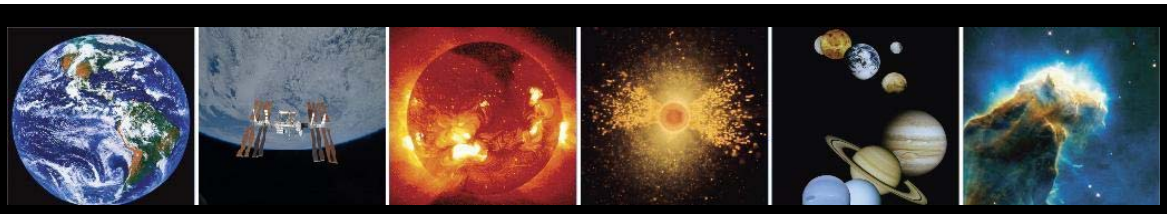
SPACE STUDIES BOARD NEWS



OCTOBER—DECEMBER

INSIDE THIS ISSUE

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—John Klineberg, Vice Chair, SSB

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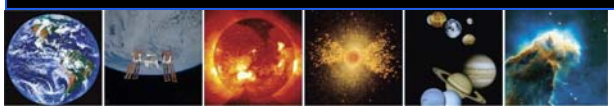

FROM THE VICE CHAIR

This month's column is authored by SSB Vice Chair John Klineberg

The SSB spent some time this past year reviewing the more important issues associated with access to space for space science missions. Ann Karagozian of UCLA, study chair of the Air Force Scientific Advisory Board (AF SAB) 2010 report entitled *The Future of Launch Vehicles Systems for the USAF* presented a review of the study's findings and recommendations to the SSB executive committee at their meeting in La Jolla, CA, in August. She repeated the presentation for the Aeronautics and Space Engineering Board via WebEx at their 2011 Fall meeting in October, which I attended as the SSB's liaison. The publicly released abstract from the AF SAB Future Launch Vehicle study is available at the SAB website (https://www.sab.hq.af.mil/TORs/2010/Abstract_FLV.pdf). This study focused on military launch systems, but there is clear relevance to NASA launch vehicle issues. In addition, the SSB convened a "Focus Session on Access to Space for Space Science Missions" at their 2011 Fall meeting in November. The session included a presentation by Michael R. Luther, deputy associate administrator for programs in NASA's Science Mission Directorate. At these meetings, a number of core issues were discussed that are outlined below and will be the subject of future attention by the SSB.

U.S. military and civil payloads are required to launch on domestic vehicles, and most government-sponsored satellite launches take place on Evolved Expendable Launch Vehicles (EELVs). Since 2006, launch services for the EELVs have been provided by the United Launch Alliance (ULA), a 50-50 partnership between Lockheed-Martin and Boeing. The EELV inventory currently consists of the Atlas V vehicle, which uses a LOX/hydrocarbon (RP-1) first-stage engine, the RD-180, produced in Russia; and the Delta IV vehicle, with a LOX/hydrogen (LH2) first-stage engine, the RS-68, produced in the United States. The different upper stage RL-10 LOX/LH2 engines and Solid Rocket Motor (SRM) boosters for these vehicles are produced domestically. EELV costs have risen substantially in the past few years, often pricing these vehicles out of the commercial market. Commercial satellite launches have accounted for less than 20% of the EELV manifest between 2006 and 2010, and the U.S. commercial satellite industry increasingly launches its payloads on foreign vehicles, e.g., the Ariane, Proton, Zenit, and other non-U.S. systems. The reduction in U.S. domestic commercial launches has led to significant challenges for the rocket launch industrial base in this country.

Historically, NASA has launched a large number of its science missions on vehicles that have been provided by ULA, primarily on the Delta II, of Boeing (and earlier Douglas) heritage, which had launched a majority of its science missions. With the discontinuation of the Delta II, effective in 2012, it is expected that NASA must migrate its science mission needs to the higher payload capacity but more expensive EELV fleet. Given that NASA is required to launch on U.S. providers and can only barter for foreign launch services, and given the rising costs of domestic launches, obtaining future launch opportunities for NASA science missions will become considerably more complicated.

With the cancellation of NASA's Constellation Program, Congress has mandated that NASA's next heavy lift launch vehicle, the Space Launch System (SLS), must be derived from legacy hardware. In many cases this restriction limits NASA to rocket engine designs that were initiated decades ago. The situation further impacts the rocket launch industry, not only the large liquid engine companies, but also the subcontractor base and solid rocket motor manufacturers.

From NASA's perspective, beyond heavy lift requirements for deep space exploration, a replacement for Delta II capability is needed for science missions. There are similar near-term needs by the Department of Defense for a small-to-medium class launch vehicle replacement. The board heard that commercial launch systems that have the potential to help to bridge this gap include vehicles developed by Orbital Sciences, SpaceX, and others. There are considerable uncertainties associated with the reliability and long term costs for these suppliers, as well as for existing government launch services, given the current state of the rocket launch industry in the United States. The SSB spent some time this Fall discussing how it may be difficult to execute many of the missions outlined in the various NRC decadal surveys because of limited launch opportunities. The question of the cost and reliability of NASA's long-term access to space is unanswered at this time.

SSB MEMBER NEWS

December – **Mark Abbott, Oregon State University**, was named the 2011 recipient of the Jim Gray eScience Award, presented by Microsoft Research for "his career-long contributions to integrating biological and physical science, making early innovations in data-intensive science, and providing educational leadership" (Microsoft Research Connections Blog; http://blogs.msdn.com/b/msr_er/archive/2011/12/05/jim-gray-escience-award-winners-announced.aspx).

DIRECTOR'S CORNER

As we start 2012 the Space Studies Board staff are busy preparing for a number of upcoming milestones. Our newest task is also going to be our first report release of 2012. On January 18 an NRC committee convened for a 3-day meeting charged with assessing a NASA plan for U.S. participation in the European Space Agency's Euclid precision cosmology missions. Owing to the schedule of approvals required by NASA and ESA between now and June, the committee has an expedited schedule, with the report due out by the end of the month. Watch the SSB's webpage for the posting of the report then. The SSB website will also be the place to watch for the release of four other reports due out in the first quarter of the year: the mid-decade assessment of NASA's Earth Science Program, a report on planetary protection standards for icy bodies in the outer solar system, a report of a workshop on the effects of solar variability on Earth's climate, and an evaluation of NASA's space radiation cancer risk models. The first quarter of the year all also see the final preparations of the decadal survey of solar and space physics, with a view to its release at the end of this quarter or early in the next. Finally, on February 1 the committee charged with assessing the needs and opportunities to develop a space-based operational land-imaging capability will gather for its first meeting.

Although the report was overseen by our sister board, the Aeronautics and Space Engineering Board, February will also see the NRC release a report on NASA's technology development roadmaps. The product of a year's work by a steering committee and six panels, the report will evaluate each of the roadmaps and prioritize the technologies in those roadmaps. The scope of the technologies to be considered include those that address the needs of NASA's exploration systems, Earth and space science, and space operations mission areas. The report's recommendations will, no doubt, be of interest to the space science community, as well as those interested in the broader goals and programs of the agency.

The second quarter promises also to be as busy with the convening of the Board meeting in Washington, DC, on April 4-5. We look forward to welcoming NASA Deputy Administrator Lori Garver to the meeting, as well as key members of NASA's leadership team, including Waleed Abdalati, Mason Peck, Bill Gerstenmaier, John Grunsfeld, and Jaiwon Shin. Meeting with the ASEB on the April 4 and in its own session on April 5, the SSB will consider NASA's budget and program plans for the coming year, as well as recent SSB studies. In addition, we look forward to the reestablishment of four SSB standing committees—the Committee on Astrobiology and Planetary Science (CAPS), the Committee on Astronomy and Astrophysics (CAA), the Committee Earth Science and Applications from Space (CESAS), and the Committee on Solar and Space Physics (CSSP; which is on hiatus until after the release of its decadal survey). Mark Abbot has been appointed by the NRC as chair of CESAS, and he is working on identifying future committee members. More announcements on the standing committee memberships will be posted on the SSB website in the coming weeks and months.

And so the Board remains a busy and vibrant place. No doubt, over the course of the year ahead, unexpected progress in space science research will be made. And, no doubt, budget constraints will continue to challenge our pursuit of progress. But the SSB will remain at the ready to respond to the resulting need for continued advice.

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For more information on the membership of the SSB please visit our website at <www.nationalacademies.org/ssb>.

