was a different approach to ionosphere-magnetosphere coupling, and would look at multiple places at the same time. The missions were:

ICON – Ionospheric Connection Explorer (budget $131 million)
OHMIC – Observatory for Heteroscale Magnetoscope-Ionsopce Coupling (budget $200 million)
ASTRE – Atmosphere-Space Transition Region Explorer – (budget $190 million)

Dr. Giles then identified the Mission of Opportunity Selections. These were:
GOLD: Global Scale Observations of the Limb and Disk
IMSA (Ion Mass Spectrum Analyzer) on SCOPE: This would supply one instrument to the Japanese SCOPE mission; currently, this mission faced challenges stemming from the earthquake
CPI (Coronal Physics Investigator) on the ISS

Dr. Giles commented that one current challenge related to whether NASA had in place the appropriate policies for allowing placement of NASA instruments or other products on foreign of commercial vehicles. Dr. Hinners asked if the International Space Station (ISS) was undertaking any activities to measure the atmosphere in advance to know whether it would be acceptable. Dr. Giles said this was being looked into; she believed the help needed had been provided. Dr. Tapley asked who was responsible for the facilities cost. Dr. Giles said that needed to be worked out; NASA Space Operations Mission Directorate (SOMD), she added, was committed to doing that. Heliophysics' commitment was in building the instruments. Dr.Tapley said that in the past, a fairly significant amount of cost had been involved in the human-interface requirements. Paul Hertz (audience) said that this was SOMD's responsibility to work out.

Giles presented (slide #17) the color-coding on the Explorer programs; she noted that some of IRIS was 'red' due to the cost situation. She then presented (slide #18) the color-coding on all current missions, noting that all seventeen missions were entirely 'green.' She noted that on Voyager the point

was being reached where it was no longer possible to power the instruments and maintain the backup systems. She believed a difficult choice would need to be made to determine what should be risked. She noted that tests on backup systems that had not been used in several years were being undertaken this week.

Dr. Giles then reported on the Sounding Rocket Program (slide #20). She identified open opportunities for a new generation of explorers; a post-doc program that was open to applicants; and a heliophysics summer school to be held next year. She noted, with pleasure, that three young heliophysics researchers had received the Presidential Early Career Award for Scientists and Engineers (PECASE).

Dr. Giles next discussed the satellite reentry that had occurred on September 24, 2011. She noted that solar activity can affect reentry. She presented photographs of the Sun taken twelve months ago; six months ago; and the previous evening – the series showed how the Sun was 'waking up.' She noted that the solar maximum was now being approached. She believed an excellent opportunity existed over the next two years: spacecraft were located in what were near-ideal locations to show how a national space weather operating system could work. It was, she said, a great time both for the scientific community and for the general public to see what could be done in the future. Dr. Boss made reference to statements that the emergence from the solar minimum involved abnormality. Dr. Giles commented there was no doubt unusual features of this solar cycle existed.

Dr. McComas noted that while sunspot activity had been charted for a long time, reliable space data existing for only a handful of eleven-year cycles. Therefore, he thought it was too soon to generalize. It was true, he added, that this emergence differed more than previous ones.

PLANETARY PROTECTION
Eugene Levy, Rice University
(By teleconference call)

Catherine Conley
NASA SMD

Eugene Levy said he would discuss how a request for a deviation from project plan sought by the Mars Science Laboratory (MSL) had been handled. The request, he noted, had come 'rather late in the game.' With MSL, he said, the focus was on forward planetary projection; this was different from when materials were being returned to Earth. The purpose is to protect any science samples gathered from contamination so that the samples might be used to ascertain whether life develops and/or continues to be present. Such protection need only be sufficiently long-term to allow investigations to be completed. He added that it was generally understood that environments were likely to become contaminated in the long run. The effort, he added, had an important content: the Martian biologically special region. The more that was learned about the planet, the more was learned about what regions of Mars might support the survival of terrestrial organisms.

