THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

QUARTERLY NEWSLETTER OF THE SPACE STUDIES BOARD

VOLUME 16, ISSUE 2 APRIL– JUNE 2005

SPACE STUDIES BOARD BULLETIN

FROM THE CHAIR

Each of the columns that I have written to date has dealt with an issue of immediate concern to the space program, usually triggered by some recent event that altered the purpose of the space program, or the balance among its various aspects, or its leadership. We are presently at a brief lull in the action. At the Subcommittee level, Congress has passed appropriations for NASA that are essentially equal to the President's request, although there are some concerns and differences in the details. The new NASA Administrator, Mike Griffin, has made statements that are very supportive of science, particularly with regard to the breadth and balance of science that is to be pursued. However, the statements will become reality only when the FY2007 budget is developed this fall. There are rumors of many leadership changes in NASA, which will have a profound effect on science, but these will have to await the 12th of August, which is when the new Administrator can make such changes.

It seems appropriate then to use this column to discuss an issue of long-term importance to the space program. Indeed it is among the most significant issues for determining our future success: the workforce. Where will the space program obtain the workforce to execute the ambitious goals we have, and how and where will they be trained?

The fact that the future workforce is an important issue should not be a surprise. The civilian space program began with a bang in the early 1960's. Starting from essentially nothing in the late 1950's, an American workforce of over 400,000 was assembled at the peak of the Apollo program in the mid-1960's. Students were encouraged to pursue careers in space. Those of us who were in high school when Sputnik was launched were both fascinated by the opportunities of space and drawn by a national imperative to serve our country by pursuing careers in space. After Apollo, however, the funding for civilian space declined, and it has remained at an essentially constant level since the early 1970's. Those of us who got in early have enjoyed successful careers, and during our prime there was relatively little need to replace us. Now we are getting old. Whether all of us are as bold as we were in our youth, or as bold as we will need to be to execute our future in space, is questionable. And while there is no mandatory retirement in the US, mortality eventually catches up with all of us.

We will probably not send humans to Mars for 30 years. Certainly the first generations of space scientists and engineers will be gone by then, and also so will many who are now in the prime of their careers. There is no plan to sprint to Mars as in Apollo, but it is not hard to imagine that on this 30-year time horizon, we will need 50,000 to 75,000 new scientists and engineers that we currently do not have.

It would be nice to think that someone in the NASA leadership is worrying about the workforce issue and doing something positive to ensure that the required workforce will be available. Unfortunately, that does not seem to be the case, as is evidenced by the fact that so many recent actions have been detrimental to creating the required workforce. I am not suggesting that these actions are malicious, only shortsighted; it is the law of unintended consequences at work.

Unless we are expecting to have the workforce trained overseas, the research universities of the United States must provide the needed scientists and engineers. At the graduate level, this training must involve participation in forefront research. Even at the undergraduate level, the training should involve hands-on experience with actual space projects. The most pressing future need will be for engineers and scientists who are able to develop hardware, and thus their training will be meaningful only if the faculty of their university is also involved in the development of space hardware.

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FROM THE CHAIR

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Regrettably, almost every recent procurement action by NASA has been detrimental to university participation in hardware programs. For example consider the following:

- It has become increasing costly to develop a competitive proposal for participation in a NASA flight mission, and the costs are beyond the resources available to universities. They have no bid-and-proposal budgets and no profit that can be applied, and proposal preparation is not an allowable overhead expense.
- Many NASA missions, particularly the smaller ones, are selected as a complete mission with a single PI who can, in principle, come from a university. However, with the exception of a few powerhouse universities, most academic research groups do not have the infrastructure to manage an entire mission. These groups are then dependent on having partners at other universities, industry or in NASA centers to participate. It is not the NASA procurement process that determines their selection, only the alliances they can build.
- In the past, the development time for space instrumentation was longer and allowed for development of new technology. Universities used these longer missions to replenish their technology base and to update their infrastructure. Now missions have a limited development time and a highly constrained budget, with the consequence that effectively no new technology can be introduced. Where then do universities develop new technologies to remain competitive? There are some programs for developing new technologies, but they are limited.
- NASA is currently imposing management requirements on how flight hardware is to be developed, with the belief that this will result in fewer failures. Many of these new processes run counter to the way university groups have learned to develop hardware, and have enjoyed considerable success in doing so. Even worse, the technical evaluation of proposals by NASA can penalize universities, in the belief that they are not able to execute NASA management processes. The result is a competitive disadvantage for universities compared to NASA centers and other national laboratories.
- Universities have their own aging problem. The distinguished faculty members who established competitive experimental groups are retiring and need to be replaced by younger faculty. Yet in today's competitive environment, it is very difficult for a young faculty member to be selected for flight hardware or to have anything to show for the effort when it is time to seek tenure.
- Balloon and sounding rocket programs have long been the mainstay of university research and graduate training. These programs are now inadequately funded for this task.

It is not surprising then that the number of university space research groups capable of building space hardware is dwindling. A professor can produce only so many graduate students. If the number of active groups is limited, the production of graduate students is limited, and the pipeline will be inadequate to meet the national need.

NASA does have an education program. However, it has focused primarily on K-12 education. This is fun stuff. It is good for NASA's image. It may even increase the number of students who will pursue careers in science and engineering. It is unlikely, however, to do anything to ensure the required workforce for space. The numbers required to pursue space exploration might seem large, ~75,000, but they are still small compared with the nation's output of scientists and engineers. The question, then, is not how many students pursue careers in science and engineering but rather how many will devote their careers to space. There is no national imperative this time. Even a vigorous human exploration program to Mars will not capture the national attention as Apollo did. Once again, it will be the universities that have the important role. They can lure students who have already decided on careers in science and engineering into the excitement of space, especially by offering research opportunities for undergraduates.