COSPAR 2012

39th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events

July 14-22, 2012
Mysore, India

Scientific Program Chair

Prof. U.R. Rao, Former Secretary Department of Space, Government of India and Chairman of ISRO

Abstract Deadline

February 10, 2012

Topics

120 meetings covering the fields of COSPAR Scientific Commissions (SC) and Panels
(full list available at http://www.cospar-assembly.org):

- SC A: The Earth's Surface, Meteorology and Climate
- SC B: The Earth-Moon System, Planets, and Small Bodies of the Solar System
- SC C: The Upper Atmospheres of the Earth and Planets Including Reference Atmospheres
- SC D: Space Plasmas in the Solar System, Including Planetary Magnetospheres
- SC E: Research in Astrophysics from Space
- SC F: Life Sciences as Related to Space
- SC G: Materials Sciences in Space
- SC H: Fundamental Physics in Space
- Panel on Satellite Dynamics (PSD)
- Panel on Scientific Ballooning (PSB)
- Panel on Potentially Environmentally Detrimental Activities in Space (PEDAS)
- Panel on Radiation Belt Environment Modelling (PRBEM)
- Panel on Space Weather (PSW)
- Panel on Planetary Protection (PPP)
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- Panel on Education (PE)
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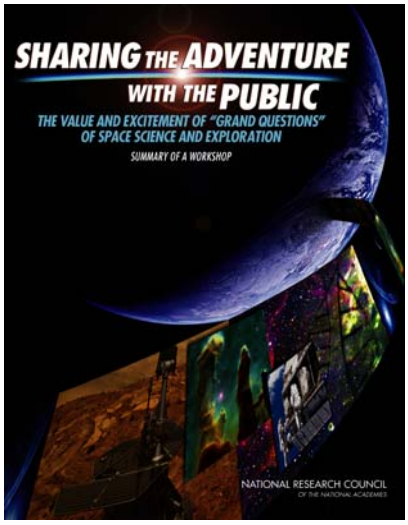
NEW RELEASE FROM THE SSB

Summaries are reproduced here without references, notes, figures, tables, boxes, or attachments.
Copies of reports are available from the SSB office at 202-334-3477 or at http://www.nap.edu/.



Sharing the Adventure with the Public: The Value and Excitement of "Grand Questions" of Space Science and Exploration Summary of a Workshop

This workshop summary was prepared by the workshop rapporteur, Marcia Smith, as a factual summary of what occurred at the workshop. The planning committee for the workshop was led by Chair Charles F. Kennel. The workshop and subsequent report preparation was staffed by Ian W. Pryke, senior program officer, Lewis Groswald, research associate, Carmela J. Chamberlain, administrative coordinator, and Catherine Gruber, editor.

Workshop Overview

The premise of the workshop was that NASA and its associated science and exploration communities have not been as effective as they could be in communicating with the public about what NASA does or how its activities contribute to resolving critical problems on Earth. Although not explicitly stated, an underlying assumption seemed to be that if the public had a better understanding, it would be more supportive of NASA, which in turn could generate more political support for the organization. In the case of global climate change, the broader issue is how to convince the public of the magnitude of the problem and the need for solutions. The role of new social media tools like Facebook and Twitter in interacting with the public was an integral part of the discussion.

HAS COMMUNICATION BEEN EFFECTIVE TO DATE?

Throughout the workshop, the topic of global climate change was put forward as a primary example of where communication between the scientific community and the public has failed. Specifically, many of the scientists concluded that the "Climategate"[1] incident demonstrated the fragility of the public's trust in the scientific community and in the data showing that climate change is human induced. Charles F. Kennel, Space Studies Board (SSB) chair, related that polls by the Pew Trust showed that the public's belief and trust that climate change was real and that scientists were telling the truth dropped 20 points after Climategate, an unprecedented drop in the history of Pew's polling.

Kennel characterized Climategate as a dramatic lesson for the climate science community that thought it had "discovered the key for communicating with decision-makers" through the "elaborate peer review process" embedded in the International Panel for Climate Change (IPCC). SSB member Berrien Moore III, former co-chair of the National Research Council's (NRC's) decadal survey on Earth science and applications from space, passionately held that the climate science community has failed to communicate successfully the seriousness of the climate change problem to the public.

Some of the communicators,[2] however, disagreed. Christie Nicholson, journalist and online contributor for *Scientific American,* asked Moore how he could consider it a failure when people think about Earth "all the time now." She and other communicators explained how the public makes decisions on issues for which they have little background or understanding, like climate change, by using "information shortcuts" and "confirmation biases" to decide who to believe or not believe. During the panel discussion for Session 5, Moore initially resisted the notion that climate change is a belief-based issue—"the data are there," he said—but Nicholson and Andrew Lawler, a science journalist, helped him understand that it is indeed a matter of belief.

Lawler said that although he had learned to trust and believe the data Moore presented, there has been a loss of trust, and he sees this in journalism, too—people do not know who to believe. He acknowledged that scientists have a difficult time understanding that some people do not believe the data charts. Nicholson concurred, adding that even two scientists can draw different conclusions from the same data. She called it a confirmation bias—the tendency for a person to believe one scientist versus another based on that person's preconceived ideas, adding: "I don't know when climate change . . . became such a strong belief system on the level of religion and political beliefs, but it has." By the end of the discussion, Moore said that he now understood that it is not whether people believe or not in global warming, it is whether they believe or not "in what we said" and thanked Lawler and Nicholson "because I learned something."

Science fiction author Kim Stanley Robinson tied his grave concern about climate change to the question of how best to communicate about the human spaceflight program, which many of the participants cited as a particularly difficult sell. Robinson emphasized that one could not discuss human spaceflight without reference to the "planetary environmental emergency that we

are now in without being escapist and doing more harm than good." He asserted that talking about human space exploration could be "easily misinterpreted as escapist and elitist, involving only a small percentage of the human population," and the focus should be on space and Earth science, especially the connection between the two, for example comparative planetology. He reacted to assertions by others that the public in general does not trust scientists by commenting that there should be posters reminding people that their doctors and the people who build and fly airplanes are scientists too. As for the climate issue, he argued that the climate science community, as a community, should "bite the bullet" and tell the public that "we are in a fight for the hearts and minds of our own population."

Washington Post science reporter Marc Kaufman's complaint about communicating with the public about the human spaceflight program, or exploration, was that he could not imagine a worse scenario than what has happened in the past 10 years. The 2003 space shuttle *Columbia* tragedy was followed by President George W. Bush's Vision for Space Exploration to return humans to the Moon by 2020 and then go on to Mars. That idea was endorsed by Congress but not funded adequately, which tells people that we are not serious, he said. When the Obama administration determined there was not enough money to execute President Bush's Vision for Space Exploration and do many other things on NASA's plate, it "understandably decided to blow up the whole process," he asserted. In terms of communicating with the public about all of this, Joan Vernikos, former director of life sciences at NASA and an SSB member, emphasized that actions speak louder than words, and if they are disparate the result is "disastrous." That was her assessment of the situation with the human spaceflight program today.

Kaufman thinks President Obama's "commercial crew" concept of relying on the commercial sector to build and operate systems that will take government astronauts, as well as tourists, back and forth to low Earth orbit, and especially the International Space Station (ISS), will reinvigorate public interest in space. Former CNN science correspondent Miles O'Brien, who gave the keynote address, also finds commercial crew to be a "very exciting" story because "we're taking free enterprise into orbit" and there are great storylines there. Linda Billings of George Washington University's School of Media and Public Affairs strongly disagreed. A former journalist who covered commercial space companies for many years and worked in the industry later in her career, she said she firmly believes that space exploration will continue to be the domain of government agencies for the foreseeable future. The private sector's interest is profit not the public interest, she insisted. However, she also is "deeply skeptical about prospects for the human future in space" today.

Robinson opined that only wealthy people could afford to go into space as tourists, referring to the practice as "bungee jumping for the ultra-rich," and that having space as a "gated community" is a "misuse" of space because space exploration is more important than that. He emphasized that eventually humans would make the solar system their "neighborhood," but now is not the time. Instead, this is the time to focus on the health of Earth, in his view.

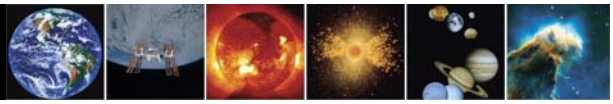
Kaufman concluded that the public is more interested in space science than exploration in any case. He uses the number of times an electronic newspaper story is shared on Facebook as a measure of its popular appeal and said that stories about space exploration do not get the same number of Facebook shares as science stories: "Science trumps [human] exploration by orders of magnitude." Using his metric of Facebook shares, Kaufman observed that looking at the websites of the *Washington Post* and the *New York Times* it is easy to tell that the public is fascinated by stories about space science, especially astrobiology—the search for life elsewhere—as well as supermassive black holes and "gas bubbles in the middle of the Milky Way." Overall he is convinced that the public is interested in stories that respond to a sense "of potential transcendence, of curiosity answered, of wonder peaked."

Conversely, Dietram Scheufele, professor and chair of science communication at the University of Wisconsin-Madison, said that he does not believe the public agrees that there is an intrinsic value to science, but rather that its interest is driven by global competitiveness. Citing the Apollo era as a period when Americans were strongly supportive of science because of the competition with the Soviet Union, he argued that the same approach needs to be taken to generate excitement again. If China does something spectacular in space, Americans will want to spend more on space to compete with them, he said. Lawler disputed that idea, arguing that the science community is still "hooked" on the Apollo model, but everything has changed, and it does not work anymore.