Catherine Conley said standard NASA policy was that missions that would land on Mars were placed in one of three categories of biological protection. Those categories are 4A – missions that are not seeking life on Mars; 4-B; missions intending to examine life on Mars; and 4-C; missions that investigate or contact 'special regions' on Mars. She noted as an additional complication that spacecraft carried a heat source; a crash landing could therefore generate a special region. In 2005, consistent with the advice then available, MSL was categorized as a 4-C mission. Conley said MSL had had two options. First, to sterilize the entire spacecraft; if this was done, there would be no further restriction on MSL's landing site. Second, to hold the entire spacecraft to Viking pre-sterilization standards, and then further sterilize any part of the lander that would contact the Martian surface. If this option were pursued, MSL would be prohibited from landing anywhere believed to contain water. MSL had sought a deviation from the protocol for handling the drills intended to contact the subsurface; otherwise, the ability to handle the drill and wheels would have been limited. MSL sought to maintain 4-C status on the grounds that the deviated protocol would sufficiently meet the standard. The MSL request had raised the issue of whether the appropriate response would come from the Planetary Protection office or from the Planetary Protection

Subcommittee. Conley noted that normally the Subcommittee recommended the level and the Planetary Protection subcommittee defined the required protocols. The decision in this case was that there was no need to convene the Planetary Protection Subcommittee.

Satisfactory resolution was achieved. The Planetary Protection Office re-categorized MSL as a 4-A mission on the grounds that, first, MSL was not conducting biological samples and, second, it would not be investigating special regions. This resolution was not a compromise on MSL project intentions, as the landing areas it had identified were not considered likely to threaten the special regions. In making the changes, MSL emphasized that it did not anticipate entering special regions. Dr. Conley said the resolution in this case was a good one. She noted that the case involved lessons learned that should be carriage forward – in particular, that action should be taken in a more relaxed time scale. Dr. Huntress asked who had initiated the request. Dr. Conley said her understanding was that due to a delay in launch, some internal project communications had gone awry. Huntress noted it was fortunate MSL had the additional time; he did not really want to know why the request came late. Eugene Levy said he thought it was problematic that the request came so late; he was confident that Planetary Protection would be discussing with this project. He was not interested in knowing why the request had been late; that was not the issue. Doug McCuistion said that Planetary Protection worked closely with the project. Part of the effort, he said, was on putting into the procedures some method for ensuring that what was known was acted upon. He noted that with MSL, there had been design changes in the wheels and in the drilling mechanism.

Dr. Boss noted that MSL would be looking for organics, which were the building blocks of life; how did one draw the line between what was and what was not 'life-seeking'? Dr. Conley said that any missions that included a camera were life-seeking; she was aware that there has been considerable concern about contamination. If MSL has been a life-detecting mission, higher standards would have been set for it. Eugene Levy commented that looking for organics was quite different from entering the special regions. Dr. Conley noted that the later were defined by the presence of water and a given temperature range.

JAMES WEBB SPACE TELESCOPE REPLAN
Mr. Richard Howard

Mr. Howard reported that NASA had made significant changes in JWST management. Communications had been greatly improved; the assessment of alternatives had been undertaken; and a replan completed on September 23, 2011. That plan looked to an October 2018 launch date. Mr. Howard then addressed program status:

Telescope: Mr. Howard made reference to the ten-year effort to complete the mirrors. There had been some problems with the science instruments: all testing had been completed with delivery due early next year. He commented on the detector problem, noting that the solution space had been accepted, with a batch made under the new criteria. Initial tests looked very good. The cracks in the optical bench of the NIRSPEC instrument seem is still under investigation but with attention had been directed to workmanship and installation errors; either proper procedure had not been followed relative to alignment or else over-torqueing had occurred during installation. The good news, he said, was that the problems created were something it was known how to fix. Mr. Howard presented a "family portrait" showing that all but six of the primary mirrors had completed their testing. Relative to mirror cryo-optical testing, Mr. Howard noted that two mirrors were not as good as had been desired – this was so by a factor of about two – 40 nanometers rather than 20. Looking into the matter, he said, it appeared that certain corrections in the surface map that needed to be made to compensate for the different behavior of materials at 40 Kelvin and at room temperature had not been appropriately made. Even these two mirrors, Howard said, met the specifications. He asserted that current thinking was that it was not worth the money and time to attempt to improve this pair of mirrors. He noted that three spares existed – one for each prescription. Two of these spares are yet to receive final polishing, a procedure he said would require four to six months.