At the beginning of the space program, NASA recognized the need for a strong university involvement. The agency encouraged university participation through research and technology grants and significant hardware opportunities. The result was an impressive infrastructure that trained the current workforce, developed innovative technology, and performed outstanding research. That infrastructure is currently being allowed to decay. Yet there is a pressing need now to rejuvenate the workforce. Our future will depend on.

Let us hope that some enlightened NASA leadership will recognize that the principal impediment to success in space is the lack of a trained workforce and that they move aggressively to ensure that it will be available. And let us hope that the agency's leadership will attack this problem in a coordinated way, recognizing that there are many aspects—from the health of the university infrastructure to NASA procurement practices—that must be addressed.

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DIRECTOR'S COLUMN

In these columns over the past seven years I have tried to take note of recent events that are relevant to space research and to ask what message should we, especially the "we" of the space research community, take away from these developments and trends. The key events have included the steady stream of Earth and space science accomplishments that regularly yield dramatic leaps forward in our understanding of the universe, our place in it, and the implications of that understanding for how we view our destiny. Notable recent examples include the continuing achievements by the Mars rovers, the exploration of the Saturn system by the Cassini-Huygens mission, and the innovative examination of a comet by the Deep Impact mission.

Frequently I have been led to conclude that the future prospects of the space program are very much subject to some combination of making the case about,

a) the value of space research in a larger national context,
b) the role of science in the larger national context, and
c) the imperatives of real strategic planning, broad participant (i.e. “stakeholder”) ownership, appreciation for the level of risk and technological challenge, meaningful international cooperation, and portfolio balance that ensures progress across the board.

This quarter offers no fewer relevant opportunities or challenges than at any time in the past. In April, a new NASA Administrator, Michael Griffin, was nominated and quickly confirmed and appointed. Many of his initial actions, including his willingness to revisit the Hubble Space Telescope servicing decision, the future of NASA’s Earth science program, the general principle that NASA’s exploration vision should include progress on a broad scientific front, and the specific fate of missions such as Voyager and Ulysses, were notably encouraging. As he entered the period in which he would be able to assemble his own senior management team that would lead the future directions of NASA’s programs there were the usual “honeymoon” expectations as well as uncertainties about what his management team signaled for the future of all aspects of NASA.

In considering that longer term outlook, it seems to me that there is a set of very fundamental principles that have proven to be crucial to the sustainability and value of the space sciences.[1] These involve ensuring,

- broad community involvement,
- clear and compelling scientific goals and priorities, and
- balanced progress in key areas of science.

I have become struck recently about the first item on that list of principles—“community involvement.” This is a term that is readily recognized and accepted as part of the lexicon of scientists and other experts who work with scientists. But what does it really mean and how is it open to interpretation in different settings?

To scientists the concept is the embodiment of a collective process of consultation, wide debate, and consensus building, all of which lead to a very direct sense of ownership of the results by participants and a wider population that participants, explicitly or implicitly, strive to represent. This is the basis, for example, for the generally wide acceptance of the NRC decadal science strategy surveys. Scientists believe intrinsically in the importance of having an opportunity weigh in on the issues, and they want to be heard.

There are compelling arguments that this process is a key to the decades-long success of NASA’s space science program. At the SSB’s November 2003 workshop on national space policy participants from government, industry, and academia agreed that the history of constructive tension between the scientific community and NASA was a key factor. The scientific community has steadfastly pushed the agency to stretch its limits with the result that the program has been a widely supported engine for achievement. The basic concept of having a stakeholder community outside the agency that simultaneously worked with NASA, challenged NASA to advance, and shared responsibility for making those advancements has distinguished the space sciences from many other NASA and national endeavors.

This process of active scientific involvement has been an asset to communicating priorities to a wide range of decision makers. Simply put, the fact that there have been priorities debated by and agreed to across a particular research discipline has been a powerful factor in convincing officials in the White House and the Congress that there exists a consensus that should provide the basis for allocation of resources.

However, there is a flip side to making arguments about community involvement. There is a risk of walking too close to a precipice when we simply make an argument to an agency official or a decision maker in Congress that so-and-so “is important for the scientific community.” The immediate questions are Who are we protecting?, Who really benefits?, and What is the difference between a particular issue and a self-serving plea to protect some status quo? We, the space research community, owe answers to the policy makers.

The answers are there, but they have to be articulated. We enjoy a situation at present in which there is a strong environment of support for science in space. But we have to make the case on fundamental, not narrow “community,” grounds for sustaining that support. That is a responsibility of all the members of the scientific community. There is no room for simply claiming an entitlement. Instead, the merits still have to be articulated and done so compellingly. This idea was captured in the SSB’s recent report on “Science in NASA’s Vision for Space Exploration,” namely,

> “When, where, and how [we explore] should depend on what best serves to advance intellectual understanding of the cosmos and our place in it and to lay the technical and cultural foundations for a space-faring civilization…The targets should be those that have the greatest opportunity to advance our understanding of how the universe works, who we are, where we came from, and what is our ultimate destiny.”

I would hope that the scientific community doesn’t lose sight of that metric and that decision makers all across the government don’t lose sight of the importance and value of sustaining healthy scientific community involvement as we move ahead with the exploration and exploitation of space.

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[1] The term “space science” is meant here in the broad sense and includes the space and Earth Sciences.