Some of the scientists and communicators felt that astrobiology is an area where scientists generally have done a good job of engaging with the public, although SSB member Robert T. Pappalardo, a senior research scientist at the Jet Propulsion Laboratory (JPL) at the California Institute of Technology, wondered if the public understands that the search is for microbes, not intelligent life. He also observed that astrobiology raises issues at the "boundary of the triple junction among science, religion, and philosophy," adding to the complexity of discussions about it.

There have been communication missteps with astrobiology and other space science stories, however, in the views of many of the scientists and communicators. Three examples cited repeatedly in the workshop were the following:

- *Mars meteorite ALH 84001.* In 1996, NASA announced that scientists had discovered biosignatures in a meteorite discovered in Antarctica that originated on Mars, which was reported in the press as demonstrating that Mars once supported life. Many scientists did not concur in that interpretation. O'Brien said that the NASA public relations department "got way ahead of the science" and had the "president of the United States saying we found life on Mars, and it really wasn't quite there yet." Kaufman said it left the public with a confusing message. Lawler added, however, that public interest translated into more money to explore Mars, even though many scientists were skeptical of the claims.
- *Pluto.* When the International Astronomical Union reclassified Pluto as a "dwarf planet" instead of a planet in 2006, the astronomy community did not adequately explain the rationale to the public. Heidi B. Hammel, senior research scientist and co-director of the Space Science Institute in Boulder, Colorado, and Lawler criticized the astronomers for ignoring the need to ex-



plain it to the public in understandable terms, thus creating unnecessary controversy.

• *Gliese 581.* A team of U.S. scientists announced in 2010 that they had discovered a planet in the habitable zone of the red dwarf star Gliese 581. The data were not released prior to the announcement, but once they were, a scientific team in Switzerland refuted the claim. Sara Seager, professor of planetary science and physics at the Massachusetts Institute of Technology, observed that the degree of uncertainty in the U.S. finding was not adequately conveyed to the public. It had a confidence level of 99.7 percent, she said, which is acceptable in science, but there are three chances in a thousand that "it could be wrong."

Overall, however, some of the communicators felt that the space science community is doing a good job in communicating with the public. In addition to Nicholson's comments about how the climate change community has made people think about Earth "all the time," SSB member Joan Johnson-Freese, a political scientist and professor at the Naval War College, observed that the scientists at the workshop "have been way, way too hard on themselves." She later added, "I think you've been doing a heck of a job, but we can always get better."

WHO ARE SCIENTISTS TRYING TO COMMUNICATE WITH AND WHY?

Johnson-Freese and others asked a key question about what the scientists really are seeking to do in sharing the adventure with the public. "I have to ask, toward what goal?" she inquired. Nicholson similarly asked what the target audience for these efforts is. These questions were raised but not directly answered.

Billings emphasized that there "is no monolithic public" for space exploration, but rather many publics. She also is not convinced that better communications would result in increased public support, stating, "Public information, public education, public interest, public engagement, public understanding, and public support are all different social processes and phenomena, and one does not necessarily lead to another." Public participation is also different, she continued, and government agencies "tend to be resistant to true public participation in planning and policy making," but that may be the only path to "enduring public involvement."

Billings believes that the space community "continually underestimates its audiences" and that it should think "more broadly and deeply about the values, functions, and meanings of space exploration and worry less about marketing the concrete benefits." She believes that the key is "public participation in exploration planning and policy making," involving "community consultations, citizen advisory boards, and policy dialogues." It would be "complicated and time-consuming" and require "power sharing," but it is a democratic approach and in keeping with President Obama's promise of "transparency, openness and participation in government."

HOW TO COMMUNICATE

Social Media

A major theme of the workshop was the tremendous ongoing changes in traditional media, especially the decline of newspapers and the reduction in the number of print and broadcast science reporters, versus the emergence of the new social media. Discussion focused on how the space community is or is not taking advantage of social media tools like Twitter and Facebook to communicate within their own communities and with the public.

Two of the scientists, Hammel and Seager in particular, lauded the benefits of the social media and exhorted their colleagues to at least try it. The reluctance on the part of many of their colleagues was palpable, however. Alan Dressler, astronomer at the Observatories of the Carnegie Institution and an SSB member, said that social media was worrisome because of all the "kook mail" he gets. Moore agreed, saying that the climate science community was not embracing it because of the "hate tweets" they have been getting since Climategate.

Nicholson was the most ardent of the communicators in encouraging scientists to at least try the various types of social media to see if any meet their goals. If a particular platform does not achieve those goals after a trial period, she advised them to stop and try another platform. She said social media can provide visibility and promotion, community and networking, monitoring of conferences (such as this workshop), testing the waters for different ideas, keeping a finger on the pulse of what is happening, and improving writing skills, especially brevity. The main advantage of social media, she repeatedly emphasized, is that it allows "many to talk to many" instead of "one to many" as in traditional communications. Scientists should first decide on the message they want to convey, and then choose which of the tools facilitates that, she said. She excitedly explained that communications is moving across platforms now—video, audio, text, and graphics: "We're in the very beginning of all of this" and have not yet begun to use the Web fully yet, she said.

O'Brien and others complimented JPL for embracing Twitter, especially in the case of the Mars Phoenix mission, which was the first space mission to "tweet." JPL's Veronica McGregor tweeted in the first person as though she was the spacecraft. In a taped interview that O'Brien played for the audience, McGregor said that people who thought they were not interested in following space missions found that they were fascinated if they could get the information in "tiny updates day by day."

O'Brien provided data showing that 44 percent of people polled want more coverage of scientific news and discoveries (Figure 1). He believes social media is the way to provide that coverage. He recommended that scientists not think about how to get on the *CBS Evening News,* but about how to use social media instead: "All of you should be tweeting" and "sharing the enthusiasm of what you all do."

Kaufman emphasized that the Facebook/Twitter era does not mean the end of books. He believes that people want long as well as short treatments of topics, noting that he just finished writing a book on astrobiology.

Seager read a Facebook message she received from a colleague in Canada who wanted to point out that there have been many new forms of communications in the past century and social media are just the latest, and their full implications are not yet known. Kennel offered his opinion that the social media revolution probably "has the same degree of importance as the invention of printing." He added that "we don't know . . . how all of that will work out" and NASA and scientists are groping to find out how to use these new ways, but "if we learn to adapt

we . . . will be among the groups that . . . survive this change in the way we communicate."

Tips on Connecting with the Public

A recurring theme from the communicators was that the space community has to take the public "along for the ride" on space missions and build that feature into missions from the beginning. O'Brien said "NASA is run by engineers, and there are no mission requirements for public affairs." That has to change, he said, adding, "It cannot be tacked on" at the end, but must be part of the mission from the beginning—a "clean sheet mission requirement."

One question, however, was how to keep the public interested in programs that proceed on an incremental basis with sometimes slow progress. Varying points of view were expressed. Pappalardo wondered, "If we find microbes" and not people on Mars, "will the people care?" Steven Benner, distinguished fellow at the Foundation for Applied Molecular Evolution, however, said that he detects no intolerance on the part of the public for the "struggle" and "incrementalism" inherent in science. Kaufman agreed, but cautioned that there is "danger when incremental change is miniscule," because with a dwindling cadre of science writers, the media may decide that something is no longer a story worth covering. O'Brien initially said that the media does a poor job of covering incremental stories, but amended that later in the workshop by observing that with the new social media, that may change.

Storytelling, narratives, frames, and "people-izing"—making stories more compelling by incorporating the personal stories and enthusiasm of the scientists involved—were all techniques communicators advised would make science communication more effective. Nicholson explained that telling stories is a narrative art, and when they involve human drama "you have a slam dunk almost every time." Inspiring awe is another method, she added, citing a *New York Times* article in February 2010[3] that looked at the most emailed stories and showed they had one thing in common—they all inspired awe, and science can do that, in her view. She also offered that it is important to decide how to frame the issue and gave examples from health communications, where different messages can be framed as a gain or a loss. Messages concerning cancer prevention are communicated quite differently if the goal is to get people to use sunscreen versus getting a mammogram. Scheufele expressed a similar theme, saying that frames, narratives, and terminology are critical aspects of relating to the public. As an example, he noted that, at the time of the economic crisis, the story was about "bank bailouts," but it quickly changed to "rescues" because while people do not want to bail out a bank, they do want to rescue the economy.

Some of the communicators advised that messages need to be conveyed in a manner that the public can absorb. Lawler said he was struck at how stark a picture Moore painted about the climate change situation. It is "doom and gloom," Lawler said, a story to which people do not respond well. Using storytelling would be better, he concluded, citing Roger-Maurice Bonnet's presentation in Session 5 as an example. Bonnet, executive director of the International Space Science Institute in Switzerland, used the ISS as an analogy to Earth in order to get across points such as population limits and the need for certain systems—like a thermal protection system (which for Earth is its atmosphere)—to function correctly for the "crew" to survive.

Such analogies were cited as an effective communication technique and one often used by scientists. Hammel used a Humpty Dumpty analogy in Session 4 for explaining how the theory of solar system creation has completely changed since she defended her dissertation in 1988. Saying that people connect to a story through narratives, Lawler commended Hammel for her skill at telling the story of the solar system as though it was a "living creature."

