Approaches to Future Space Cooperation and Competition in a Globalizing World: Summary of a Workshop

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James V. Zimmerman, Rapporteur; National Research Council

APPROACHES TO FUTURE SPACE COOPERATION AND COMPETITION IN A GLOBALIZING WORLD

SUMMARY OF A WORKSHOP

James V. Zimmerman, Rapporteur

Space Studies Board
and
Aeronautics and Space Engineering Board
Division on Engineering and Physical Sciences
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Preface

The ad hoc Planning Committee for the Workshop on U.S. Civil Space Policy was set up under the auspices of the Space Studies Board, working in collaboration with the Aeronautics and Space Engineering Board, to organize a public workshop for the purpose of reviewing past and present cooperation, coordination, and competition mechanisms for space and Earth science research and space exploration; identifying significant lessons learned; and discussing how those lessons could best be applied in the future, particularly in the areas of cooperation and collaboration. (See Appendix A for the full workshop statement of task.) The workshop, held on November 18-20, 2008, at the Arnold and Mabel Beckman Center of the National Academies in Irvine, California, utilized a format involving invited presentations, panel discussions, and general discussions, both in plenary sessions and in subgroups. The workshop was attended by approximately 60 participants from government, academia, and industry, both U.S. and non-U.S., with expertise spanning the fields of civil and commercial space programs, science and technology policy, international relations, and history. (See Appendix B for the agenda and list of participants.)

Presentations and initial discussion focused on past and present experiences in international cooperation and competition to identify "lessons learned." Those lessons learned were then used as the starting point for subsequent discussions on the most effective ways for structuring future cooperation or coordination in space and Earth science research and space exploration. The goal of the workshop was not to develop a specific model for future cooperation or coordination, but rather to explore the advantages and disadvantages of various approaches and stimulate further deliberation on this important topic.

This report presents a summary of the discussions at the workshop and does not represent a consensus of the views of the workshop participants, but instead captures highlights of the discussions and notes major themes that emerged. While the workshop's mandate covered both cooperation and competition, workshop discussions tended to focus more on cooperation.

Acknowledgment of Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

Ralph Braibanti, U.S. Department of State (retired),
Joan Johnson-Freese, U.S. Naval War College,
Eric Sterner, House Armed Services Committee (retired professional staff), and
Lyn Wigbels, RWI International.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the views summarized, nor did they see the final draft of the report before its release. The review of this report was overseen by Eugene B. Skolnikoff, Massachusetts Institute of Technology. Appointed by the NRC, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the author and the institution.

Contents

Summary

With the end of the Cold War, space and Earth science research and space exploration were no longer dominated by competition between two superpowers. Numerous countries and regions now have very active space programs, and the number is increasing. These maturing capabilities around the world create a plethora of potential partners for cooperative space endeavors, while at the same time heightening competitiveness in the international space arena. In assessing the effectiveness of specific past and present cooperation or coordination mechanisms and in seeking to determine how best to proceed in the future, it is important to recognize that the world has become more globalized.

International cooperation and coordination on both a bilateral and multilateral basis have played a significant role in civil space activities since the beginning of the space age. Generally speaking, cooperation involves two or more countries working together, each contributing to the execution of a single mission. Coordination involves two or more countries that keep each other apprised of their activities in order to minimize duplication of effort and to obtain the maximum return through complementary activities. International cooperation and coordination have occurred extensively in Earth and space science research, Earth applications from space, human spaceflight and microgravity science, and to a lesser extent satellite telecommunications, satellite navigation, and launchers.

Currently, most space-faring nations have space-related aspirations that exceed the resources available to them individually. At the same time, more countries are working to enter the field. Thus, it is appropriate to review the models for international cooperation and coordination that have or have not worked in the past to identify the most effective approaches for the future, including how best to involve nations with an emerging space capability. There are also lessons to be learned from the competitive space arena that may have relevance to developing future modes of cooperation.

In opening the November 2008 workshop, Space Studies Board chair Charles Kennel noted that the ongoing globalization in today's world and the current global financial crisis have implications for space. He expressed the opinion that the international order is going to be restructured, with major shifts in international relationships that will impact space. In his view there will therefore be a need for the space community to respond by working to develop a global approach to space.

While the workshop's charge covered both cooperation and competition, workshop discussions tended to focus more on cooperation, given the backgrounds of the majority of participants.

WORKSHOP PLENARY DISCUSSIONS

Following keynote presentations by former NOAA administrator Conrad Lautenbacher, entitled "Scientific and Technological Cooperation and Competition in a Globalizing World" (Appendix D), and historian Roger Launius of the National Air and Space Museum, entitled "Governmental Space Cooperation and Competition During and After the Cold War—Lessons Learned" (Appendix E), the workshop moved to panel sessions with four panels addressing different aspects of space cooperation and competition.

The first panel on lessons learned from previous cooperative efforts emphasized space and Earth science cooperation, with the International Space Station (ISS) as one model; the International Traffic in Arms Regulations (ITAR), seen as a space cooperation inhibitor; and international cooperation within the commercial sector.

The second panel discussed lessons learned from past and present competitive activities. Speakers were drawn from commercial launch services and commercial remote sensing sectors.

The third panel addressed space and national security. Major issues that surfaced related to ITAR, attitudes of the U.S. Congress with regard to international cooperation, and the implications of seeking to engage China in future cooperative space activities.

The fourth panel focused on the potential offered by space cooperation as a tool for the engagement of new and emerging space nations. Particular emphasis was placed on continuing activities within the Global Exploration Strategy/International Space Exploration Coordination Group, U.S.-Japanese space cooperation, and China's emergence as a major space power.

Following panel presentations, workshop participants collectively discussed the issues raised.

WORKSHOP DISCUSSION GROUPS

Following the plenary discussions, workshop participants were divided into four parallel discussion groups that were each given one of the following topics to address:

- International space cooperation as a tool for engagement with emerging space power,
- The role of international cooperation in the future of space exploration,
- The role of Earth observations in supporting international efforts in climate and sustainability, and
- New approaches to global space cooperation in a time of limited resources.

The views of discussion group participants were reported back to the final plenary session and are summarized below. They do not represent consensus findings or conclusions on the part of the National Research Council, the Space Studies Board, the workshop as a whole, or any other group.

Engaging New and Emerging Space Powers in International Cooperation

The discussion group on engaging new and emerging space powers in international cooperation observed that new and emerging space powers may desire to cooperate with the United States on space projects for a variety of reasons including:

- Enhancement of their prestige;
- Acceleration of their economic and technical development; and
- Greater access to knowledge, experience, and technology.