BOARD AND COMMITTEE NEWS

- The **Space Studies Board** (SSB) held its 146th meeting on June 7-9, 2005, at the Jet Propulsion Laboratory (JPL) in Pasadena, CA. Highlights of the meeting included a briefing by Charles Elachi, Director of JPL, on roles and responsibilities of the lab and subsequent tours of the spaceflight operations facility and Cassini operations (see photos on page 11), the Mars Exploration Rovers science and operations areas and the rover operations test area, and the interferometry test laboratory. A major portion of the meeting was related to preparations for review of the new NASA science roadmaps. Marc Allen of NASA Headquarters provided an overview of the NASA planning roadmaps, and SSB members and committee chairs presented reviewers' comments on the Mars exploration, solar system exploration, Earth science, sun-solar system, Earth-like planets, and exploration of the universe roadmaps.

On the second day of the meeting Terri Lomax from the NASA Headquarters Exploration Systems Mission Directorate briefed the board on International Space Station planning. Dennis Matson, of JPL, briefed the board on the Cassini-Huygens Saturn mission. Scott Pace, NASA Associate Administrator for Program Assessment and Evaluation, joined the board via teleconference to discuss issues related to NASA's roadmaps, after which the SSB held an extended discussion of cross-cutting issues with respect to the review of the roadmaps.

On the final day of the meeting Ed Stone, U.S. representative to COSPAR, briefed the Board on recent developments and future plans in COSPAR; Gerhard Haerendel, chair of the European Space Science Committee (ESSC), briefed the board on the ESA Aurora program and a review of the program by the ESSC; and SSB member Reta Beebe summarized a new planning activity for a possible NASA-ESA Europa mission. The board discussed planning for the Executive Committee meeting on August 9-11, 2005 and the next Board meeting, which will be held on November 8-10, 2005 at the Beckman Center in Irvine, CA.

During the meeting Board chair Len Fisk saluted retiring members Ana Barros, Margaret Kivelson, Harry McSween, Anna-Louise Reysenbach, Roald Sagdeev, and Carolus Schrijver, who will rotate off of the board at the end of June, 2005.

- The **Committee on Astronomy and Astrophysics** (CAA) met in Washington, DC on May 19-20, 2005. The committee heard presentations from various organizations, including Anne Kinney of NASA, Amy Kaminsky of the Office of Management and Budget, and Wayne Van Citters of the National Science Foundation (NSF). The committee heard presentations from John Carlstrom of the University of Chicago regarding the NSF Radio/ Millimeter/Sub Millimeter long range plan and from Caty Pilachowski of the University of Indiana regarding the NSF Optical/Infrared long range plan. The committee also heard a presentation by Michael Turner of the NSF regarding strategic planning and the status of responses to the decadal survey at NSF. The next CAA meeting will be November 29-30, 2005, in Irvine, CA.

- The **Committee to Review the Science Requirements for the Atacama Large Millimeter Array** (ALMA), is a multinational project being carried out between North America (the United States and Canada), Europe (the European Southern Observatory [ESO] and Spain), and Japan. Initial bidding on construction of the individual antennas in the array has raised the possibility that the project may need to be descoped in order to manage its cost. The ALMA committee met at Stanford University in Palo Alto, CA on May 6-7, 2005. Most of the meeting was devoted to the generation of an outline and initial draft of the report. The committee released the a prepublication version its final report on June 10, 2005.

- The **Committee on Planetary and Lunar Exploration** (COMPLEX) met in Washington, DC on April 18-20, 2005 and held a teleconference on June 3, 2005. Both activities were associated with COMPLEX's contributions to the review of NASA's Strategic Roadmaps. Three new members were appointed this quarter. Additional appointments are pending. The committee has had preliminary, informal discussions with NASA about examining the scope of missions to be considered in the competition for the third New Frontiers launch opportunity. The next meeting of COMPLEX will be July 20-22, 2005 at Wesleyan University in Middletown, CT. The meeting will focus on issues associated with the exploration of the Moon and outer planets.

- The **Task Group on Exploring Organic Environments in the Solar System** (TGOESS) did not meet during the quarter. Work on revising the draft report in response to comments from NRC external review is continuing. The anticipated release of the final report is scheduled for early fall 2005.

- The **Task Group on the Limits of Organic Life in Planetary Systems** (LIMITS) did not meet this quarter. Task group members continue to work on the report. A meeting of a subset of members may be scheduled fall in Washington, DC.

- The **Committee on the Origins and Evolution of Life** (COEL) met on May 31-June 2, 2005 in Woods Hole, MA. The meeting was devoted to gathering committee members' input to the review of NASA's strategic roadmaps and to organizing a study concerning the planetary protection requirements for Venus missions. The dissemination of committee's new report, *The Astrophysical Context of Life,* is near completion and very few copies of the report remain available. Craig Wheeler's term as co-chair of the committee ends on June 30, he will be replaced by Bruce Jakosky. Additional committee appointments are pending and should be finalized by late summer. The next meeting of the committee will be October 3-5, 2005 at the Southwest Research Institute in Boulder, CO.

- The **Committee on Space Science Enabled by Nuclear Power and Propulsion** submitted its draft for review in late spring. The anticipated release of the final report is scheduled for early fall 2005.

- The **Committee on Solar and Space Physics** (CSSP) did not meet during the this quarter. Committee members did participate in the review of the NASA Sun-Solar System Connection strategic roadmap. CSSP also received approval for a new study, which is to begin with a CSSP/NASA-sponsored workshop on the solar system radiation environment and the NASA vision for exploration. The workshop will examine the characterization, prediction, and mitigation of the impacts of the radiation environment in the solar system on robotic and human exploration. The next meeting of the committee will be October 17-20, 2005 at the Wintegreen resort in Virginia, concurrently with the October 16-21 radiation workshop.