Robinson cautioned, however, that analogies can be misleading. He asserted that space is not like the New World or the Wild West, but more like Antarctica, which he found to be difficult and boring when he was there.

Scientists and communicators also discussed the need for accuracy in reporting about science, although Kaufman said all science stories in publications like his are likely to have factual errors. The discussion included the fact that scientific interpretations may evolve over time, and discovery by its nature means an ever-changing landscape. As to how to communicate that to the public, Benner stressed that it is not the job of scientists or the media to represent science as anything other than what it is—there are wrong answers or sometimes the need for the reinterpretation of data. Scientists "are not better than the average bear" and should not be represented that way, he said.

Kennel suggested that scientists should use the media as intermediaries, but Vernikos strongly disagreed. She said that scientists were excited about what they were doing, and "it's an energy transfer" when they tell their stories. Bonnet agreed in general, but added that climate scientists did not communicate effectively and could have benefited from taking advantage of professional communicators. Instead, they have opened the door to undue criticisms, in his view.

Scheufele remarked that engaging with the interested public is easy, but the question is how to reach the people who are not inclined, for example, to go to science museums. Fifty percent of highly educated Americans go to museums at least once a year, which means that the other 50 percent never go, he pointed out. For people who only went to high school, attendance is less than 10 percent. Science is not an issue the public cares about, he asserted. He also noted that half of the American public does not know how long it takes Earth to move around the Sun.

What to Avoid

Hammel said astronomers "failed miserably" in explaining to the public why Pluto was demoted from being a planet. She insisted that it was an easy story to tell, and it only takes her 15 minutes to explain it, but astronomers did not think they had to tell it. Lawler agreed, saying that astronomers did not understand that there is "a real emotional tie that people have with planets," going back to astrology. They are mythical figures and "when you mess with [them], people get upset." He said that the public felt Pluto was being "knocked off its throne," and they needed a new story, not just for their old story to be destroyed. Hammel tells that new story, he said.

Kennel cited a colleague who believes the public needs to be better educated so that scientists can communicate with

them, but thinks any such effort will fail. He wryly noted that the message from the communicators is that there is a new way to communicate now, but many scientists have not mastered the old way.

Scheufele listed five ways to ensure a communications failure:

- Be reactive instead of proactive; i.e., only start going public after a crisis/event occurs.
- Address only issues and ignore values, emotions, etc., that people bring to the table.
- Assume that science will ultimately prevail.
- Assume that new and social media do not matter as much as traditional media.
- Assume that communication is an art rather than a science.

ASSESSMENTS OF NASA'S PUBLIC AFFAIRS EFFORTS

Kaufman offered an unsolicited compliment that NASA public affairs "is far and away the best one I've dealt with," and while there may be problems with how some information in conveyed, he felt the agency deserved a "shout out" because it is doing a better job than most agencies.

Later, NASA official Alan Ladwig directly asked for feedback on how NASA is doing. Dexter Cole of the Science Channel and Lawler both agreed with Kaufman's assessment that NASA is better than typical federal agencies. However, Lawler also offered a list of improvements NASA could make both at headquarters and the NASA field centers.

Separately, Billings observed that NASA's efforts over the decades have focused on branding and marketing, which she concludes is ineffective. "The aim of marketing is to build public support, and what we all are talking about here is . . . informing people about the work of the science and scientists." She believes the key to success is public participation, as described above.

IMPLICATIONS OF THE NEW COMMUNICATION ERA AND HOW THE NATIONAL ACADEMIES SHOULD RESPOND

In his remarks at the conclusion of the workshop, SSB chair Kennel commented that the convergence of computing and communications via the Internet and space communications at end of the 20th century has accelerated to this day. That, too, is a product of the science and technology revolution, he said, but because it changes relationships between human beings, it has the potential—combined with science—to produce a second enlightenment in the century we are now entering.

It is that second enlightenment, created by a partnership between science and communication, that will be critically needed to cope with stark problems of climate change and sustainability, Kennel believes. He feels that in the climate change area, the science community's "honest attempts to communicate" failed. While a failure of communication in inspirational areas of space science may have consequences such as delaying funding, the failure of communication in the climate area "threatens our entire civilization," he said.

In closing, Kennel voiced a clarion call to the National Academies to adjust to the revolution in communications.

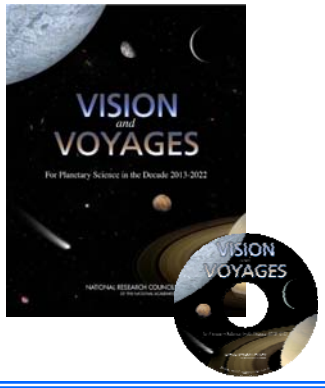
> "[The] final message . . . is for our own National Academy. It is the principal social tool by which the United States translates scientific knowledge into the public and policy arena and therefore it cannot neglect the revolution in communications. We have also heard of how venerable media institutions who did not react to this revolution have failed and we have heard how those who did have continued to prosper in the present world because of the importance . . . of their brand and what they do. I think it is essential for the Academy in the next couple of years—and that is the time scale on which things are occurring—it is necessary for the Academy to adjust to the revolution in communications and the new media.
>
> This doesn't mean getting a few geeks into the back room and providing equipment to people, it means, like everything else, adjusting the social processes by which science is communicated and the people who work on it. I'm not sure I know how that will be done, but I think I can see the need. I am hoping that as we go forth with our study of the potential for human exploration beyond 2020 that we will be able to stimulate—this is an area where this kind of work is critical—and I hope we will be able to stimulate and help the Academy go through this transition. The one thing that is clear, it draws on the talents of many of the smartest people in the United States and it certainly can do it and I'm sure it will."

REPORT NEWS

Two SSB reports now in print and available on CD—Available from the SSB free of charge *while supplies last*. See p. 20 of this newsletter to order. Copies are also available from http://www.nap.edu.

Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era

Vision and Voyages for Planetary Science in the Decade 2013-2022



SSB ACTIVITIES

THE BOARD AND ITS STANDING COMMITTEES

The **Space Studies Board (SSB)** met November 8-9, 2011, at the National Academies Arnold and Mabel Beckman Center in Irvine, CA, to receive briefings from NASA, representatives of different scientific disciplines, and NRC staff and committee chairs to update them on the progress of current SSB studies. In addition, staff and board members welcomed four new members to the board.

Prior to SSB meeting, the SSB and the Board on Physics and Astronomy (BPA) held a joint session at the BPA's board meeting on November 7, where they were briefed by representatives of NASA, the National Science Foundation (NSF), the Department of Energy (DOE), and staffers from the relevant Senate and House of Representatives committees. Both boards were updated on the progress of the James Webb Space Telescope (JWST), which dominated much of the discussion of the two boards over the course of each board's meeting.

Topics presented to the SSB on November 8 included NASA's views on access to space for space science (presented by Mike Luther, NASA), hosted payloads (presented by Steven Volz, NASA), and the planning for the human spaceflight study requested in the 2010 NASA Authorization Act.

The final day of the SSB meeting was dedicated to a session on life and physical sciences research in space, with a focus on research on the International Space Station (ISS). This session followed up on the 2011 release of the joint SSB-Aeronautics and Space Engineering Board decadal survey on life and physical sciences in space, *Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era* (available at http://www.nap.edu/catalog.php?record_id=13048). With an eye toward stewardship of the decadal survey, the SSB received scientific presentations from David Weitz of Harvard University and Scott Trappe of Ball State University on soft matter research in microgravity and skeletal muscle health with spaceflight, respectively. The session and board meeting concluded with presentations on NASA's plans for science and engineering on the ISS (presented by Gale Allen, NASA Office of the Chief Scientist) and an overview of the newly created Space Life and Physical Sciences Research and Applications Division by acting director Brad Carpenter.

The next SSB meeting will take place in Washington, DC, in April 2012. Please visit http://www.nas.edu/ssb to stay up to date on board and study committee meetings and developments.

For more information on the SSB and ASEB Board Meetings go to sites.nationalacademies.org/SSB/SSB_054577 (for SSB) or sites.nationalacademies.org/DEPS/ASEB/DEPS_058923 (for ASEB)

The **Committee on Astronomy and Astrophysics (CAA)** is being stood up following a hiatus during the astronomy and astrophysics decadal survey. The CAA is expected to meet in the Spring.

The **Committee on Earth Studies (CES)** has been renamed the Committee on Earth Sciences and Applications from Space. The committee did not meet during this quarter; however, several former members of the committee are serving on an ad hoc committee that is assessing Earth science programs at NASA at the mid-point of the decadal survey cycle (the first NRC decadal survey in Earth science, *Earth Science and Applications from Space,* was published in 2007). As noted in last quarter's progress report, the NRC is preparing to stand up CESAS and the Board's other standing committees. As a first step, it was announced in January 2012 that Mark Abbott, Dean of the College of Oceanic and Atmospheric Sciences at Oregon State University and a member of the Space Studies Board, will be the chair of the new CESAS. Appointments to the committee are expected to be completed by early Spring 2012.