From a U.S. perspective, the group identified benefits from collaboration that included:

- Support for U.S. foreign-policy goals;
- Increased access to key decision makers;
- Insight into capabilities, approaches, and plans;
- Identification of new ideas and new technologies;
- Reduction in U.S. costs; and
- Expansion of instrument flight opportunities and data analysis capabilities.

Opportunities for the Future

One particularly valuable effort, the group suggested, could involve the convening of forums through which existing space powers could engage in dialogue with new and emerging space powers. Such forums could provide opportunities to:

- Improve mutual understanding of capabilities, programs, and plans,
- Assess the current state of cooperation,
- Identify potential collaborative programs,
- Recommend promising mechanisms for continued joint consultations,
- Promote open participation, and
- Develop personal and institutional relationships.

The discussion group members, including participants from Europe and Japan, noted that the Space Studies Board might wish to consider implementing such forums and to do so in a collaborative fashion that involves the European Space Science Committee and a counterpart organization in Japan.

International Cooperation in the Future of Space Exploration

Participants in the discussion group on international cooperation in the future of space exploration observed that with the world becoming increasingly interdependent, space activities need to be conducted in a manner consistent with this reality. For international space activities to offer maximum benefits, they must be conducted in genuine partnerships, where benefits flow to all partners and interdependency underlies the relationships.

The discussion group members also observed that increased space collaboration can provide broad benefits to the United States by making space a routine place for all nations to operate (thereby enhancing the security of space assets), by expanding the economic sphere into space, and by demonstrating that the United States is a cooperative society desiring to work productively with all nations (which could improve the U.S. image).

Opportunities for the Future

The workshop group identified a number of steps that could be taken into account by the United States as it pursues future space exploration projects. These include:

- Assessing cooperative opportunities on their merits instead of excluding “critical path” roles for potential partners as a matter of policy;
- Developing a workforce (at all levels) capable of and interested in working on international programs; and
- Recognizing that U.S. partners need to be able to demonstrate the political and economic benefits of collaboration to the same extent as the United States.

The group observed that the ISS program offers opportunities for engaging new and emerging space powers with human spaceflight capabilities and/or interests. China presents a unique opportunity in this regard, the group observed. They added that if the station becomes a tool for engagement, then ISS operations would necessarily have to be extended beyond 2016—a step could provide greater opportunities for current ISS partners to achieve acceptable returns on investments. The consequences of expanding the ISS partnership to include China and the potential impact on NASA of continuing the program beyond 2016 engendered considerable discussion during the workshop, including the broader political context of U.S. engagement with China and the impact on other NASA program areas.

International Cooperation in Support of Climate Change and Sustainability

Initial discussions in the workshop discussion group on international cooperation in support of climate change and sustainability concerned a redefinition of its title and mandate. The group decided that the topic should be "the role of Earth observations in supporting international efforts in climate change and sustainability," which would be more consistent with overall workshop objectives. They observed that:

- Global warming is unequivocal and human actions are contributing to abrupt and irreversible climate changes and impacts;
- Earth observations are national and global imperatives that are fundamental to monitoring and understanding climate change, achieving sustainability, and protecting our economy and society; and
- Climate monitoring requires timely access and quality controlled, continuous measurements of the Earth system.

Opportunities for the Future

The workshop group then elaborated a number of potential "paths forward" in international cooperation which included:

- Allocating the necessary resources to establish a national Earth observing system, including vital research and operational elements, as part of a comprehensive global effort;
- Continuing to provide U.S. leadership and support to the Group on Earth Observations (GEO)[1];
- Engaging other GEO member nations to provide adequate resources for space-based Earth-observation systems;
- Supporting expanded GEO principles for full and open exchange of national data sets;
- Pursuing, through the Committee on Earth Observations Satellites (CEOS), a global architecture for continuity and coherence of space segment data sets that includes, for example, virtual satellite constellations from multiple providers;
- Encouraging, through GEO and CEOS among others, nations to promote open utilization of remote sensing data;
- Seeking improved communications between GEO and industry through establishment of a mechanism for industry representation in GEO; and
- Making the public aware of impending challenges posed by and consequences expected from global change as well as the necessity of space-based Earth observations to address those challenges.

Approaches to International Cooperation in a Time of Limited Resources

The group discussing approaches to international cooperation in a time of limited resources initially considered several factors that might influence future approaches to global space cooperation and coordination, including the following:

[1] See http://www.earthobservations.org/.

- Additional country partners (e.g., China, India, and other countries),
- New potential sponsors (philanthropic and military organizations),
- New opportunities (e.g., space solar power and participatory technologies), and
- Threats (e.g., global climate change and asteroids).

They noted that today's global environment is different from the past. The growth of space capabilities around the world, including those of new players, means that it is not always clear which country is dominant in a particular sphere of space activity.

Opportunities for the Future

The group reviewed various current and prospective models for international space cooperation, including the "benchmark" bilateral or multilateral government-to-government cooperation, and the advantages and disadvantages were noted. The group also discussed the potential for collaboration through public/private utilities (such as INTELSAT), military alliances, and philanthropic initiatives.

Group participants noted that cooperation initiatives that are based on clear threats (e.g., near Earth objects and climate change) might be better served through the establishment of treaty-based collaborative mechanisms. They also noted three questions that merit further consideration, perhaps as discussion topics in a future Space Studies Board workshop:

- How will emerging space companies, philanthropic initiatives, and so on, interact with traditional organizations pursuing space cooperation?
- How will participatory technologies[2] be incorporated into space collaboration efforts?
- Can evolutionary paths and approaches lead to better outcomes for space cooperation (e.g., could the ISS program evolve into a treaty organization and eventually into a public/private utility)?

CONCLUDING OBSERVATIONS

During the final workshop plenary session each of the participants offered concluding observations focused on the following themes:

- Pursuing a dialogue and exploring new opportunities to cooperate with new and emerging space powers.
- Identifying roles for civil space programs that contribute to broader national goals (space cooperation offers unique opportunities in this regard, several participants noted);
- Engaging youth in the pursuit of space cooperation;
- Modifying the U.S. approach to leadership; and
- Revising ITAR regulations to make them more efficient and effective.

[2] "Participatory technologies" refers to the popular Google Sky, Google Mars, and other examples of technological tools used as a means of "seeing" space and "almost being there," from the three-dimensionality of the Google visualization. It also refers to opportunities to see images sent by the cameras on rovers such as Spirit and Opportunity—you can use your computer and pan around for different camera angles. In the future, perhaps people will be able to propose where they would like a rover to go and virtually "drive it" from their computer. In short, people could virtually be in space.