- The **Committee on Earth Studies** did not meet during the quarter, but committee members completed a draft of the report, *Extending the Effective Lifetimes of Earth Observing Research Missions*. The report entered NRC external peer review in late June.
- The Steering Committee for **Earth Science and Applications from Space** (ESAS) published its interim report, *Earth Science and Applications from Space: Urgent Needs and Opportunities to Serve the Nation*, on April 25, 2005. The purpose of the interim report was to identify urgent, near-term issues that require attention prior to completion of the full decadal survey, including (a) the absence of a robust mission queue for the future Earth science missions that will build logically on the highly successful EOS missions; (b) a precarious plan to use instruments on the nation's next generation of weather satellites; and (c) threats to the viability of programs for advanced technologies, research and analysis, and climate data programs. Committee co-chair, Berrien Moore, testified on the interim report at a hearing of the House Committee on Science on April 28. The committee is now turning its attention to the decadal survey, which is scheduled to be completed in late 2006. The next meeting of the committee will be on July 14, 2005 at the National Academies Keck Center in Washington, DC.
- The ESAS **Panel on Water Resources and the Hydrologic Cycle** held its first meeting on May 9-10, 2005 in Boulder, Co; the ESAS **Panel on Weather** held its first meeting on June 22-23 in Boulder, Co.; and the ESAS **Panel on Solid-Earth Hazards, Resources, and Dynamics**, held its first meeting on June 28-29 in Washington, DC. The other panels were planning their initial meetings as the quarter came to a close. A joint meeting of the panels and the executive committee is planned for August 29-September 1, 2005 in Irvine, CA. The committee has also established a web site at http://qp.nas.edu/decadalsurvey where interested members of the community can stay up to date with the study and provide views to the committee.
- The **Committee on Space Biology and Medicine** (CSBM) was not active during this period, except for various tracking and dissemination activities such as providing requested materials and information on prior reports or assistance to related studies by other committees.
- The **Committee on Microgravity Research** (CMGR) was not active during this period, except for various tracking and dissemination activities such as providing requested materials and information on prior reports.
- The **Committee on Assessment of Options for Extending the Life of the Hubble Space Telescope** released its report *Assessment of Options for Extending the Life of the Hubble Space Telescope* on CD-ROM in April 2005. The committee formally disbanded on April 30.
- The SSB, working jointly with the Aeronautics and Space Engineering Board, is organizing independent reviews of strategic road maps that are were developed by NASA's Advanced Planning and Integration Office. The **Panel to Review NASA's Science Strategic Roadmaps** met on June 13-15, 2005 in Washington, DC. The panel heard presentations from representatives for each of the NASA science roadmap teams. Most of the meeting was devoted to preparing an outline and initial draft of the report. This report will address the following topics:
  1) robotic and human exploration of Mars;
  2) a sustained program of solar system exploration;
  3) advanced telescope searches for Earth-like planets and habitable environments around neighboring stars;
  4) exploration of the origin, evolution, structure, and destiny of the universe;
  5) Earth science and applications; and
  6) sun-solar system connections.

The panel's report is scheduled to begin the external review process in July and to be released in August. A separate panel to review NASA's plans for research on the International Space Station will be organized in the fall.

- The **Committee on Preventing the Forward Contamination of Mars** (PREVCOM) is revising its draft report in response to external reviews. A prepublication version of the report is expected in late July 2005.
- The **Committee on Principal-Investigator (PI)-Led Missions in the Space Sciences** has completed its draft report and the report is currently undergoing external review. A prepublication version of the report is expected in late summer 2005.
- In response to a NASA request, the **Committee on NASA Astronomy Science Centers** is being established and nominations for the membership are being prepared.
- In response to a NASA request, the **Committee on Large Optics in Space** is being established and nominations for the membership are being prepared.
- The **Committee on Space Research (COSPAR)** held its annual business and program meetings March 21-24, 2005. COSPAR's Program Committee met to begin to organize the scientific program for 2006 Scientific Assembly to be held in Beijing, China. The COSPAR Bureau met to review COSPAR business and operations, and the Publications Committee met to consider issues relevant to COSPAR's scientific journal, *Advances in Space Research*, and the *COSPAR Information Bulletin*. Prior to its business meetings, COSPAR held a meeting to follow-up on "The Future of COSPAR" brainstorming session held last July following the COSPAR scientific assembly in Paris. Since the July 2004 meeting, task groups have been considering specific aspects of the COSPAR organization—international cooperation; relations with external organizations; scientific structure; scientific vision for the future; capacity-building; developing nations; and young scientists and students—and how COSPAR should handle or change those functions over the future. Representatives of the task groups reported on their results. COSPAR's Bureau and Program Committee will meet next in the Spring of 2006.

An announcement for COSPAR Awards and Medal nominations follows:

SEEKING NOMINATIONS FOR COSPAR AWARDS AND MEDALS

The Committee on Space Research (COSPAR) is seeking candidates to be nominated for COSPAR Awards and Medals, which recognize the outstanding achievements of space scientists throughout the world. COSPAR will present the awards at its 36th COSPAR Scientific Assembly to be held in Beijing, China, July 16-23, 2006.

It is important to honor the contributions of your colleagues. Please take a moment to consider nominees for the following awards and medals:

COSPAR Space Science Award

This award honors a scientist who has made outstanding contributions to space science. Previous recipients include: J. Blamont (2004), V. Moroz (2004), S. Krimigis (2002), C. Russell (2002), R. M. Bonnet (2000), D. Hunten (2000), M. Neugebauer (1998), C. Cesarsky (1998), M. Oda (1996), N. Ness (1996), J. Trümper (1994), G. Haerendel (1994), E. Stone, Jr. (1992), J. Simpson (1990), S. Mandelshtam (1988), K. Gringauz (1988), L. Biermann (1986), and J. Van Allen (1984).