Sunshield: Mr. Howard reported that testing of a one-third sunshield had been successful. The full sunshield, he said, was about the size of a tennis court and each layer half the thickness of a sheet of paper. Measurements had been done under vacuum and simulated solar radiation environment; everything

looked good. He noted that all materials for test units had been purchased and were in storage. Dr. Tapley asked what the purpose of the sunshield was. Mr. Howard noted that one side of JWST would face the Sun; the sunshield would prevent the solar energy from hitting the telescope and instruments. He noted that JWST was passively-cooled. Dr. McComas said it was understood that solar pressure provided both a radiation pressure and a solar wind pressure, the latter of which was a variable. Mr. Howard said this was correct.

Mr. Howard then presented a diagram (slide #7) showing the completion of the ambient optical alignment stand. He called attention to the amount of ground need to support the alignment stand, and made reference to a media event held at the manufacturer's site in Syracuse. Regarding Optical Telescope Element (OTE) testing (slide #9), Mr. Howard noted that modification to Johnson Space Center test chamber was progressing. He said it would be the largest cryo-vacuum test chamber in the world; the chamber door would be forty feet in diameter. Mr. Howard then presented (slide #11) the FY'11 JWST milestones. These, he said, had been established last January. He noted that all but two of the milestones had been met.

Mr. Howard then presented (slide #12) the hardware fabrication completion percentages. These ranged from 100 percent for the primary mirror and the all-optics systems bench; to 95 percent for the secondary mirror; to 90 percent for the science instrument module; down to 40 percent for the sunshield membranes and 25 percent spacecraft bus. He noted that these figures were regularly updated. Howard then presented (slide #13) the JWST Master Schedule, which showed thirteen months of critical path schedule reserves.

JWST Budget Profile: Mr. Howard provided (slide #15-17) the JWST Breach Report, which had been delivered to Congress on October 24, 2011 and which covered costs, schedule and alternatives. He noted the funding profile presented in July 2011 and approved in September 2011 carried costs through 2019. FY'11, he said, included an extra $44 million; FY'12 included an additional $150 million. He termed the new budget as 'robust' and said it met the 80 percent cost confidence, and made up for the failure to have provided sufficient reserves. Mr. Howard noted that the total cycle cost for JWST would be as $8.8 billion, a figure that including thirteen months of schedule reserves. Funding exists in the budget to cover all threats that are viewed as having a greater than fifty percent chance of occurring. The assumption is that *all* such threats will in fact happen and funding to cover them has been built into the base. Mr. Howard observed that NASA typically had a 70 percent confidence for cost and schedule; perhaps for major missions this was simply not adequate. On JWST, current budget cost reserves were greater than 80 percent. Mr. Howard noted that in total, the new baseline figure would require the addition of $1.2 billion in funding: 'however you slice it,' he said, this will have an impact upon and cause pain to everybody in the agency. About half of this figure will come from SMD, he said; the other half from cross-agency support. He noted that Congressional approval was required for this step. He said the mission would continue to work with the Administration over actual adjustments; he noted that a request had been received from Congressman Frank Wolf (R-Virginia) for more detailed information.

Dr. Huntress asked if Mr. Howard knew what pending missions would be delayed by the reallocation of division funds. Mr. Howard said that remained under discussion. He noted that no funds would come out of the Earth Science Division. Dr. Huntress said that announcing that future missions would be delayed without specifying which missions would be affected would 'set the rumor mills ablaze.' Mr. Howard acknowledged that this was the case; that was why, he said, hard work has been done to determine at least for FY'12 what the affects would be. They were working as hard as possible to get the information out to the appropriate people. Mr. Howard reported that through FY'11 $3.536 billion had been expended on JWST. He gave Phase A/B (formulation) cost as $1.8 billion; Phase C/D (formulation) cost as $6.198 billion; and Phase E (five years operation plus two years data analysis) costs $837 million. He noted that the total cost had been estimated to Congress as 'about' $8.7 billion because there had not been a recent review of the Phase E costs.