1

Background

The Workshop on U.S. Civil Space Policy was developed based on an idea proposed by Space Studies Board (SSB) chair Charles Kennel that was refined during discussions at the SSB Executive Committee meeting in August 2008. The workshop theme recognizes that, with the end of the Cold War, space and Earth science research and space exploration are no longer dominated by competition between two superpowers. Furthermore, numerous countries and regions now have very active space programs, and that number is increasing. Maturing capabilities worldwide have created a plethora of potential partners for cooperative space endeavors, while at the same time heightening competitiveness in the international space arena. While international cooperation can make a particular program more affordable to an individual nation, the overall cost of the initiative tends to increase, as does the overall management complexity. Cooperation and coordination[1] tap into an extended base of scientific and technological expertise and can add robustness and redundancy through the use of multiple systems (e.g., launchers, launch facilities, ground networks, in-orbit transportation, and so on). They can also serve to enhance the political legitimacy of an initiative. Workshop planners felt that all these aspects needed to be taken into consideration in assessing the effectiveness of specific past and present cooperation or coordination mechanisms and in seeking to determine how best to proceed in the future, recognizing that the world is becoming more globalized.

International cooperation and coordination are topics that have been addressed in numerous SSB workshops and study committees over the past two decades. They have occurred extensively in space science, Earth science research and applications from space, human spaceflight and microgravity science, and, to a lesser extent, satellite telecommunications, satellite navigation, and launchers.

Currently, most space-faring nations have space-related aspirations that exceed the resources available to them individually. Furthermore, additional countries are working to enter the field. Thus, it was considered to be an appropriate time to review the international cooperation and coordination mechanisms that have or have not worked in the past to identify the most effective approaches to such cooperation and coordination in the future. Such a review should include how best to involve nations that have new and emerging space capabilities. Lessons to be found in the competitive space arena might also have relevance to developing future modes of cooperation. Among the factors to emphasize in identifying effective approaches is that they maximize the use of available resources, minimize duplication of effort, and make optimum use of the broad and ever-increasing base of scientific and technical talent that exists internationally.

[1] International cooperation and coordination on both a bilateral and multilateral basis have played a significant role in civil space activities since the beginning of the space age. Generally speaking, cooperation involves two or more countries working together, each contributing to the execution of a single mission. Coordination involves two or more countries that keep each other apprised of their activities in order to minimize duplication of effort and to obtain the maximum return through complementary activities.

2

Opening Remarks

The opening session of the workshop[1] was moderated by Space Studies Board chair Charles Kennel. In his opening remarks Kennel referred to the ongoing globalization in today's world, and specifically mentioned the current global financial crisis and its implications for space. The international order is likely to be restructured, with major shifts in international relationships that will impact space. "The 21st century starts in 2008," Kennel observed. There will therefore be a need for the space community to respond by working to develop a global approach to space. He noted that the National Aeronautics and Space Act[2] assigned NASA an important role in international relations, and that the agency has exercised extraordinary discretion in forging partnerships with other agencies around the world. The space program has seen the development of a broad spectrum of international relationships from purely financial to those based on engineering interdependence (e.g., the International Space Station).

Calling on workshop participants to speak up and share experiences and to develop new ideas on how to respond to a restructured international order and how to integrate future space activities into a truly global enterprise, Kennel posed three questions:

- How does one start a dialog that is not naive on a long-range future, without compromising the present?
- What should we do to enable a more inclusive global space enterprise (e.g., How do we build an international space community that integrates new and emerging space powers like China and India)?
- What should we avoid doing so as to create a stronger global space enterprise?

Kennel then introduced two keynote presentations that set the stage for subsequent discussions by the workshop participants.

In his opening keynote, Vice Admiral Conrad Lautenbacher (former administrator, National Oceanic and Atmospheric Administration) provided an overview on the challenges of scientific and technological cooperation and competition in a globalizing world.[1] He also reviewed past and current efforts to monitor the environment and climate, noting that there are enormous opportunities for collaboration on the horizon today—nationally and internationally—as well as between government and the private sector. Lautenbacher noted that Earth observations organizations throughout the world must demonstrate that they can work together at the science and technology level as well as at the governing political level, because no single nation by itself can understand the global environment. He also noted the following challenges facing the Earth observations community:

- Earth observations must be relevant to economic and social needs,
- The organizations active in Earth observations must work together to create a unified and much larger voice,

[1] See the workshop agenda in Appendix B.
[2] The National Aeronautics and Space Act of 1958, as amended. See http://www.nasa.gov/offices/ogc/about/space_act1.html.

- Coherent and realistic planning from research to operations is needed, and
- Successful Earth-observation activities require high-level involvement and support (e.g., ministerial-level).

Lautenbacher concluded his remarks by observing that rising costs, economic priorities, technological and scientific needs, and expanding benefits combine to make collaboration both necessary and appealing.

Vincent Sabathier (Center for Strategic and International Studies, CSIS) also contributed to the opening session by discussing the efforts of CSIS to address the policy aspects of space activities at the global level. Space activities are increasingly globalized, he noted, adding that the rapid expansion of space activities in Asia, including competition relating to the Moon, is particularly striking. Looking ahead, Sabathier made reference to the growing role of the private sector and stressed the need to pursue sustainable space programs. The establishment of the Group on Earth Observations in 2003 and the subsequent efforts to create a Global Earth Observing System of Systems are important steps in this regard, he added.

The second keynote presentation, delivered by Roger Launius (National Air and Space Museum) reviewed the history of and lessons learned from governmental space cooperation and competition during and after the Cold War.[3] During the Cold War, the United States pursued cooperation to advance its national interest, enhance the image of the United States, develop closer relations with other countries, and reinforce the perception of U.S. openness. In carrying out these objectives, NASA structured cooperation on a project-by-project basis and sought to ensure that the projects pursued were scientifically valid, mutually beneficial, and that they involved no exchange of funds.[4] NASA has concluded more than 2,000 agreements with other nations for various international space ventures during the past 50 years—almost always as the senior partner. In the post-Cold War era, however, NASA's role in collaborative projects has gradually changed. U.S. pre-eminence in space has begun to decline as U.S. commitment to maintain pre-eminence has waned and as other countries have developed sophisticated space capabilities. The U.S. commitment to large-scale international ventures has also diminished, in part as a result of International Traffic in Arms Regulations constraints and in part because of U.S. preferences to go it alone. As a result, the United States today is not automatically viewed as the partner of choice.