COSPAR International Cooperation Medal

This medal is awarded to a scientist (or group of scientists) who has made distinguished contributions to space science and whose work has contributed significantly to the promotion of international scientific cooperation. Previous recipients include: S. Holt (2004), A. Brack (2002), J.H. Carver (2000), R. Lüst (1998), A. Grigoriev (1996), R. Daniel (1994), H. Curien (1992), B. Hultqvist (1990), C. de Jager (1988), The Inter-Agency Consultative Group (1986) and R. Sagdeev (1984).

COSPAR William Nordberg Medal

The Nordberg Medal is presented to a scientist who has made a distinguished contribution to the application of space science. Previous recipients include: L. Lanzerotti (2004); M. Chahine (2002), K. Ijiri (2000), A. Thompson (1998), C. Elachi (1996), P. Morel (1994), J. Houghton (1992), D. King-Hale (1990), S. I. Rasool (1988).

COSPAR Distinguished Service Medal

This medal serves to honor extraordinary services rendered to COSPAR over many years. Previous recipients include: S. Grzedzielski (2000), R. Hart (1996), A. Somogyi (1994), J-F. Denisse (1993) Z. Niemirowicz (1992).

COSPAR/Massey Award

The Massey Award is an award of the Royal Society of London and recognizes outstanding contributions to the development of space research in which a leadership role is of particular importance. Previous recipients include: Y. Tanaka (2004), J. Paul (2002), G. Bignami (2002), S.C. Bower (2000), R.Sunyaev (1998), J. Geiss (1996), R. Wilson (1994), H. Friedman (1992), and H. van de Hulst (1990).

COSPAR/Vikram Sarabhai Award

This medal is awarded by the Indian Space Research Organization (ISRO) in honor of Vikram Sarabhai, for outstanding contributions to space research in developing countries. Eligible candidates for next years award must have performed relevant work mainly in 2000-2005. Previous recipients include: A. Willmore (2004), R. Xu (2002), Z. Liu (2000), J. Baker (1998), U.R. Rao (1996), J. Blamont (1994), C.-Y. Tu (1992), and V.Kotelnikov (1990).

COSPAR/Zeldovich Medal

Zeldovich Awards are conferred by the Russian Academy of Sciences to young scientists for excellence and achievements. Medals are presented to a scientist in each of COSPAR's Scientific Commissions. Recipients of the 2004 Zeldovich Medals were: C. Peters-Lidard (Commission A); H. Kawakita (Commission B); E. Lucek (Commission D); A. Vikhlinin (Commission E); I. Shumilina (Commission F); T. Boeck (Commission G); W. Weber (Commission H).

Nomination forms can be obtained from Pamela Whitney (202-334-3477, e-mail: pwhitney@nas.edu) at the National Academies', Space Studies Board (SSB), which is the U.S. adhering body to COSPAR. All nominations will be processed by the SSB and will be reviewed by the U.S. National Representative to COSPAR, Dr. Edward C. Stone. Completed nomination packages must be submitted to the SSB **no later than SEPTEMBER 28, 2005**.*

NEW REPORTS FROM THE SSB

Free copies of SSB reports are available while supplies last. To request copies of reports, please contact the SSB office at 202/334-3477 or via email SSB@nas.edu.

Earth Science and Applications from Space: Urgent Needs and Opportunities to Serve the Nation

This report by the Committee on Earth Science and Applications from Space: A Community Assessment and Strategy for the Future is available in prepublication format online at http://www.nap.edu/catalog/11281.html. The study was staffed by Arthur Charo, Study Director, Space Studies Board, Ann Linn, Senior Program Officer, Board on Earth Sciences and Resources Smith, Theresa Fisher, Senior Project Assistant, Space Studies Board and Cathy Gruber, Assistant Editor. The following is adapted from the executive summary of the report, which was released on April 25, 2005.

EXECUTIVE SUMMARY

The decades of the 1980s and 1990s saw the emergence of a new paradigm for understanding our planet—observing and studying Earth as a system of interconnected parts including the land, oceans, atmosphere, biosphere, and solid Earth. At the same time, satellite observing systems came of age and produced new and exciting perspectives on Earth and how it is changing. By integrating data from these new observation systems with in situ observations, scientists were able to make steady progress in the understanding of and ability to predict a variety of natural phenomena, such as tornadoes, hurricanes, and volcanic eruptions, and thus help mitigate their consequences. Decades of investments in research and the present Earth observing system have also improved health, enhanced national security, and spurred economic growth by supplying the business community with critical environmental information.

Yet even this progress has been outpaced by society's ongoing need to apply new knowledge to expand its economy, protect itself from natural disasters, and manage the food and water resources on which its citizens depend. The aggressive pursuit of understanding Earth as a system—and the effective application of that knowledge for society's benefit—will increasingly distinguish those nations that achieve and sustain prosperity and security from those that do not. In this regard, recent changes in federal support for Earth observation programs are alarming. At NASA, the vitality of Earth science and application programs has been placed at substantial risk by a rapidly shrinking budget that no longer supports already-approved missions and programs of high scientific and societal relevance. Opportunities to discover new knowledge about Earth are diminished as mission after mission is canceled, descoped, or delayed because of budget cutbacks, which appear to be largely the result of new obligations to support flight programs that are part of the Administration's vision for space exploration. In addition, transitioning of the scientific successes at NASA into operational capabilities at NOAA and other agencies has failed repeatedly, even as the United States has announced that it will take a leadership role in international efforts to develop integrated, global observing systems.