The **Committee on Planetary and Lunar Exploration (COMPLEX)** was disestablished on September 18, 2011. Responsibility for planetary science activities will be transferred to the SSB's proposed new Committee on Astrobiology and Planetary Science.

The **Committee on the Origins and Evolution of Life (COEL)** was disestablished on September 18, 2011. Responsibility for astrobiology will be transferred to the SSB's proposed new Committee on Astrobiology and Planetary Science.

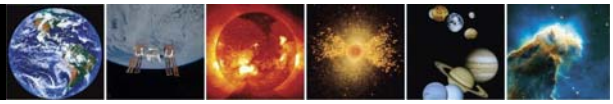
The **Committee on Astrobiology and Planetary Science (CAPS)** is a new activity combining the responsibilities formerly exercised by COMPLEX and COEL. Pending NRC approval, the co-chairs and members of CAPS will be identified and appointed during the first quarter of 2012 . It is anticipated that the committee's first meeting will occur during the second quarter of 2012.

The **Committee on Solar and Space Physics (CSSP)** is on hiatus until the completion of the solar and space physics (heliophysics) decadal survey. The committee will be stood up again in the late Spring or early Summer of 2012.

STUDY COMMITTEES

The ad hoc **Committee on the Assessment of NASA's Earth Science Program** was formed to review the alignment of the NASA Earth Science Division's program with previous NRC advice, primarily the 2007 NRC decadal survey report, *Earth Science and Applications from Space*. In carrying out this study, the committee is directed to neither revisit nor alter the scientific priorities or mission recommendations provided in the decadal survey and related NRC reports; however, the committee may provide guidance about implementing the recommended mission portfolio in preparation for the next de-

(Continued on page 11)



(Continued from page 10)

cadal survey. The committee began work in March 2011 and held meetings on April 27-29 in Washington, DC; on July 6-8 in Seattle, WA; and on September 21-23 in Irvine, CA. The committee's report entered external peer review in late December 2011; release of an NRC-approved prepublication version of the committee's report is anticipated in mid-February 2012. For more information, go to http://www8.nationalacademies. org/cp/projectview.aspx?key=49354.

Final publication of the report of the **Committee for the Decadal Survey on Biological and Physical Sciences in Space,** *Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era,* was completed during this period. Dissemination activities for the report continued and the committee co-chair, Betsy Cantwell, gave an invited talk on the report at International Space Station (ISS) Utilization Workshop on Dec. 16 in Tokyo, Japan.

Many activities occurred this quarter in connection with the second **Decadal Strategy for Solar and Space Physics (Heliophysics)**, including the sixth and final meeting of the survey steering committee in Irvine, CA, on November 16-18, 2011. As the quarter closed, drafts of all sections of the committee's report were complete and revisions and editing were underway to prepare the report for external review. The target date for approval of a pre-publication report remains March 31, 2012; however, as noted in earlier progress reports, a short delay to accommodate changes in the study's work plan may be required. We now estimate approval of a prepublication report may be delayed by approximately 2 weeks. Detailed information about the survey is available at http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_056864. Plans for the public release of the report, including a live webcast, will be posted on the SSB website.

The ad hoc **Committee on Planetary Protection Standards for Icy Bodies in the Solar System** is developing recommendations for planetary protection standards for future spacecraft missions, including orbiters, landers, and subsurface probes, to the icy bodies in the outer solar system. The committee has completed all of its scheduled meetings. A complete draft of the report was assembled during the late-Summer/early-Fall months. The draft text was sent to nine external reviewers in late October. All reviews were received by late November. The committee is currently in the final stages of responding to reviewer comments. Delivery of a final NRC-approved document to NASA is scheduled for March 2012.

The **Planetary Science Decadal Survey**, *Vision and Voyages for Planetary Science in the Decade 2013-2022*, was released in its final printed form in late December. The dissemination of the entire print run was completed by mid-January. No additional copies are available at this time. A second printing is anticipated in the second quarter of 2012. The full text of the report (plus the reports of all of the mission and technology studies conducted in support of the survey) is available for download at http://www.nap.edu/catalog.php?record_id=13117 and is available on a single DVD from the SSB. To request a DVD, send an email to ssb@nas.edu.

An illustrated version of the survey report intended for a popular audience is currently in preparation and is currently scheduled for publication in 2012.

The **Committee for Evaluation of Space Radiation Cancer Risk Model** continued to finalize its draft report during this period, and the draft entered external review in late October. After receiving the comments of each reviewer, the committee continued to refine the report to address all issues raised and this work was completed in mid-December. Release of the report in prepublication form is anticipated in very early 2012.

The summary report of the workshop for **Effects of Solar Variability on Earth's Climate** is approaching review and will be available in Spring 2012. The workshop agenda and abstract booklet is available at http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_061983.

The slate of candidates has been approved for the **Implementation of a Sustained Land Imaging Program**, a study sponsored by the U.S. Geological Survey. The committee will hold its first meeting on February 1-3, 2012, in Washington, DC. The committee will hear briefings from various government agency and private-sector users of land imaging data and information products. More information is available at http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_065886.

OTHER ACTIVITIES

The next scientific assembly of the **Committee on Space Research (COSPAR)** will be held in Mysore, India, on July 14-22, 2012 (see the announcement on page 4 of this newsletter). The 2014 scientific assembly will be held on August 2-10 at the Lomonosov Moscow State University in Russia. COSPAR has provisionally accepted a proposal from Thailand to host the first COSPAR off-year symposium in 2013. The overall theme of the symposium is "Planetary Systems, Both of Our Sun and of Other Stars." More details concerning the symposium will be available later this year.

In partnership with other boards, SSB exhibits at several conferences during the year, including the upcoming **American Astronomical Society**, Austin, TX, January 8-12, 2012.

Selected staff will attend the **American Meteorological Society** meeting in New Orleans, LA, January 22-26, 2012.

CONGRESSIONAL TESTIMONY

Exploring Mars and Beyond: What's Next for U.S. Planetary Science?

Steven W. Squyres, chair of the Committee on the Planetary Science Decadal Survey, testified at the November 15 hearing of the House Space and Aeronautics Subcommittee. His prepared statement is reprinted here (without references, notes, appendices, tables, or figures). Also testifying at the hearing was Jim Green, Planetary Science Division Director, Science Mission Directorate, NASA. For his testimony and more details, go to http://science.house.gov/legislation.

Jim Green (left) and Steve Squyres (right). Credit: Committee on Science and Technology.

Statement of Steven W. Squyres
Goldwin Smith Professor of Astronomy
Cornell University

Before the Committee on Science and Technology
Subcommittee on Space and Aeronautics
House of Representatives
November 15, 2011

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear today. My name is Steven W. Squyres, and my title is Goldwin Smith Professor of Astronomy at Cornell University. I have participated for the past thirty years in a number of NASA solar system exploration missions. Recently I chaired the planetary decadal survey for the National Research Council.

The Planetary Decadal Survey

The NRC's decadal survey report was requested by NASA and the National Science Foundation to review and assess the current status of planetary science and to develop a comprehensive science and mission strategy. The committee that was established to write the report broadly canvassed the planetary science community to determine the current state of knowledge and to identify the most important scientific questions to be addressed during the period 2013-2022. The report presented, to the greatest extent possible, the consensus view of the planetary science community.

The principal support for research related to solar system bodies in the United States comes from the Planetary Science Division (PSD) of NASA's Science Mission Directorate. The annual budget of PSD is currently approximately $1.3 billion. The bulk of this is spent on the development, construction, launch and operation of spacecraft. Two types of spacecraft missions are conducted: large "Flagship" missions strategically directed by the PSD, and smaller Discovery and New Frontiers missions proposed and led by principal investigators. In my testimony today, I will focus, as requested, on the issue of Flagship missions.

Flagship Missions in a Balanced Program

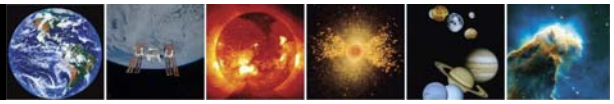
Because my testimony today concerns Flagship missions, I will particularly stress the issue of programmatic balance. The challenge faced by NASA is to assemble a portfolio of missions that achieves a regular tempo of solar system exploration and a level of investigation appropriate for each target object. A program consisting of only Flagship missions once per decade or even less frequently could result in long stretches of relatively little new data being generated, leading to a stagnant community. However, a portfolio of only smaller missions would be incapable of addressing important scientific challenges like in-depth exploration of the outer planets or returning samples from Mars. A key finding of the decadal survey was that "NASA's suite of planetary missions for the decade 2013-2022 should consist of a balanced mix of Discovery, New Frontiers, *and Flagship missions* (emphasis added), enabling both a steady stream of new discoveries and the capability to address larger challenges like sample return missions and outer planet exploration." The program recommended by the NRC was designed to achieve such a balance.