In his remarks Launius observed that the International Space Station program, begun by NASA in 1984, will be remembered not so much for its science and technological achievements (though these may be significant) but because it brought together engineers, scientists, managers, and technicians from various backgrounds and cultures who successfully worked together to achieve common goals. There may be opportunities to pursue similar initiatives in the future, he added.[5]

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[3] Available in Appendix F of this report and at http://www7.nationalacademies.org/ssb/InternationalCooperationWorkshop2008.html.

[4] The "no exchange of funds" policy is not inviolate, however; for example, NASA has made considerable payments to the Russians in the course of the International Space Station cooperation.

[5] Workshop participants also heard a dinner presentation by Roald Sagdeev (University of Maryland) titled "Real World Implications for International Cooperation," in which he provided personal reflections on the history of Soviet-U.S. space cooperation.

3

Perspectives on Space Cooperation and Competition

The second segment of the workshop consisted of four panel discussions[1] and provided an opportunity for all participants to hear perspectives from a variety of viewpoints—including representatives from government, industry, and academia, both U.S. and non-U.S.—on previous, current, and prospective international collaboration and competition.

COOPERATION—LESSONS LEARNED

The first panel discussion on lessons learned from previous cooperative projects was moderated by Space Studies Board member Joan Vernikos (Thirdage LLC) and included presentations by Jean-Pierre Swings (European Science Foundation), Linda Moodie (National Oceanic and Atmospheric Administration), Margaret Finarelli (George Mason University), and Mark Albrecht (International Launch Services, former president).

Panel participants reviewed rationales for and lessons learned from international cooperation activities in space science, Earth science, human spaceflight, and commercial programs. Space agencies cooperate, Peggy Finarelli observed, to make programs more affordable, expand program scope, eliminate gaps and reduce overlaps, add legitimacy, and pursue foreign policy objectives. The panelists also mentioned a number of impediments to international collaboration. In space science these include misalignment, called attention to by Jean-Pierre Swings, between the budget cycles of NASA and some of its international partners.[2] Space science collaboration has also been constrained by the International Traffic in Arms Regulations (ITAR). Swings also observed that some European organizations are reacting to the impediments created by ITAR by seeking to develop space systems that no longer use U.S.-built technology (termed "ITAR free"). Linda Moodie mentioned several impediments to cooperation on Earth observations projects, including differing national security and economic agendas of the prospective partners, differing budget and approval cycles, divergence of policies on data availability, and ITAR restrictions. Mark Albrecht observed that in commercial collaboration close ties to governments can help projects succeed initially, although later these ties can sometimes hinder the project's growth. International commercial projects fail, he observed, when the value added disappears, when ad hoc governmental initiatives are not converted into ongoing commercially viable ones, and when partners decide that individual government business is more attractive than co-partner commercial business. Partnerships succeed best when the leadership of one partner is well established and when normal partnership contractor/subcontractor relationships are formed.

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[1] See Appendix B for the names of session moderators and panelists.

[2] For further background on findings and lessons on U.S.-European space collaboration, see National Research Council and European Space Science Committee (ESSC), *U.S.-Europe Collaboration in Space Science,* National Academy Press, Washington, D.C., 1998). For background on impediments to U.S.-European space see, for example, ESSC-European Science Foundation, Future of International Collaboration in Space Science, ESSC-ESF Position Paper, ESF, Strasbourg, France, November 2000.

Looking ahead to future collaboration, panelist Peggy Finarelli observed that, given the increased capabilities of its partners, the United States might wish to re-examine its approach to leadership of major international space programs. One alternative (as opposed to excluding partners from involvement in critical-path elements), she observed, would make all key partners dependent on the others for successful implementation. Workshop participants then discussed models and approaches to collaboration in robotic and human exploration. In response to several questions, Finarelli observed that NASA's approach to collaboration on space exploration has been pursued from the bottom up, whereas the collaboration on the International Space Station (ISS) program was pursued from the top down, beginning with a presidential-level effort to engage prospective partners at the political level. Participants also discussed multilateral collaboration on the International Charter for Space and Major Disasters[3] as well as the Group for Earth Observations.[4] Several participants noted that the engagement of new and emerging space powers in multilateral Earth observations initiatives is growing; China and Brazil have been particularly active in this regard.

COMPETITION—LESSONS LEARNED

Although the main thrust of the workshop concerned international cooperation, the planning committee recognized that there were lessons to be learned from international competitive activities. This was the focus of the second panel. The panel discussion was moderated by Space Studies Board member Joan Vernikos (Thirdage LLC) and included presentations by Clay Mowry (Arianespace), Mark Brender (GeoEye), and Andrew Aldrin (United Launch Alliance).

During the discussion the panelists reviewed their companies' international business experiences and highlighted several generic problems that have had an impact on commercial space activities. internationally. Clay Mowry commented that in space launch services there is significant overcapacity, with eight countries currently having demonstrated space launch capabilities and five more countries emerging in the field. He further observed that this situation is driven by a variety of individual national interests**.** Once a nation establishes a launch capability there is tremendous pressure to maintain it through commercial sales, underpinned by government support. Although the situation is very inefficient and counterproductive, it is unlikely to change. Mark Brender observed that significant competition also exists in the commercial remote-sensing-satellite sector. GeoEye and DigitalGlobe, the two U.S. space remote sensing companies, compete in most markets. Additionally, competition is increasing from the growing number of foreign remote sensing satellites. Further, the U.S. government has stated a desire to build and operate its own commercial-class satellites to provide basic broad-area Earth coverage. If realized, these satellites would compete with the commercial data providers in the U.S. government market. Looking ahead, he observed that commercial remote sensing satellites are contributing to increased global transparency through release to the general public of images of natural disasters, areas of conflict, and military installations. Clay Mowry was of the opinion that a potential opportunity exists for space launch service providers in Europe, Japan, and the United States to develop a parallel path for delivering cargo—under a mixed fleet approach—to the ISS.

During the panel session, several participants commented on space competition with China, particularly with respect to how the situation today differs from the Cold War era competition with the Soviet Union. Andrew Aldrin observed that U.S. competition with China today is largely economic, not ideological, as was the case with the Soviet Union. Trying to generate political support for the U.S. space program based on a space race with China would be ill-advised, he added, because China stands to gain much more from competition than the United States. One workshop participant agreed, noting that the United States is not in a space race with China.

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[3] See http://www.disasterscharter.org/index_e.html.
[4] See http://www.earthobservations.org/.