Mr. Howard then reported on the alternatives to JWST that had been considered. He described a very broad range of possible options including ground-based science; space-based science; airborne science and variants to the JWST baseline. Twelve alternatives were investigated – some involved a simpler design; some involved dropping an instrument from the science payload. He noted that the National Science Foundation had agreed with the results of the Aerospace Corp. analysis. The conclusion was that the JWST baseline was the best value, even if a higher cost. Dr. Boss asked if that assessment

given to Congress could be provided to the APS. Mr. Howard said that the documents were not as yet public; NASA policy, he explained, was that when it was requested to submit a report to Congress, it was up to Congress to decide when to make it public. He added that he had received permission to release the report to the JWST community on the understanding that no community member would post it on a public site. He said he knew there was a great deal of interest in this subject; still, he believed it to be proper protocol that NASA did not release to the general public reports made to Congress without the permission of Congress. Dr. McComas asked if the Science Committee could obtain copies; Mr. Howard said: yes, for internal use. Mr. Howard was asked what was meant by the phrase 'best value' as opposed to saying the minimum cost to fulfill the baseline science requirements. Best value, he replied, combined both cost and readiness into an assessment of capability. There was one alternative that was comparable in cost, but did not meet the baseline science requirements by a considerable margin. Dr. McComas asked if the alternatives studied included simply reducing or scaling down the size of the mission. Mr. Howard said one alternative involved descoping the instruments. He noted that some options were ruled out as they required a heavy lift capability that does not exist. Dr. Boss asked whether consideration was given to the possibility that costs could be cut in half if the Level 1 science requirements were reduced. Mr. Howard said the project had already relaxed a number of requirements: for example, the requirement that the mirrors be checked to two microns was loosened to three microns. Further, he said, a number of descope possibilities had been considered. Almost all reviewers said that these steps were not going to save any money for the existing program.

Dr. Boss asked whether something 'more radical' had been considered; that is, to toss away what had already been built and try a different path altogether. Mr. Howard said that one option was a new 6.5 meter observatory; this approach did not come in at a cost or Level 1 science requirements that JWST would meet. Boss asked if it came close to meeting the level I science requirements. Howard said it did not. Dave McComas asked if there was much leeway between the baseline requirements and the Level I requirements. An audience member said there were about eight requirements; the difference between the Level I and baseline requirements was that the latter permitted use of a less specific piece of equipment. Dr. McComas commented that if you do not have resiliency in requirements, then either you get the full requirement or the whole thing falls through.

Mr. Howard presented (slide #18) information on JWST Near-Term Program/Project Efforts. He noted that the report to Congress was complete; he believed the likelihood of getting a FY'12 budget by the start of the fiscal year was very small; the ramping down of the workforce was going to be difficult. Mr. Howard added that some work had been moved from FY'13 to FY'12; contractors and teams had been contacted to see what work could be moved forward. He noted that a letter had been sent to Northrup-Grumman instructing them to reduce the schedule for the Primary Mirror Backplate Assembly by six to eight months. Discussions were underway to accelerate by four to six months the Critical Design Review (CDR) of the Spacecraft, which was the last remaining element that had not passed CDR.