I should also remark on the NRC's recommended decision rules, which dealt with how to reshape the program if necessary in the face of declining budgets. The decadal report did not state that Flagship missions have lower priority than other smaller missions. It stated that an appropriate response to declining budgets is to *delay or descope* Flagship missions—a very different matter from eliminating them.

Flagship Mission Priorities

Based on the broad inputs from the planetary science community and the prioritization criteria described above, the decadal survey identified and prioritized a number of candidate Flagship missions.

The highest priority Flagship mission identified by the NRC is a Mars rover mission that would be the first of three missions in a campaign to return samples from the surface of Mars. It would be responsible for characterizing a landing site that has been selected for high science potential, and for collecting, documenting, and packaging samples for return to Earth. The Mars community, in their inputs to the decadal survey, was emphatic in their view that a sample return mission is the logical next step in Mars exploration.



Mars science has reached a level of sophistication that fundamental advances in addressing the important questions above will only come from analysis of returned samples. This mission would also explore a new site and significantly advance our understanding of the geologic history and evolution of Mars, even before the cached samples are returned to Earth. A crucial aspect of the entire Mars sample return campaign is that it would be carried out in partnership with the European Space Agency, reducing the costs to NASA. I will return to this point below.

The second highest priority Flagship mission identified by the NRC is a mission to characterize Jupiter's moon Europa. Europa is likely to have a deep ocean of liquid water beneath its icy crust, making it an object of enormous interest as a possible abode for life. The mission would put a spacecraft in orbit around Europa, investigating its probable ocean and interior, its ice shell, its chemistry and composition, and the geology of prospective landing sites.

The third highest priority Flagship mission is an orbiter and probe mission to the ice giant planet Uranus. Galileo and Cassini have performed spectacular in-depth investigations of the Jupiter and Saturn systems, respectively. The Kepler mission has shown that many exoplanets are ice-giant sized. Exploration of a planet like Uranus is therefore the obvious and important next step in the exploration of the giant planets. This mission would deploy an atmospheric probe into Uranus and then enter orbit, making measurements of the planet's atmosphere, interior, magnetic field, and rings, as well as multiple flybys of the larger uranian satellites.

The Problem

The NRC's decadal recommendations to NASA covered many topics. These included recommended funding levels and content for the planetary research and analysis program and technology development program. They also included specific recommendations for the structure and content of the small Discovery and medium-sized New Frontiers mission lines. I'm pleased to report that in all of these areas, the Agency's response has been to follow the NRC recommendations closely.

Unfortunately, the one area to date where NASA has not followed the NRC's recommendations has been implementation of Flagship missions. As outlined above, Flagship missions are vital to the health of planetary science. And as stressed in the NRC decadal report, Flagship missions are an essential part of a balanced program of planetary exploration. The lack of progress in implementing the recommended approach to Flagship missions is cause for serious concern.

An obvious issue regarding Flagships is their cost. Because the costs of Flagship missions are high, even proportionally modest cost overruns can have serious consequences for the rest of the program. This is the reason that the decadal report placed strong emphasis on independent and conservative cost estimation processes. But even in the current cost-constrained environment the lack of progress in implementing a Flagship mission is surprising.

The Solution

In my view, the publicly available budget guidelines that have been provided to NASA by the Office of Management and Budget are sufficient to allow the Agency to carry out the Mars sample collection and caching mission recommended as the highest priority by the NRC. The key to achieving this in an affordable way is partnership with the European Space Agency.

As the spectacularly successful Cassini/Huygens mission to Saturn has Titan shown, international partnerships can be enabling for Flagship missions. The NRC report concluded that partnership with ESA is essential for the Mars sample caching mission, and for the Mars program overall. ESA can bring substantial capabilities and resources to a partnership, lessening both the risk and the financial burden to NASA. To date, however, the Administration has not committed to this partnership.

A potential objection to the proposed mission is that it would be the first in a series of three missions required to return the samples to Earth, each involving significant costs. This concern is offset by three factors. First, the first mission in the campaign would do significant new science on its own, partially providing an immediate justification for its costs. Second, the campaign has been intentionally designed so that the three missions can be spread out in time, substantially if necessary, to spread the costs over an acceptable period. Third, partnership with ESA throughout the entire campaign will substantially lower the total costs to NASA.

Important steps have already been taken to reduce both cost and cost risk. NASA's current concept for the Mars sample caching mission is substantially descoped from the original one, in line with the decadal recommendation to descope Flagship missions in the face of declining budgets. In addition, the current concept makes extensive use of existing hardware designs, reducing the risk of unexpected cost growth. Despite this important progress, however, no commitment to the mission has been made.

Summary

If no commitment to a Flagship mission is made in response to the decadal survey recommendations, the result will be highly detrimental to the future of U.S. planetary science. More pragmatically, I fear that an inability to enter into a mutually beneficial partnership with a willing, eager, and highly capable agency like ESA would jeopardize future international partnerships as well.

I would also like to stress a critical point: The ability to carry out the most challenging tasks in deep space exploration —tasks like landing and roving on Mars—is one of our nation's scientific and technical crown jewels. If we give up that capability by abandoning planetary Flagship missions, then we do a disservice not just to ourselves, but also to future generations of American scientists, engineers, and explorers. In my view, it is essential that NASA maintain this unique capability. The resources to do it within a balanced program are available. What is needed is a willingness to commit those resources to this essential task.

So my message to the Subcommittee today is simple: In order to achieve a balanced program of planetary exploration, and to maintain American leadership in this field, NASA must be permitted to use its available resources to implement the Flagship mission program recommended by the NRC's decadal survey.

CONGRESSIONAL TESTIMONY, CONTINUED

The Next Great Observatory: Assessing the James Webb Space Telescope

Roger D. Blandford, chair of the Committee for a Decadal Survey of Astronomy and Astrophysics, testified at the December 6 hearing of the House Committee on Science, Space, and Technology. His prepared statement is reprinted here (without references, notes, appendices, tables, or figures). Also testifying at the hearing were Rick Howard, Garth Illingworth, and Jeffrey D. Grant. For their testimony and more details, go to http://science.house.gov/legislation.

Testimony of

Dr. Roger D. Blandford
Luke Blossom Professor in the School of Humanities and Sciences Stanford University and
Chair, Committee for a Decadal Survey of Astronomy and Astrophysics National Research Council
The National Academies
before the
Committee on Science, Space, and Technology U.S. House of Representatives

December 6, 2011

Good morning. My name is Roger Blandford and I am the Luke Blossom Professor in the School of Humanities and Sciences at Stanford University. I chaired the 2010 National Research Council's Decadal Survey in Astronomy and Astrophysics, "New Worlds, New Horizons" (NWNH). The National Research Council (NRC) is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology.

I thank you for the opportunity to comment on James Webb Space Telescope (JWST) which was the highest priority recommendation in the 2001 decadal survey, Astronomy and Astrophysics in the New Millennium (AANM) and is a cornerstone of the scientific program advanced in NWNH. These comments are largely my own, although at times I will be referring to the findings of the 2001 and 2010 NRC Decadal Surveys.

Chairman Hall, Ranking Member Johnson, allow me to begin by thanking you and your colleagues for your support of this project, most recently through the House-Senate Conference, H.R. 2112 where the budget to complete the project under the NASA "replan" was restored and protection against further cost growth was instituted. I believe that this is a courageous recognition by you of the scientific importance and value of the telescope and an expression of confidence that NASA now has the management of this project under tight and realistic control.

JWST (formerly known as Next Generation Space Telescope) is a 6.5 meter diameter telescope. It is much larger than the Hubble Space Telescope (HST—2.4 meter diameter) and unlike HST, it will observe the universe from near the "second Lagrange Point,"

Left to right: Rick Howard, Roger Blandford, Garth Illingworth, Jeffrey Grant Credit: Committee on Science and Technology.

roughly four times as far away from the Earth as the moon but along the opposite direction to the sun. It will be protected from the sun by an elaborate sunshield. JWST is an engineering marvel and its 18 beryllium mirrors will be furled up within a rocket for launch and then deployed at its destination. This operation has to work perfectly as there will be no means of servicing it after launch.

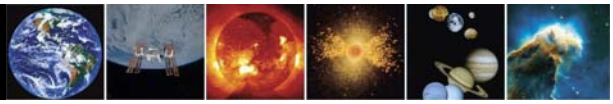
The principal scientific goals of JWST are bold and exciting and a culmination of nearly fifty years of extraordinary discovery about the universe and our place in it. They are:

- To observe the very first stars, galaxies and black holes which formed at a time when the universe was about four percent of its present age
- To discover how stars and planets actually form today within our Galaxy
- To study planets orbiting nearby cool stars and assess their habitability

However, JWST will also operate as an astronomical observatory and many, and perhaps most, areas of astronomy will be transformed by JWST in much the same way as they have been revolutionized by HST.