NATIONAL SECURITY CONSIDERATIONS

The third panel discussion focused on space cooperation and competition from a national security perspective. The panel discussion was moderated by Space Studies Board member Warren Washington (National Center for Atmospheric Research) and included presentations by A. Thomas Young (Lockheed Martin, retired) and Eric Sterner (independent consultant).

Both panelists noted that because space is a critical element of U.S. national security, national security considerations will always be taken into account by the administration and Congress as civil space programs are pursued. Panelist Eric Sterner (former staff member, U.S. House of Representatives Armed Services Committee and Science Committee), observed that Congress does not have a common viewpoint with regard to “national security.” Congress does, in general, view international space cooperation as positive, although it is not a major area of interest, Sterner observed. International space cooperation does occasionally get congressional attention when the proposed collaborative project impacts a domestic issue of interest to members of Congress. One such concern is the need to ensure that the United States preserves its industrial base to conduct national security activities. In some cases, Sterner observed, congressional officials express interest in cooperation with a specific country, because of their overall interest in U.S. relations with that country, and necessarily because of the substance of the joint project. Sterner added that most congressional officials who focus on national security matters do not believe that collaborative space projects will fundamentally improve the behavior of another country, such as Russia, toward the United States.

The panel paid particular attention to the impact of U.S. export control regulations on international cooperation—in particular ITAR. Young noted that while it is necessary to maintain an ITAR regime, the implementation of the current regulations has had unintended consequences that may in some cases be hurting U.S. national security objectives. The current ITAR regime, for example, may have accelerated, not slowed, the efforts of some countries to become space capable. Both panelists took the position that ITAR has had a significant impact of space cooperation between the United States and other countries.[5] One consequence of these difficulties, a panelist observed, is that increasingly the United States is no longer viewed as the partner of choice.

The panelists and workshop participants discussed in considerable detail the current impact of and prospects for modifying the ITAR regime. Although improvements to the ITAR process have been made in recent years, further improvements, such as issuing “blanket” licenses on a program basis (for the ISS program, for example), should be considered, several workshop participants suggested. The lack of such “blanket” program-level licenses can inhibit effective communications among the partners, and in some cases could present serious threats to the success and safe conduct of joint projects. Several workshop participants thought that reform of the ITAR process should be treated as a higher priority by the new administration and Congress. Others, including the panelists, noted that some administration and congressional officials are very concerned that any changes to the ITAR regime could undermine U.S. national security. The fact that the ITAR regulations have stimulated foreign manufacturers to develop “ITAR free” satellites is a small price to pay, in the view of these officials. The negative impact that the ITAR regime is having on U.S. industry and on scientific cooperation is also not compelling to those in Congress who prefer to maintain the current ITAR regulations, if doing so will save one American life. As a consequence, changes to the current ITAR regime will be difficult to achieve, they both observed. Several participants expressed interest in taking a proactive approach with the new administration and Congress on how the ITAR process could be revised to make it more efficient and effective. A point to be emphasized in such discussions, one panelist noted, is that the ITAR regime as it is currently being implemented is having counterproductive consequences in some cases.

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[5] For a more thorough discussion of the impacts of ITAR on space science, see National Research Council, *Space Science and the International Traffic in Arms Regulations: A Workshop Summary*, The National Academies Press, Washington, D.C., 2008.

The national security panel also discussed prospects for closer civil space cooperation with China. Eric Sterner suggested that if the administration pursues collaboration with China on the ISS, this would introduce the controversies of U.S.-China relations into the space program, such as disagreements over human rights, which could have negative consequences for congressional support for NASA. A workshop participant also noted, however, that a U.S. invitation to China to participate in the ISS program could be viewed as part of an overall effort by the United States to improve its relationship with China.

During the national security panel discussion several participants noted that although civil and commercial space cooperation have sometimes been impeded by national security constraints (e.g., ITAR), cooperation can also contribute to increased national security. If through cooperation space becomes a more routine place for doing business, this could support U.S. national security goals, including the protection of U.S. assets in space, Lennard Fisk (University of Michigan) observed. He added that closer space collaboration with China—which already has extensive trade and financial relationships with the United States—should perhaps be considered from this perspective.

COOPERATION AS A TOOL FOR FUTURE ENGAGEMENT

The fourth panel discussion considered cooperation and collaboration in space activities as a tool for future engagement. The panel discussion was moderated by former Space Studies Board chair Lennard Fisk (University of Michigan) and included presentations by Gregory Kulacki (Union of Concerned Scientists), Yoshinori Yoshimura (Japan Aerospace Exploration Agency; JAXA), and Gib Kirkham (NASA). The panel members discussed current and prospective collaboration activities of the United States and Japan as well as the space activities of China and U.S. interactions with China. Panelist Gib Kirkham discussed the origins and evolution of the Global Exploration Strategy,[6] which was developed through the collaboration of fourteen space agencies working to develop a document that provides a rationale for exploration as well as common themes and objectives for internationally coordinated space exploration activities. The agencies participating in the GES, both existing and emerging space powers, also have established a coordination mechanism-the International Space Exploration Coordination Group (ISECG)[7] where space agencies can exchange information and consider opportunities for future cooperation. The ISECG has set up a working group that is currently focusing on different aspects of an initial international lunar exploration architecture. Several workshop participants commented that the approach taken by the ISECG participants is a positive step, although one participant suggested that participation in the ISECG should be elevated to the program-head level.

Panelist Yoshinori Yoshimura reviewed Japanese space activities and interests. JAXA cooperates closely with NASA and NOAA on a variety of joint projects, the largest of which involves Japanese participation in the ISS program. One challenge facing JAXA is to ensure that—since Japan's hardware elements are only now arriving at the station—Japan's investment in the ISS is fully utilized. The ISS is part of Japan's exploration program, Yoshimura stated. JAXA is also actively participating in the ISECG and looks forward to collaborating with the United States and other ISECG participants on future exploration projects.

Panelist Gregory Kulacki provided historical background on China's space program and addressed U.S.-Chinese interactions on space matters. A primary driver of China's human space program, he noted, is to inspire young people and encourage them to pursue careers in science and engineering. Though they are frustrated over U.S. efforts to contain their space activities, the Chinese do not today view themselves as competing with the United States in human spaceflight he added. At the same time, Kulacki observed, there is considerable uncertainty in China over U.S. intentions and motivations with regard to future space collaboration between the two countries.

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[6] ISECG, *The Global Exploration Strategy: The Framework for Coordination,* May 2007, available at http://esamultimedia.esa.int/docs/isecg/Global_Exploration_Strategy_Framework.pdf.

[7] See http://esamultimedia.esa.int/docs/exploration/InternationalCoordination/ISECG_ToR.pdf.