Dr. Huntress asked if the FY'11 money was secure. Mr. Howard said: yes. Dr. Huntress then asked about the FY'12 budget. Mr. Howard said it was included in the Senate version but, as yet, not in the House version. Dr. Huntress commented that the JWST program had had enough to deal with without the budget uncertainties. Mr. Howard commented that budget discussions were in progress and he could not speak to them in any detail. He noted that if he put himself in Congressman Wolf's position then while he would want to help, he would need to know where from within NASA the money would be taken. Dr. Boss asked if Mr. Howard could predict when an answer might be forthcoming. Mr. Howard said no, adding that at some point somebody had to proceed with a number. Dr. Huntress noted that, in the meanwhile, many in the community would be very concerned; without some knowledge of what the real plan is, they are going to invest in rumors. Dr. Boss asked where a list of all pending missions could be obtained. Mr. Howard noted that it was in the Division's website.

PUBLIC COMMENTS:

Ms. Bethany Johnson said that the previous day reference had been made to a particular document as public; it was not. She could be contacted for additional information, if need be. Dr. Mark Sykes said that evidently the report had been posted and was publicly available; Dr. Feeley requested a copy be sent to him. Dr. Melissa McGrath said the statement had first been sent to persons on the lunar list, then to the

lunar group. That had been the method of distribution. Ms. Bethany Johnson said two statements were being confused; there had been a public statement about the group's office visit; however, there was also an internal document about the visit: this has been identified as public, and was not.

FINDINGS AND RECOMMENDATIONS:

Dr. Huntress invited board members to review the meeting's content to identify any recommendations that it might wish to take the full NASA Advisory Committee. He noted that the NAC meeting originally scheduled for the current week had been postponed until February. That being the case, he said, the NAC would not review any recommendations until that time. The NAC Science Committee would itself meet in advance of the next NAC meeting and could make recommendations at that time; announcing findings at the present meeting appeared moot.

Dr. Huntress said that, in regard to JWST, he wished to place on the record the committee's gratitude that the Administration was making it an Agency priority, with a plan to ensure launch by 2018. However, he noted, the fact that this plan requires that $600 million be drawn from other NASA divisions is a matter of grave concern. In consequence, it was difficult to make any findings on the status of space science until it was known from where these funds would be drawn. Dr. Huntress noted that on this matter he held proxies from three board members who had needed to depart: Dr. McComas, Professor Hubbard and Dr. Hinners.

Dr. Feeley said he could supply members with a full mission list. Dr. Huntress said such a list would not indicate which missions were in jeopardy. Dr. Boss asked if the Council should state explicitly that this was something about which information was needed in the near future. He noted that given the postponement of the NAC meeting the public would have no near-term awareness of any statement from the NAC Science Committee. Dr. Tapley noted that the Committee was not taking any official action as part of the day's meeting. Dr. Boss said he support the statement as presented. Dr. Huntress accepted the clarifying phrase that the $600 million was to come over five years. He then repeated his statement, which said in gist:

> Without an understanding of what missions are likely to be delayed to accommodate the new JWST plan, we can make no findings on the vitality of the Space Science in the agency as a result of this plan.

Dr. Boss raised the question of whether the NAC Science Committee should direct that lessons learned from JWST actually be implemented. Dr. Huntress said he thought this a worthwhile topic: perhaps the question of actually learning from lessons learned could be made an agenda item for the next meeting. Dr. Feeley said he would place "lessons learned from JWST" on the agenda for the next meeting. Dr. Tapley suggested that a broader question could be addressed; namely, what is being done in the area of lessons learned.

On behalf of the group, Dr. Boss expressed its thanks to Mr. Chuck Gay for taking over as Acting Associate Administrator on short notice.

Dr. Huntress adjourned the November 1, 2012 meeting at 1:35 p.m.

APPENDIX A: AGENDA

NAC Science Committee

NASA Headquarters

October 31-November 1, 2011

Agenda

Monday, October 31 (MIC-3)

8:30-8:45:	Opening Remarks: T. Jens Feeley; Wesley Huntress
8:45-9:45:	Astrophysics: Geoff Yoder; Alan Boss
9:45-10:00:	**Break**
10:00-11:30:	Planetary Science: James Green; Jim Bell
11:30-12:30:	**Lunch**
12:30-1:30:	Discussion with Acting Associate Administrator Charles Gay
1:30-3:00:	**Break:** Dr. Richard Fisher's Retirement Gathering
3:00-3:30:	Joint Agency Satellite programs: Marcus Watkins; David Schurr
3:30-4:00:	Earth Science: Peg Luce; Jack Kaye; Byron Tapley
4:00:	**Adjourn for the day**