The committee affirms the imperative of a robust Earth observation and research program to address such profound issues as the sustainability of human life on Earth and to provide specific benefits to society. Achieving these benefits further requires that the observation and science program be closely linked to decision support structures that translate knowledge into practical information matched to and cognizant of society's needs. The tragic aftermath of the 2004 Asian tsunami, which was detected by in situ and space-based sensors that were not coupled to an appropriate warning system in the affected areas of the Indian Ocean, illustrates the consequences of a break in the chain from observations to the practical application of knowledge.

The committee's vision for the future is clear: The nation should meet the grand challenge of effectively enhancing and applying scientific knowledge of the Earth system both to increase fundamental understanding of our home planet and how it sustains life and to meet increasing societal needs. This vision reflects and supports established national and international objectives, built around the presidential directives that guide the U.S. climate and Earth observing system initiatives. Realizing the vision requires a strong, intellectually driven Earth sciences program and an integrated land- and space-based observing system—the foundation essential to developing knowledge of Earth, predictions, and warnings—as well as better decision-support tools to transform new knowledge into societal benefits and more effectively link science to applications. The payoff for our nation and for the world is enormous.

The current U.S. civilian Earth observing system centers on the environmental satellites operated by NOAA; the atmosphere-, biospheres-, ocean-, ice-, and land-observation satellites of NASA's Earth Observing System (EOS); and the Landsat satellites, which are operated by a cooperative arrangement involving NASA, NOAA, and the U.S. Geological Survey (USGS). Today, this system of environmental satellites is at risk of collapse. Although NOAA has plans to modernize and refresh its weather satellites, NASA has no plan to replace its EOS platforms after their nominal 6-year lifetimes end (beginning with the Terra satellite in 2005), and it has canceled, descoped, or delayed at least six planned missions, including a Landsat Data Continuity "bridge" mission.

These decisions appear to be driven by a major shift in priorities at a time when NASA is moving to implement a new vision for space exploration. This change in priorities jeopardizes NASA's ability to fulfill its obligations in other important presidential initiatives, such as the Climate Change Research Initiative and the subsequent Climate Change Science Program. It also calls into question future U.S. leadership in the Global Earth Observing System of Systems, an international effort initiated by the current Administration. The nation's ability to pursue a visionary space exploration agenda depends critically on its success in applying knowledge of Earth to maintain economic growth and security at home.

Moreover, a substantial reduction in Earth observation programs today will result in a loss of U.S. scientific and technical capacity, which will decrease the competitiveness of the United States internationally for years to come. U.S. leadership in science, technology development, and societal applications depends on sustaining competence across a broad range of scientific and engineering disciplines that include the Earth sciences.

In this interim report, the committee identifies a number of issues that require immediate attention in the FY 2006 and FY 2007 budgets:

- Proceed with some NASA missions that have been delayed or canceled,
- Evaluate plans for transferring needed capabilities from some canceled or descoped NASA missions to NPOESS,
- Develop a technological base for exploratory Earth observation systems,
- Reinvigorate the Explorer missions program,
- Strengthen research and analysis programs, and
- Strengthen the approach to obtaining important climate observations and data records.

The committee's final report, expected in late 2006, will identify high-priority Earth observing system investments for the next decade.

Proceed with Missions That Have Been Delayed or Canceled

Recently, six NASA missions with clear societal benefits and established support of the Earth science and applications community have been delayed, descoped, or canceled. Two of these missions should proceed immediately:

- *Global Precipitation Measurement (GPM)*. The Global Precipitation Measurement mission is an international effort to improve climate, weather, and hydrological predictions through more accurate and more frequent precipitation measurements. It is an approved mission that has been delayed several times by NASA.

The committee recommends that the Global Precipitation Measurement mission be launched without further delays.

- *Atmospheric Soundings from Geostationary Orbit*. The Geostationary Imaging Fourier Transform Spectrometer (GIFTS) will provide high-temporal-resolution measurements of atmospheric temperature and water vapor, which will greatly facilitate the detection of rapid atmospheric changes associated with destructive weather events, including tornadoes, severe thunderstorms, flash floods, and hurricanes. The GIFTS instrument has been built at a cost of approximately $100 million, but the mission has been canceled for a variety of reasons.

The committee recommends that NASA and NOAA complete the fabrication, testing, and space qualification of the GIFTS instrument and that they support the international effort to launch GIFTS by 2008.

Three other missions—Ocean Vector Winds, Landsat Data Continuity, and Glory—as well as development of enabling technology such as the now canceled wide-swath ocean altimeter, should be urgently reconsidered, as described below.

Evaluate Plans Needed for Transferring Capabilities to NPOESS

Instruments on the following three canceled missions may be either transferred from NASA or replaced with other instruments for flight on the National Polar-orbiting Operational Environmental Satellite System (NPOESS). This approach has both advantages (e.g., transfer of research capabilities to operational use) and disadvantages (e.g., decrease in instrument capability, gaps in data continuity).

- *Ocean Vector Winds*. Global ocean surface vector wind observations have enhanced the accuracy of severe storm warnings, including hurricane forecasts, and have improved crop planning as a result of better El Niño predictions. However, NASA has canceled the Ocean Vector Winds mission, a previously planned follow-on to the active scatterometer currently operating on the QuikSCAT mission, which has already exceeded its design life.
- *Landsat Data Continuity*. For more than 30 years, Landsat satellites have collected data on Earth's continental surfaces to support Earth science research and state and local government efforts to assess the quality of terrestrial habitats, their resources, and their degradation due to human activity. The president's budget for NASA for FY 2006 discontinues plans for launch of this satellite system and instead directs NASA to assume responsibility for providing two Operational Land Imager (OLI) instruments for delivery to NPOESS (the second OLI is to be delivered 2 years after the first).
- *Glory*. Glory carries two instruments—the Advanced Polarimetric Sensor (APS) and the Total Irradiance Monitor (TIM). Part of the framework of the president's Climate Change Research Initiative, Glory was developed to measure aerosol properties (via the APS) with sufficient accuracy and coverage to quantify the effect of aerosols on climate. Glory would also monitor the total solar irradiance.