JWST is specialized to observe in the infrared region of the spectrum. This is relevant because, although much light emitted by the most distant galaxies is in the optical and ultraviolet spectral bands, the wavelengths of this light are stretched roughly tenfold through the expansion of the universe into the infrared band, as we push out to greater distance and earlier times. There is a second reason why it is preferred to observe in the infrared and this is that the star-forming regions that will be intensively studied by JWST are filled with tiny grains of dust. These dust grains absorb and scatter optical and ultraviolet light but leave infrared radiation alone, enabling us to see deep inside them at these wavelengths. In addition, the light that is absorbed by dust will be re-emitted at infrared wavelengths and we can also observe the dust itself as a tell-tale tracer of star formation.

As well as being the natural successor of HST, JWST is the



infrared successor of the much smaller (0.85 meter diameter) Spitzer Space Telescope, with over 50 times the light-gathering ability and 40 times the resolution as well as the Herschel telescope, led by the European Space Agency, which only observes at longer infrared wavelengths than JWST. Given this huge increase in performance over and complementarity to previous telescopes, JWST promises to be a scientific "game changer."

One reason AANM chose JWST as its highest priority recommendation was its capacity to trace light from the first stars and galaxies during our "Cosmic Dawn" and to watch them grow up and change as the universe expanded. We now have a fairly precise "standard model" of cosmology, which allows us to predict the approximate date when the first stars and galaxies formed. This lies well within JWST's reach and it will be able to observe the resulting "redshifted" optical and ultraviolet light. It will help explain just how the gas in the universe was converted from atomic to ionized form during the so-called "Epoch of reionization" which marked the end of our cosmic "dark age." One of the many important discoveries that have been made in this area since the publication of AANM has been that massive black holes are rapidly grown in the nuclei of galaxies surprisingly soon after the formation of the first stars. We see these as the most distant "quasars" and JWST will help us understand how they formed and their impact on their surroundings.

A second reason for JWST's recommendation in AANM was that it is expected to revolutionize our understanding of how stars and planets form in our Galaxy today. The scientific questions have become much more tightly framed largely through developing the capability to see deeper into the stellar nurseries and measuring stellar masses. The Atacama Large Millimeter/submillimeter Array (ALMA), a ground-based telescope that was a top priority in the 1991 decadal survey, has just begun Early Science Operation at a site in Chile and is expected to complement JWST in this research.

A third major use for JWST has been largely developed over the past decade. The study of "New Worlds"—exoplanets orbiting other stars—has blossomed. Over seven hundred certified examples are now known, with many more suspected cases under investigation. The diversity of these planets and their host stars is remarkable. Understanding their nature and potential habitability was a major component of the NWNH prioritized science program. As an infrared telescope, JWST is especially well-suited to observe planets orbiting smaller and cooler stars than the sun, that emit mainly in the infrared band. A planet orbiting such a cool star at the right distance should be habitable and perhaps capable of supporting life. JWST has the capacity to see through the atmospheres of many of these planets and determine their composition so as to see if they have life-sustaining oxygen and water, for example. This technique, which was pioneered by Spitzer should work extremely well with JWST exploiting its superb performance in the middle range of the infrared spectrum. JWST also has the capability to observe planetary systems, including those like our solar system, in the process of formation. Here it will be able to observe the extensive disks of gas, stones and rocks, orbiting the host star, out of which planets are eventually assembled. The ability of JWST to tune into different wavelengths enables it to study both the hot regions close to the central star and the cooler parts that are further away.

So, the list of scientific attributes of JWST that justified top ranking in AANM a decade ago, not only remain relevant today but has actually grown. Indeed JWST as well as the ground-based telescope, ALMA, are cornerstones of the recommended new program from NWNH. In terms of the first stars and galaxies, ALMA is expected to detect the cold gas and the tiny grains of dust associated with the first large bursts of star formation. JWST, by contrast, should provide unparalleled sensitivity to the light emitted by the first galaxies and pinpoint the formation sites of the first stars. Furthermore, the highest-ranked, new large space project recommended by NMNH, the Wide Field InfraRed Space Telescope, WFIRST, is expected to complement the targeted infrared observation of JWST with a wide field investigation of dark energy and exoplanet studies. In addition, the highest ranked ground-based recommendation of NWNH, the Large Synoptic Survey Telescope will be the telescope that will find many of the most interesting galaxies and stars that will be followed up in detail by JWST. Likewise, the third-ranked large, ground-based project from NWNH, the Giant Segmented Mirror Telescope was recommended as a spectroscopic complement to JWST. In other words, JWST is central to the scientific program that was recommended by NWNH.

Decadal surveys have been a feature of American astronomy since the 1960s. They compel the astronomy community, through its representatives on the survey committee, to plan a realizable program for the coming decade and beyond. They invariably involve hard choices as the number of feasible missions and facilities greatly exceeds what can be afforded. The astronomy community respects and has always respected the outcome of these deliberations. It recognizes that the process represents the best way to advance the whole field under the constraint of finite resources. The community also acknowledges that the largest and most ambitious projects typically take more than a decade to bring to fruition and that this can lead to delays in realizing newer entries into the program. Space missions, in particular, can encounter unanticipated difficulties and costs can increase from those advertised when a project is first recommended. Although, the delay in the JWST launch was not appreciated at the time NWNH was written, it was acknowledged that there would be little new activity in space astronomy until JWST was launched, presumably in mid-decade. The American Astronomical Society (AAS) which reflects the views of the general astronomy and astrophysics community, continues to support JWST despite the strain its delay is placing on other potential space science missions. The American Physical Society has also endorsed the program. Importantly, JWST is an international collaboration and our European and Canadian partners have invested heavily in it and have been resolute in their support.

The most recent astronomy and astrophysics decadal survey (NWNH) broke new ground in many ways. It was the most inclusive survey to date through inviting white paper submissions from the astronomical community to help define the science program as well as the challenges in areas such as technology development, education, laboratory astrophysics, etc.—over 450 were received—and through requesting specific mission proposals—over 100 were reviewed. It exposed the freshly recommended projects to an independent cost, schedule and risk assessment and used the results to help de-

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fine a program that conformed with agency-generated funding projections. The lessons learned from this exercise were shared with the leadership of the following two NRC decadal studies, in planetary science and heliophysics. Following its statement of task, NWNH adopted the performance, cost and schedule of JWST as supplied by NASA as part of its baseline set of programmatic and budgetary assumptions. The survey did not perform any independent study of JWST.

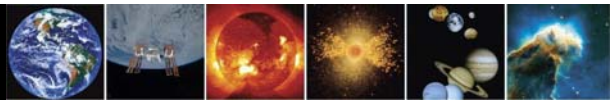
In view of the centrality of JWST in addressing the NWNH-recommended science program, the additional complement of space- and ground-based telescopes and facilities in the recommended program were definitely predicated upon the completion of JWST. I believe that, if JWST were not to be completed, then a very large part of the combined science program of AANM and NWNH would not be executable and there would be a consequent call to propose new infrared facilities to replace JWST. Indeed, if JWST were assumed not to exist at the time of white paper submissions to NWNH, then undoubtedly a similar infrared facility would have been proposed. Since the recommendations of the decadal survey were science-driven, the science priorities would not have changed without a JWST. However, I believe the recommended mission portfolio would have changed.

As I have outlined, JWST is confidently expected to achieve its science goals—explore cosmic dawn, examine stellar nurseries and probe exoplanets orbiting cool stars. However, as has been the case with HST, I expect that its ultimate scientific impact will be even greater including much "unscripted" discovery, Dramatic findings like the realizations that 96 percent of the universe is in an unseen "dark" form, that massive black holes reside at the centers of most galaxies and that most sun-like stars are also orbited by planets are still likely to be made. I believe that NASA should continue to support JWST because of the insight that it will provide into fundamental, longstanding questions of extraordinary scientific and popular appeal and its capacity for opening up discovery space. A considerable effort has gone into developing the NASA replan and, whereas any project can encounter unforeseen problems, JWST is now much better understood than it was a year ago and I am optimistic that it will be able to launch on its new schedule. Further grounds for confidence rest on the extraordinary success rate of recent space astrophysics missions. The performances of NASA's fleet of currently operating astrophysics missions—Chandra, Fermi, GALEX, HST, Kepler, RXTE and Swift—have all far exceeded scientific expectation. Similar remarks can be made about recently completed astrophysics missions and missions led by other countries with U.S. partnership. Collectively, these voyages of discovery have maintained the long-held position of global scientific leadership for the U.S. in this field.

In summary, launching and operating JWST would be scientifically transformational, internationally inspirational. It would also make a powerful statement that the United States still has the resolve to execute large, technically challenging and innovative scientific projects. No other country currently has this capability.

Thank you again for the opportunity to address you. I hope that my testimony will be helpful and I look forward to answering your questions.

NASA engineer Ernie Wright looks on as the first six flight ready James Webb Space Telescope's primary mirror segments are prepped to begin final cryogenic testing at NASA's Marshall Space Flight Center. Credit: NASA/ MSFC/David Higginbotham.



STAFF NEWS

Lloyd V. Berkner Space Policy Internship

During this quarter the Lloyd V. Berkner Space Policy Internship Program said goodbye to its Fall 2011 intern **Danielle Piskorz**.