Tuesday, November 1 (MIC-3)

8:30-8:45:	Recap of First Day
8:45-9:45:	Heliophysics: Barbara Giles; David McComas
9:45-10:15:	Planetary Protection – Eugene Levy; Cassie Conley
10:15-11:45:	James Webb Space Telescope (JWST) Replan: Richard Howard
11:45-1:00:	**Lunch on Own**

1:00-1:10:	Public Comment
1:10-2:00:	Findings and Recommendations
2:00-2:15:	Second Day Wrap-up: Wesley Huntress; T. Jens Feeley
2:15pm:	**Adjourn**

APPENDIX B: NASA ADVISORY COUNCIL SCIENCE COMMITTEE MEMBERSHIP

Dr. Wesley T. Huntress, Jr., Carnegie Institution of Washington (chair)
Dr. Byron Tapley, University of Texas (vice chair)
Dr. Alan P. Boss, Carnegie Institution of Washington
Dr. Noel W. Hinners, Lockheed-Martin (retired)
Professor G. Scott Hubbard, Stanford University
Dr. Eugenia Kalnay, University of Maryland
Dr. Eugene H. Levy, Rice University
Dr. David McComas, Southwest Research Institute
Dr. Charles F. Kennel, University of California/San Diego (*ex officio* member)
Dr. T. Jens Feeley, Executive Secretary, NAC Science Committee

APPENDIX C: Presentations

Astrophysics Subcommittee Summary, Dr. Alan Boss; Geoff Yoder

James Webb Space Telescope, Mr. Howard

Joint Agency Satellite Division, Marcus Watkins

Heliophysics, Barbara Giles

NASA's Earth Science Division, Dr. Tapley

Planetary Science Division Status, Jim Bell, Jim Green*

Presentation to the NAC Science Committee, Peg Luce; Jack A. Kaye

Red Dragon, John Karcz

SMD Update, Dr. Feeley

APPENDIX C: Meeting Attendees

Monday, October 31, 2011:

NASA Advisory Council Science Committee Members:

Alan Boss	Carnegie Institute of Washington
Noel Hinners	Lockheed-Martin
G. Scott Hubbard	Stanford University
Wes Huntress	Carnegie Institute of Washington
Dave McComas	SuRI
Byron Tapley	University of Texas
T. Jens Feeley	NASA HQ (Executive Secretary)

Other NASA attendees:

Chuck Gay	NASA HQ
Jim Adams	NASA HQ
Marc Allen	NASA HQ
Jaya Bajpayee	NASA HQ
Victoria Elsbernd	NASA HQ
Teresa Fryberger	NASA HQ
Barbara Giles	NASA HQ
Jim Green	NASA HQ
Colleen Hartman	NASA HQ
Paul Hertz	NSAS HQ
Mr. Howard	NASA HQ
W. Vernon Jones	NASA HQ
John Karcz	NASA ARC
Lawrence Lemke	NASA ARC
Melissa McGrath	NASA MSFC
Doug McCuistion	NASA HQ
Michael P. Moon	NASA HQ
Sarah Noble	NASA HQ
Marian Norris	NASA HQ
Adriana Ocampo	NASA HQ
Mario R. Perez	NASA HQ
Gary Rawitscher	NASA HQ
Diane Rausch	NASA HQ
Rita Sambruna	NASA HQ
Tina Swindell	NASA HQ
Terry Walton	NASA
Lisa Wainio	NASA HQ
Michael White	NASA GSFC
Dan Woods	NASA HQ
Geoff Yoder	NASA HQ

Other attendees:

Anne Conner	House of Representatives Science Committee
Don Conte	Orbital Sciences Corporation
Randall Correll	Ball Aerospace
Andrea Diekmann	ESA
Mr. Dissly	Ball Aerospace
Ed Feddeman	House of Representatives Science Committee
R. D. Gafley	University of Texas
Eric Hand	Nature
Brad Keelor	British Embassy
John Malay	Lockheed Martin
Michael Moloney	NRC SSB
Kaitlan Chell	Lewis-Burke
(two illegible)	

Tuesday, November 1, 2011:

NASA Advisory Council Science Committee Members:

Alan Boss	Carnegie Institute of Washington
Noel Hinners	Lockheed-Martin
G. Scott Hubbard	Stanford University
Wes Huntress	Carnegie Institute of Washington
Dave McComas	SwRI
Byron Tapley	University of Texas
T. Jens Feeley	NASA HQ (Executive Secretary)

NASA Attendees:

Marc Allen	NASA Headquarters
Catherine Conley	NASA Headquarters
Victoria Elsbernd	NASA Headquarters
Charles Gay	NASA Headquarters
Barbara Giles	NASA Headquarters
Jim Green	NASA Headquarters
Colleen Hartman	NASA Headquarters
Paul Hertz	NASA Headquarters
Rick Howard	NASA Headquarters
Cuong Huynh	NASA Headquarters
Raymond Kinzer	NASA Goddard Space Flight Center
W. Vernon Jones	NASA Headquarters
Lawrence Lemke	NASA Ames Research Center
Doug McCuistion	NASA Headquarters
Melissa McGrath	NASA Marshall Space Flight Center
Marian Norris	NASA Headquarters
Adriana Ocampo	NASA Headquarters
Jonathan Rall	NASA Headquarters
Gary Rawitscher	NASA Headquarters
R. Sambruna	NASA Headquarters
Mike Seablom	NASA Headquarters
Eric Smith	NASA Headquarters
Nicholas White	NASA Goddard Space Flight Center
Dan Woods	NASA Headquarters

Other attendees:

Terry Blankenship	Booz Allen
Anne Conner	House of Representatives Science Committee
Randall Correll	Ball Aerospace
Kathryn Flanagan	Space Telescope Science Institute
Brad Keelor	British Embassy
Michael Maloney	National Research Council

Conference Call Participants:

Bill Adkins	ASG
Mark Adler	NASA Jet Propulsion Laboratory
Jim Bell	Arizona State University
Yudhijit Bhatacharee	*Science* magazine
Michael Bicay	NASA Ames Research Center
David Desmarais	NASA Ames Research Center
Kristen Erickson	NASA Headquarters
Teresa Fryberger	NASA Headquarters
Daniel Golombek	Space Telescope Science Institute
Kirstin Grantham	SpaceX
Richard Griffiths	NASA Headquarters
Jennifer Heldmann	NASA Ames Research Center
Dan Hendrickson	AIA
Jeffrey Hollingsworth	NASA Ames Research Center
Terry Hurford	NASA Goddard Space Flight Center
Bethany Johns	AAS
Louis Kaluzienski	NASA Headquarters
Anne Kinney	NASA Goddard Space Flight Center
Dan Leone	Space News
Dan Lester	University of Texas
Eugene Levy	Rice University
Sanjay Limaye	University of Wisconsin
John McCarthy	Orbital Sciences
Chris McKay	NASA Ames Research Center
William McKinnon	Washington University
Michael New	NASA Headquarters
Bill Oegerle	NASA Goddard Space Flight Center
Robert Pappalardo	NASA Jet Propulsion Laboratory
Marc Postman	Space Telescope Science Institute
Steve Price	Lockheed Martin
Richard Rogers	Stellar Solutions
Martin Ruzek	USRA
Marcia Smith	*spacepolicyonline.com*
Carol Stoker	NASA Ames Research Center
Mark Sykes	Planetary Science Institute
Azita Valinia	NASA Goddard Space Flight Center
Brian Vastag	*Washington Post*
Michael Vicay	NASA
Richard Vondrak	NASA Goddard Space Flight Center
Meenakishi Wabhwa	Arizona State University