4

Opportunities and Challenges

During plenary and panel discussions, workshop participants offered ideas for opportunities and challenges in future space cooperation and competition. These suggestions for further consideration are focused on the four panel discussion topics:

- Engaging new and emerging space powers in international cooperation,
- International cooperation in the future of space exploration,
- International cooperation in support of climate change and sustainability, and
- Approaches to international cooperation in an era of limited resources.

The results of these discussions were presented at the workshop and are summarized below.

ENGAGING NEW AND EMERGING SPACE POWERS

The first of the four groups, led by Space Studies Board (SSB) chair Charles Kennel (University of California, San Diego), focused on international space cooperation as a tool for engagement with new and emerging space powers.[1] These countries, the participants observed, may be interested in collaborating with the United States on space projects for a wide variety of reasons, including a desire to enhance their prestige, accelerate their economic and technical development, and gain greater access to knowledge, experience, and technology. Likewise, the participants observed, the United States could benefit from pursuing greater collaboration with new and emerging space powers. Possible benefits include supporting U.S. foreign policy goals; facilitating U.S. access to key decision makers; gaining insight into capabilities, approaches, and plans; identifying new ideas and new technologies; reducing U.S. costs; and expanding instrument flight opportunities and data analysis capabilities.

The discussion group participants considered in depth possible approaches to enhance U.S. space cooperation with new and with emerging space powers. They observed that a number of existing mechanisms are already in place that promote dialogue, particularly in non-governmental multilateral forums and at the scientist-to-scientist level. At the same time, the group observed that to strengthen the current relationships, additional efforts could be made by the United States. One particularly valuable effort, the group noted, could involve the convening of forums through which existing space powers could dialogue with new and emerging space powers. Such forums could provide opportunities to:

- Improve mutual understanding of capabilities, programs, and plans;
- Assess the current state of cooperation;
- Identify potential collaborative programs;
- Recommend promising mechanisms for continued joint consultations;
- Promote open participation; and
- Develop personal and institutional relationships.

[1] Participants agreed that new and emerging space powers include countries capable of developing and/or launching spacecraft, which could include China, India, Brazil, Korea, Argentina, Israel, and Ukraine.

The discussion group participants, including those from Europe and Japan, suggested that the SSB might wish to consider implementing such forums and do so in a collaborative fashion that involves the European Space Science Committee and a counterpart organization in Japan.

COOPERATING ON SPACE EXPLORATION

The second discussion group, led by Margaret Finarelli (George Mason University), considered the role of international cooperation in the future of space exploration. The participants in this group observed that the world today has become interdependent. For space activities to offer maximum benefits, they must be conducted in accord with this larger reality, i.e., internationally, cooperatively, and in genuine partnerships, so that benefits flow to all partners, and interdependency underlies the relationships. The group also considered international cooperation on space exploration in the context of the broad benefits it can provide to the United States. Participants observed that increased space collaboration can provide broad benefits to the United States by making space a routine place for all nations to operate (thereby enhancing the security of space assets), expanding the economic sphere into space, and demonstrating that the United States is a cooperative society desiring to work productively with all nations (which could improve the image of the United States). The discussion group did not attempt to develop a programmatic approach to international collaboration on space exploration. However, the participants did identify several steps that could be taken into account by the United States as it pursues future space exploration projects. These include:

- Assessing cooperative opportunities on their merits instead of excluding “critical path” roles for potential partners as a matter of policy;
- Developing a workforce (at all levels) capable of and interested in working on international programs; and
- Recognizing that U.S. partners need to be able to demonstrate the political and economic benefits of collaboration to the same extent that the United States does.

Considering the significant U.S. investment in space activities, group participants observed that the administration and Congress will want to continue referring to U.S. leadership in defining and pursuing the global space agenda. But the group also discussed steps that the United States could take to pursue its goals in a fashion that is sensitive to the interests and needs of its partners. These steps include forging high-level, long-term commitments; ensuring that the tone of U.S. space policy statements reflects a global role; and revising current export control regulations.

During their consideration of U.S. space exploration cooperation opportunities, participants focused on the ISS program. The group was of the opinion that the ISS program offers unique opportunities for engaging new and emerging space powers with human spaceflight capabilities and/or interests. When focusing their attention in particular on China, which today is the third nation with independent human spaceflight capabilities, participants recognized that the ISS partnership could be expanded to include other nations. The ISS, the they noted, provides an excellent opportunity for the current partners to work with their Chinese counterparts, and in so doing, to learn about one another’s program management practices; communication, decision-making, and confrontational styles; design practices; approaches to documentation; and so on.

Group participants also observed that if the ISS were to be seriously considered as a tool for engagement, its operations would have to be extended beyond 2016. This step would also provide greater opportunities for the current partners to achieve an acceptable return on their investments. The European and Japanese laboratories, participants noted, have just arrived at the International Space Station (ISS). Participants pointed out that a great deal of research can be done on the space station in areas such as the effects of long-duration weightlessness and exposure to radiation, as well as physical, biological, and chemical aspects of life support—activities that could provide opportunities for international collaboration in preparation for future robotic and human exploration missions.

A number of comments were raised by workshop participants at the conclusion of the space exploration cooperation presentation. Several participants noted that bringing China into the ISS program would be politically controversial and could have a negative impact on NASA. Other participants disagreed, stating that China's participation in the program could be part of a broader foreign policy initiative to engage China. Two participants added that in considering the risk of collaboration with China, it is important to take into account the experience of U.S. industry, which has made massive investments in China that exceed the U.S. civil space budget. Another participant questioned the assumption with regard to extending the ISS operations beyond 2016, noting that this is a complex step that needs to be considered very carefully, given the funding impact it would likely have on other NASA programs, including lunar exploration. The space exploration cooperation group moderator agreed that continuation of the ISS beyond 2016 would represent a significant undertaking that must be considered carefully by the United States and the other ISS partners that would have to provide the funding.

COOPERATING IN SUPPORT OF ADDRESSING CLIMATE CHANGE AND SUSTAINABILITY

The third discussion group, led by Conrad Lautenbacher, considered the role of Earth observations in supporting international efforts in climate and sustainability. In beginning of their discussion, participants noted that revising their charge to "the role of international space cooperation in Earth research and operations in support of climate and sustainability" would better suit the objectives of the workshop by putting emphasis on coordinating international activities instead of supporting them and by emphasizing space-based observations. The group agreed on several starting principles as the basis for their discussions:

- "Global warming is unequivocal and humans' actions are heading towards abrupt and irreversible climate changes and impacts" (IPCC, Fourth Assessment, November 2007[2]).
- Earth observations are national and global imperatives that are fundamental to climate, sustainability, our economy, and society.
- Climate monitoring requires timely access and quality controlled, continuous measurements of the Earth system.