The goal of the program is to provide promising students with the opportunity to work in the area of civil space-research policy in the nation's capital, under the aegis of the SSB. Additional information on the program can be found in this newsletter and at http://sites.nationalacademies.org/SSB/ssb_052239.

Katie Daud, *who completed her assignment as an SSB Summer 2011 Lloyd V. Berkner Space Policy Intern in July, reflects on her experience with the SSB*

Working in space policy has always been a dream of mine. Learning of the space policy internship was so exciting since it allows me to get a taste of what it means to combine my passion in space science and my love of policy into a career.

This internship provided me with a wealth of knowledge concerning day-to-day activities of space policy and I am so grateful to have been able to experience it. During this internship, I was able to go to congressional hearings and hear key issues being discussed and debated. I was also able to attend many meetings with the key players in space policy to talk about career goals and how others combined their love of science with the calling to make a difference in policy.

During this time, I had the opportunity to attend a committee meeting out in Irvine, California on Icy Bodies in the Outer Solar System. From this, I was able to learn about the process of how recommendations and findings are made and how they are conveyed to the public. My daily tasks consisted of helping out staff with current projects that ranged from looking at NASA's funding levels for certain Earth Science programs over the last decade to reading reports and deriving glossaries from them.

The knowledge that I have gained from this internship will help me advance a future career in space policy. The staff have been so kind and helpful and have made this such a rewarding and positive experience at the National Academies.

Rachael Alexandroff, *who completed her assignment as an SSB Summer 2011 Lloyd V. Berkner Space Policy Intern in July, reflects on her experience with the SSB*

Arriving in Woods Hole, MA, for a committee meeting not having formally met any of my coworkers is probably not the typical way to start an SSB internship. But it's not a bad one either. And luckily for me my wonderful experience in Woods Hole was only the first glimpse of an amazing summer to come.

I am still stunned by some of the amazing opportunities that were presented to me this summer. Working at the SSB put me at the very heart of the space policy field, and that was made apparent at numerous talks I attended outside the walls of the Keck building that cited SSB studies when presenting their vision of NASA's future. Working for the SSB, I was able to

LLOYD V. BERKNER SPACE POLICY INTERNSHIPS

WE ARE CURRENTLY ACCEPTING APPLICATIONS FOR INTERNSHIPS FOR THE SUMMER 2012 PROGRAM

The goal of the Lloyd V. Berkner Space Policy Internship program is to provide promising undergraduate and graduate students with the opportunity to work in the area of civil space research policy in the nation's capital, under the aegis of the SSB.

Established in 1958 to serve as the focus of the interests and responsibilities in space research for the National Academies, the Board provides an independent, authoritative forum for information and advice on all aspects of space science and applications, and it serves as the focal point within the National Academies for activities on space research. It oversees advisory studies and program assessments, facilitates international research coordination, and promotes communications on space science and science policy between the research community, the federal government, and the interested public. The SSB also serves as the U.S. National Committee for the International Council for Science Committee on Space Research (COSPAR).

The Lloyd V. Berkner Space Policy Internships, named after the first chair of the SSB, are offered twice annually. The summer program is restricted to undergraduates, and the Fall program is open to both undergraduate and graduate students.

The SSB is now accepting applications from undergraduates for its summer 2012 program. The deadline for applications is February 3, 2012. Successful candidates will be contacted no later than March 2, 2012.

Individuals seeking a Lloyd V. Berkner Space Policy Internship must have the following minimum qualifications:

- *Be a registered student at a U.S. university or college;*
- *Have completed his/her junior year, majoring in physics, astronomy, chemistry, biology, or geology (other areas considered on a case-by-case basis);*
- *Have long-term career goals in space science research, applications, or policy;*
- *Possess good written and verbal communications skills and a good knowledge of his/her particular area of study;*
- *Be capable of responding to general guidance and working independently; and*
- *Be familiar with the internet, world wide web and basic research techniques (familiarity with Microsoft Word and HTML is highly desirable, but not essential).*

NOTE: SELECTION OF INTERNS AND INITIATION OF PROGRAM IS DEPENDENT ON AVAILABILITY OF FUNDS.

Visit http://sites.nationalacademies.org/SSB/ssb_052239 to learn more about the internship program and to get application information.

(Continued from page 17)

fully immerse myself in the world of space policy. I derived a rich sense of the report-writing process as I worked on different projects at various stages in their life; I did background research, observed meetings, edited, wrote glossaries, and attended briefings on a variety of subjects. I have never known as much about orbital debris, heliophysics, or NASA's hypersonics flight test program as I do now.

I also had the opportunity to interact with members of the space policy field from all across DC. My interactions with staff from OMB, OSTP, and NASA HQ, not to mention a very memorable trip to the Pentagon, helped provide me with a well-rounded understanding of possible job opportunities in space policy, and I am very grateful to David Smith for arranging these opportunities.

Most of all, I want to thank all of the members of the SSB, especially Dr. Smith and my fellow intern Katie Daud for ensuring I had an amazing summer. Everyone was extremely welcoming and willing to engage me in discussion about policy, space science, and occasionally *Battlestar Galactica*. My summer was truly enriched by your presence.

Christine Mirzayan Science and Technology Policy Graduate Fellowship Program

The Christine Mirzayan Science and Technology Policy Graduate Fellowship Program within the Policy and Global Affairs Division of the National Academies is designed to engage its fellows in the analytical process that informs U.S. science and technology policy. Fellows develop basic skills essential to working or participating in science policy at the federal, state, or local levels. More information about the fellows program can be found at http://sites.nationalacademies.org/PGA/policyfellows/index.htm.

***Anna Williams** completed her Fall 2011 Mirzayan Fellowship. Her reflections on her experience with the SSB appear below.*

My fascination with the interface of science and the public sector originated during my undergraduate studies of chemistry and philosophy. During graduate school, while pursuing doctoral studies in organic chemistry, I continued to develop an interest in the relationship between empirical research and public policy, and, in August 2011, immediately following the defense of my Ph.D., I came to the Space Studies Board of the National Academies as a Mirzayan Science and Technology Policy Fellow.

My decision to work at the SSB, rather than other areas of the Academies, appeared unlikely to some, but was primarily influenced by my long-standing fascination with origins of life research, particularly as relates to the intersection of geological and biological chemistry. Space science mission objectives have increasingly been influenced by scientific curiosities to explore the potential for extraterrestrial life and to understand the chemical origins of biological systems. The Mirzayan Fellowship therefore offered me a two-fold opportunity, as I partook in the science policy immersion program offered by the fellowship program while additionally becoming better acclimated to origins research, astrobiology, and planetary science, as well as various other aspects of space science and exploration mission objectives.

As I continue to explore further career prospects, I feel that I have benefitted tremendously from the opportunity to work within the SSB and to understand the model employed by the Academies by which relevant members of the scientific community are gathered to offer consensus recommendations in order to guide further policy determinations. My various experiences, including contributing to National Research Council reports, attending numerous congressional hearings, and presenting before the SSB, have cemented my decision to transition from the laboratory bench to science policy, and I very much appreciate the efforts made by the staff of the SSB, the Aeronautics and Space Engineering Board, and the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program to provide this exceptional opportunity.

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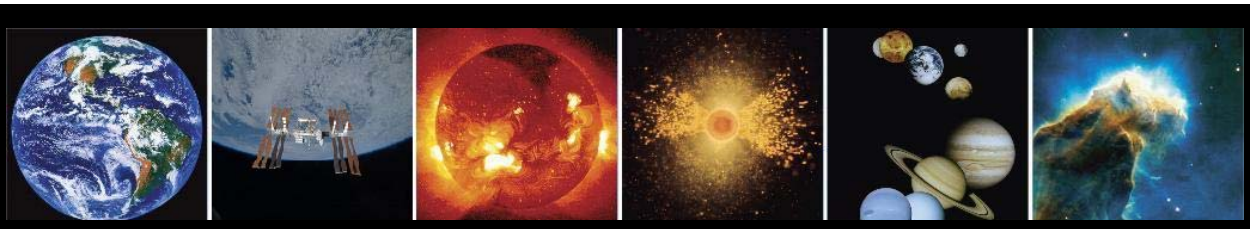
Lloyd V. Berkner Space Policy Interns
DANIELLE PISKORZ, Fall

Christine Mirzayan Fellow
ANNA WILLIAMS

*Staff of other NRC boards who are shared with the SSB



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JANUARY						
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January 18-20 — *Committee on Assessment of a Plan for U.S. Participation in Euclid*—**Washington, DC**

March 12-15 — *COSPAR*—**Paris, France**

TBD — *Committee on Astrobiology and Planetary Science (CAPS)*—**TBD**

TBD — *Committee on Earth Sciences and Applications from Space (CESAS)*—**TBD**

TBD — *Committee on Astronomy and Astrophysics (CAA)*—**TBD**

FUTURE SSB MEETINGS

April 4-5, 2012, in Washington, DC (April 4 joint with ASEB)
August 7-8, 2012, Woods Hole, MA (Executive Committee)
November 12-14, 2012, Irvine, CA
April 4-5, 2013, Washington, DC
November 7-8, 2013, Irvine, CA

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