The committee recommends that NASA and NOAA commission three independent reviews, to be completed by October 2005, regarding the Ocean Vector Winds, Landsat Data Continuity, and Glory missions. These reviews should evaluate:

- **The suitability, capability, and timeliness of the OLI and CMIS instruments to meet the research and operational needs of users, particularly those that have relied on data from Landsat and QuikSCAT;**
- **The suitability, capability, and timeliness of the APS and TIM instruments for meeting the needs of the scientific and operational communities;**
- **The costs and benefits of launching the Landsat Data Continuity and Glory missions prior to or independently of the launch of the first NPOESS; and**
- **The costs and benefits of launching the Ocean Vector Winds mission prior to or independently of the launch of CMIS on NPOESS.**

If the benefits of an independent NASA mission(s) cannot be achieved within reasonable costs and risks, the committee recommends that NASA build the OLI (two copies, one for flight on the first NPOESS platform), APS, and TIM instruments and contribute to the costs of integrating them into NPOESS. APS, TIM, and the first copy of OLI should be integrated onto the first NPOESS platform to minimize data gaps and achieve maximum utility.

The reviews could be conducted under the auspices of NASA and NOAA external advisory committees or other independent advisory groups and should be carried out by representative scientific and operational users of the data, along with NOAA and NASA technical experts.

Develop a Technological Base for Exploratory Earth Observation Systems

Much of the recent progress in understanding Earth as an integrated system has come from NASA's Earth Observing System (EOS), which is composed of three multi-instrumented platforms (Terra, Aqua, and Aura) and associated smaller missions. Initial plans, made in the 1980s, called for three series of each of the platforms to ensure a 15-year record of continuous measurements of the land surface, biosphere, solid Earth, atmosphere, and oceans. However, by the late 1990s, budget constraints and other factors led NASA to abandon plans for follow-ons to the first series of EOS satellites. Knowledge anticipated from analysis of EOS long-term data records depends now on a precarious plan to use instruments on the nation's next generation of weather satellites—NPOESS, scheduled for launch in 2009, and a new GOES series, scheduled for launch in 2012—foreign missions, and the occasional launch of small Explorer-class missions. In fact, aside from several delayed Explorer-class missions, the Ocean Surface Topography Mission (a follow-on to the current Jason-1 mission), and the Global Precipitation Measurement mission, the NASA program for the future has no explicit set of Earth observation mission plans.

The committee's final report will include a prioritized list of new Earth observing missions and capabilities. In the meantime, a healthy scientific and technological base for future missions must be maintained.

• *Enabling technology base.* The paucity of missions in active planning mode undercuts the observational capability for which a strong enabling technology base is essential. Particularly disturbing is the absence of development activities for identified measurement capabilities that have been extensively studied, vetted within the community, and endorsed by NASA.

The committee recommends that NASA significantly expand existing technology development programs to ensure that new enabling technologies for critical observational capabilities, including interferometric synthetic aperture radar, wide-swath ocean altimetry, and wind lidar, are available to support potential mission starts over the coming decade.

Reinvigorate the NASA Earth Explorer Missions Program

NASA developed its Earth System Science Pathfinder (ESSP) program as "an innovative approach for addressing Global Change Research by providing periodic 'Windows of Opportunity' to accommodate new scientific priorities and infuse new scientific participation into the Earth Science Enterprise. The program is characterized by relatively low to moderate cost, small to medium sized missions that are capable of being built, tested and launched in a short time interval." ESSP missions were intended to be launched at a rate of one or more per year.

ESSP missions provide a mechanism for developing breakthrough science and technology that enables future societal benefits and for ensuring that human capital is maintained for future missions. New ESSP missions within this program need to be initiated on a frequent basis to fuel innovation, and missions must be launched soon after selection to keep the technology from becoming obsolete. Some of the missions now being planned may not be launched until nearly 10 years after they were selected.

The committee supports continuation of a line of Explorer-class missions directed toward advancing understanding of Earth and developing new technologies and observational capabilities, and urges NASA to:

- **Increase the frequency of Explorer selection opportunities and accelerate the ESSP-3 missions by providing sufficient funding for at least one launch per year, and**
- **Release an ESSP-4 announcement of opportunity in FY 2005.**

Strengthen Research and Analysis Programs

The committee is concerned that a significant reallocation of resources for the research and analysis (R&A) programs that sustain the interpretation of Earth science data has occurred either as a result of the removal of the "firewall" that previously existed between flight and science programs or as an unintended consequence of NASA's shift to full-cost accounting. Because the R&A programs are carried out largely through the nation's research universities, there will be an immediate and deleterious impact on graduate student, postdoctoral, and faculty research support. The long-term consequence will be a diminished ability to attract and retain students interested in using and developing Earth observations. Taken together, these developments jeopardize U.S. leadership in both Earth science and Earth observations, and they undermine the vitality of the government-university-private sector partnership that has made so many contributions to society.

Strengthen Baseline Climate Observations and Climate Data Records

The nation continues to lack an adequate foundation of climate observations that will lead to a definitive knowledge about how climate is changing and will provide a means to test and systematically improve climate models. NASA and NOAA should enhance their observing systems to ensure that there are long-term, accurate, and unbiased benchmark climate observations for a well-defined set of critical climate variables, including atmospheric temperature and water vapor, spectrally resolved Earth radiances, and incident and reflected solar irradiance.