The group also discussed a number of key issues, including inadequate levels of investment in remote sensing capabilities by national governments; lack of worldwide, open access to many public-good datasets; limited or degraded release of national datasets due to security concerns; the ad hoc or undefined role of the private sector in international coordinating bodies; and the lack of public understanding and awareness of the value of space assets in Earth observations.

In considering the role of international cooperation in support of climate and sustainability, the discussion group elaborated a number of possible paths forward, including:

- Allocating the necessary resources to establish a national Earth-observing system, including vital research and operational elements, as part of a comprehensive global effort;
- Continuing U.S. leadership and support to the Group on Earth Observations (GEO);[3]
- Encouraging other GEO member nations to provide adequate resources for space-based Earth observation systems;

[2] See Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report, Summary for Policymakers,* available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

[3] See http://www.earthobservations.org/.

- Working with GEO to facilitate more comprehensive engagement with public and private sector users to integrate their needs into future plans;
- Supporting expanded GEO principles for full and open exchange of national datasets;
- Pursuing, through the Committee on Earth Observations Satellites (CEOS),[4] a global architecture for continuity and coherence of space segment datasets that includes, for example, virtual satellite constellations from multiple providers;
- Encouraging, through GEO and CEOS among others, nations to promote open utilization of remote sensing data;
- Encouraging efforts like GEONETCast,[5] GEOPortal,[6] and Google Earth that provide open user access across all borders;
- Seeking improved communications between GEO and industry through establishment of a mechanism for industry representation in GEO;
- Improving data availability for the international community through national government reviews of remote sensing licensing restrictions;
- Encouraging governments to review restrictive export controls with the aim of facilitating international collaboration in Earth observations; and
- Making the public aware of impending challenges and consequences of global change as well as the necessity of space-based Earth observations to address those challenges.

APPROACHES TO INTERNATIONAL COOPERATION

The fourth discussion group, led by Molly Macauley (Resources for the Future), considered new approaches to global space cooperation in a time of limited resources. The group considered several factors that might influence future approaches to global space cooperation, including the addition of new partners (China, India, and several other nations), new sponsors (philanthropic and military organizations), new opportunities (e.g., space solar power and participatory technologies), and threats (e.g., global climate change and asteroids). The discussion group also noted that the global environment is different today than in the past; national economies and technology bases are increasingly globally integrated. New barriers to global space collaboration (such as ITAR) have emerged. Nations have newly developed space capabilities, and the capabilities of some current space-faring nations are expanding. Group participants observed that it is less obvious today which country is dominant in civil space activities. The group also recalled that limited availability of resources for space activities is not a new factor, and noted too that the constraints facing space-faring nations are perhaps greater today than in the past.

The discussion group reviewed current and prospective structures for international space cooperation. The "benchmark" approach, the group noted, involves bilateral and multilateral projects arranged between governments (intergovernmental arrangements), where some space activities are conducted under treaty arrangements, such as those of the European Space Agency. The discussion group further observed that space activities are sometimes pursued under United Nations auspices, for example through the U.N. Framework Convention on Climate Change.[7] Participants reviewed several advantages and disadvantages of each of these current approaches.

The group discussion then examined three potential additional approaches to collaboration: through public/private utilities such as INTELSAT[8]/INMARSAT[9] and spaceports, through military alliances, and through philanthropic initiatives. Collaboration through public/private utilities could be

[4] See http://www.ceos.org/.
[5] See http://earthobservations.org/geonetcast.shtml.
[6] See http://www.geoportal.org/web/guest/geo_home.
[7] See http://unfccc.int/2860.php.
[8] See http://www.intelsat.com/.
[9] See http://www.inmarsat.com/.

user/consumer driven and provide opportunities for private-partner roles and cost sharing. Such activities would typically focus on a specific application or commodity. Collaboration through military alliances such as NATO[10] might involve cost sharing with defense organizations, could benefit from existing operational and coordination structures, and could be "ITAR friendly" for participating countries. At the same time, military alliance collaboration might be limited to the existing partners and might create public-acceptability concerns in countries where civil and national security space activities have been pursued separately. Collaboration that involves philanthropic organizations offers the potential of utilizing foundation seed funding, could stimulate public interest, and perhaps could be initiated rapidly. On the other hand, philanthropic-related initiatives are likely to be limited in scale and to focus on single "one off" activities rather than sustainable projects. Such philanthropic activities may also not be compatible with national space program priorities.

The discussion group concluded their review by noting that a lot has been learned from past collaborative initiatives. Based on these experiences the group believes that bilateral and multilateral projects arranged between governments (intergovernmental arrangements) have evolved, and today provide a proven and workable collaboration approach. Cooperation through an intergovernmental arrangement approach has the advantage of creating focus among the partners and providing unique benefits to each participant. The discussion group members considered, however, that the intergovernmental arrangements approach can add complexity and be affected by changes in the contributions of partners during long-term projects. The group participants suggested that lessons from past projects among governments should be taken into account as new projects are structured. The group participants were also of the opinion that the intergovernmental approach would likely be well suited to projects undertaken with new and emerging space partners such as China.

At the same time, the discussion group participants also observed that cooperation initiatives that focus on clear threats, such as those associated with near Earth objects and climate change, might better be served through the establishment of treaty-based collaborations. They also noted that in cases where the cooperation involves new economic opportunities (for example, involving energy) the public/private utility approach may be best.

In its consideration of current and prospective cooperation approaches, the participants listed three questions that might merit further consideration, perhaps as discussion topics in a future SSB workshop:

- How will emerging space companies, philanthropic initiatives, and so on, interact with traditional organizations pursuing space cooperation?
- How will participatory technologies be incorporated into space collaboration efforts?
- Can evolutionary paths and approaches lead to better outcomes for space cooperation? For example, can a philanthropic initiative evolve into a public/private utility, and could the ISS program evolve into a treaty organization and eventually into a public/private utility?

[10] See http://www.nato.int/.

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Concluding Observations

During the closing plenary session of the workshop, moderator Ravi Deo (Northrop Grumman), Aeronautics and Space Engineering Board member, invited all workshop participants to provide concluding observations based on what they had heard from the keynote speeches, panel discussions, and topic discussion groups. These observations are summarized below in three theme areas: pursuing space cooperation at the global level, contributing to broad national objectives, and considering new opportunities and challenges.