The committee recommends that NASA, NOAA, and other agencies as appropriate accelerate efforts to create a sustained, robust, integrated observing system that includes at a minimum an essential baseline of climate observations, including atmospheric temperature and water vapor, spectrally resolved Earth radiances, and incident and reflected solar irradiance.

Finally, as recommended in previous National Research Council reports, an expanded set of long-term, accurate climate data records should continue to be produced to monitor climate variability and change. A climate data and information system for NPOESS is needed that will make it possible to assemble relevant observations, remove biases, and distribute and archive the resulting climate data records. A corresponding research and analysis effort is also needed to understand what these records indicate about how Earth is changing.

The committee recommends that NOAA, working with the Climate Change Science Program and the international Group on Earth Observations, create a climate data and information system to meet the challenge of ensuring the production, distribution, and stewardship of high-accuracy climate records from NPOESS and other relevant observational platforms.

Today the nation's Earth observation program is at risk. If we succeed in implementing the near-term actions recommended above and embrace the challenge of developing a long-term observation strategy that effectively recognizes the importance of societal benefits, a strong foundation will be established for research and operational Earth sciences in the future, to the great benefit of society—now and for generations to come.

The Atacama Large Millimeter Array (ALMA): Implications of a Potential Descope

This report by the Committee to Review the Science Requirements for the Atacama Large Millimeter Array is available in prepublication format online at http://books.nap.edu/catalog/11326.html.

The study was staffed by Donald C. Shapero, Director, Board on Physics and Astronomy, Brian D. Dewhurst, Study Director, and Celeste A. Naylor, Senior Project Assistant, Space Studies Board. The report summary is reproduced here without footnotes.

EXECUTIVE SUMMARY

The Committee to Review the Science Requirements for the Atacama Large Millimeter Array conducted a study to evaluate the consequences of a descope of the Atacama Large Millimeter Array (ALMA), which is intended to be the major, ground-based observational facility for millimeter and submillimeter astronomy for the next three decades. The committee was asked to consider the scientific consequences of reducing the number of active antennas from 60 to either 50 or 40 antennas. The committee concluded that:

- A 60-element array would be greatly superior to any current or planned comparable instrument for several decades and would revolutionize millimeter and submillimeter astronomy.
- Two of the three level-1 requirements, involving sensitivity and high-contrast imaging of protostellar disks, will not be met with either a 40- or a 50-antenna array. It is not clear if the third requirement, on dynamic range, can be met with a 40-antenna array even if extremely long integrations are allowed for.
- Speed, image fidelity, mosaicing ability, and point source sensitivity will all be affected if the ALMA array is descoped. The severest degradation is in image fidelity, which will be reduced by factors of two and three with descopes to 50 and 40 antennas, respectively.
- Despite not achieving the level-1 requirements, a descoped array with 50 or 40 antennas would still be capable of producing transformational results, particularly in advancing understanding of the youngest galaxies in the universe, how the majority of galaxies evolved, and the structure of protoplanetary disks, and would warrant continued support by the United States.
- Furthermore, it is the committee's appraisal that a 40-antenna array would retain ALMA's strong support within the general astronomical community. However, the rapid decline in imaging capability that would result with a further reduction below 40 antennas would erode this support.

FROM OUR SUMMER INTERN

Matthew Broughton
2005 Summer Space Policy Intern

I first heard about the Space Studies Board's summer undergraduate internship during my sophomore year. Even though I was a year away from being eligible for the internship, Professor Mark Engebretson, my adviser at Augsburg College, suggested that I keep it in mind as a way to combine my two majors (English and physics).

As the year progressed, I had the opportunity to read parts of *The Sun to Earth—And Beyond: A Decadal Research Strategy in Solar and Space Physics*. I first noticed the quality of writing. Rarely had I seen science communicated with such grace and clarity. Also, reading *The Sun to Earth—And Beyond* gave me a macroscopic perspective on space physics. While I loved the research I had done with Professor Engebretson and Dr. Slava Pilipenko, I found that after looking at hundreds of spectrograms or writing multiple data conversion programs, I lost the ability to place research into a larger context. Reading the executive summary of the report *The Sun to the Earth—And Beyond* helped me see how the work I was doing fit into a research strategy.

Most importantly, this internship has allowed me to interact in a larger scientific community. As I have studied physics, my idea of research changed from a romantic view of a lone scientist in a lab to the notion that research is often the product of a community of dedicated people who are there to educate, support, and critique each other while pursuing one of the most exciting endeavors: discovery.

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25-26	EARTH SCIENCE AND APPLICATIONS FROM SPACE: — CLIMATE PANEL	STATE COLLEGE, PA
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9-11	SSB EXECUTIVE COMMITTEE MEETING	WOODS HOLE, MA
16-18	COMMITTEE ON NASA ASTRONOMY SCIENCE CENTERS	WASHINGTON, DC
29-**SEPT. 1**	EARTH SCIENCE AND APPLICATIONS FROM SPACE: COMMITTEE & PANELS	IRVINE, CA
OCTOBER		
3-5	COMMITTEE ON THE ORIGINS AND EVOLOTION OF LIFE	BOULDER, CO
16-21	COMMITTEE ON SOLAR AND SPACE PHYSICS: WORKSHOP ON RADIATION ENVIRONMENT IN THE SOLAR SYSTEM	WINTERGREEN, VA
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New NAS President

Ralph J. Cicerone begins his six-year term as the new president of the National Academy of Sciences July 1, 2005. Cicerone is an atmospheric chemist and former chancellor of the University of California's Irvine campus. Outgoing president, Bruce Alberts, will return to California where he is a cell biologist on the faculty of the University of California, San Francisco.

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