PURSUING SPACE COOPERATION AT THE GLOBAL LEVEL

In reflecting on the workshop discussions, it was clear that more than half of the comments related to an interest in pursuing dialogue and exploring new opportunities for cooperation with new and emerging space powers.[1] Such interactions, one participant noted, should promote the development of open synergistic science programs with full and open access to each other's data. The interactions, another participant observed, need not be one-way—the United States (and other established space powers) have much to learn from emerging space nations. One participant noted that space exploration can provide exciting opportunities for established space powers to interact with new and emerging ones. Other participants emphasized the opportunities for global collaboration through expanding participation in the ISS program, the Group on Earth Observations, and other activities. Global challenges such as exploring the universe and understanding climate change, several participants suggested, can best be addressed at the global level. Several workshop participants representing foreign space programs expressed interest in working closely with the United States to explore new global collaboration opportunities.

CONTRIBUTING TO BROADER NATIONAL OBJECTIVES

Another frequently cited theme during the workshop was identifying roles for civil space programs that contribute to broader national goals. Space cooperation offers unique opportunities in this regard, a number of participants noted. One speaker commented that we live in a globalized world, and that the time has come to pursue the U.S. space program in a manner that recognizes this fact. Doing so can have economic development and national security benefits for the United States. This, the speaker concluded, also provides an opportunity to make the U.S. space program and NASA more relevant on the national agenda. Expanding participation in the ISS program to include China and other countries was cited by several participants as a particular opportunity in this regard. Other participants cautioned that,

[1] During the workshop, the discussion group with the topic "International Space Cooperation as a Tool for Engagement with New and Emerging Space Powers" listed Argentina, Brazil, China, India, Israel, Korea, and Ukraine, along with several regional entities, as possible candidates.

although such initiatives may prove to be attractive, they will have to be carefully considered prior to being pursued.

CONSIDERING NEW OPPORTUNITIES AND CHALLENGES

During the concluding session of the workshop, a number of new opportunities and challenges were cited by workshop participants. Several speakers emphasized the opportunity and challenges associated with engaging youth—the so-called "iPod generation"—in the pursuit of space cooperation. This generation, one speaker emphasized, will be charged with carrying on the long-term projects begun in the current era. Several speakers commented on the approach the United States takes to leadership, noting that an opportunity exists for the United States to pursue a new approach. "Space is a non-sovereign, multinational place," one speaker observed, adding that nations—including the United States—that pursue multinational collaboration should "check their hubris and ego at the door." Some workshop participants offered comments regarding the challenges ahead. One speaker expressed the view that despite a strong imperative for cooperation, national security considerations must also be kept in mind as civil space collaboration is pursued. This is particularly important to bear in mind when changes to the International Traffic in Arms Regulations (ITAR) regime are proposed and discussed. Other participants recalled that ITAR restrictions remain a significant challenge for those seeking to pursue new international projects. One speaker considered that international cooperation on a scale necessary for the exploration and development of space is a "fantasy" until export controls are fixed and the United States learns to implement truly equal partnerships. This, he added, may require a generational change. Another workshop participant recalled that while cooperation must be pursued, competition also plays an important role in the pursuit of government and commercial space activities. Competition can spur innovation and contribute to excellence in the conduct of space programs. It should not be overlooked. One speaker concluded that with the new and the emerging capabilities in space around the world, and recognize from that the United States cannot do everything, the question space-faring nations should ask is how to seek alignment in their programs so that the projects pursued have the greatest benefit for all. This is one of the major challenges we face, he observed.

In closing the final session, Space Studies Board (SSB) chair Charles Kennel noted that the discussions during the 3-day workshop were both valuable and timely. They provided useful observations that may be of interest to the incoming administration and Congress. The workshop deliberations also have identified several initiatives that the SSB may wish to take in the coming year. One such initiative would be to begin a series of discussions and information exchanges with new and emerging space powers, and to do so in collaboration with colleagues in Europe and Japan. Another step, mentioned by several SSB members, would be to pursue some of the topics identified during this workshop during a follow-up session. Both ideas merit further SSB consideration, Kennel observed.

Appendixes

A

Statement of Task

An ad hoc committee under the auspices of the Space Studies Board, working in collaboration with the Aeronautics and Space Engineering Board, will organize a public workshop for the purpose of reviewing past and present cooperation and coordination mechanisms for space and Earth science research and space exploration, identifying significant lessons learned and discussing how those lessons could best be applied in the future. The workshop will utilize invited presentations, panel discussions and general discussions, both in plenary sessions and in subgroups.

Presentations and initial discussion will focus on past and present mechanisms to identify "Lessons Learned." Those lessons learned then will be used as the starting point for subsequent discussions on the most effective ways in which future cooperation or coordination in space and Earth science research and space exploration could be structured. The goal of the workshop is not to develop a specific model for future cooperation/coordination but to explore the advantages and disadvantages of various approaches and stimulate further deliberation on this important topic.

An individually authored summary of the workshop will be prepared in accordance with institutional guidelines. The summary report will not contain findings or recommendations.

B

Workshop Agenda and Participants

AGENDA

November 18, 2008

1:00 p.m. *Welcome/Introduction* Charles F. Kennel, Space Studies Board (SSB)
Ravi B. Deo, Aeronautics and Space Engineering Board (ASEB)

Session 1

1:15 **Scientific and Technological Cooperation and Competition in a Globalizing World**

Moderator Charles F. Kennel, Scripps Institution of Oceanography, University of California, San Diego (UCSD)
Keynote Speaker Conrad Lautenbacher, NOAA (retired)
Discussant Vincent Sabathier, Center for Strategic and International Studies

Session 2: Lessons Learned

2:30 **Governmental Space Cooperation and Competition During and After the Cold War: Lessons Learned**

Keynote Speaker Roger Launius, National Air and Space Museum, Smithsonian Institution

3:15 *Panel 1: Cooperation and Collaboration in Space Activities: Lessons Learned*

Moderator Joan Vernikos, Thirdage LLC
Panelists Jean-Pierre Swings, European Space Sciences Committee
Linda Moodie, NOAA-NESDIS
Peggy Finarelli, George Mason University
Mark J. Albrecht, former President, International Launch Services

4:30 *Panel 2: Competition in Space Activities: Lessons Learned*

Moderator Joan Vernikos, Thirdage LLC
Panelists Clay Mowry, President, Arianespace, Inc.
Mark Brender, GeoEye
Andrew Aldrin, United Launch Alliance

6:00 p.m. Reception and Dinner

Real World Implications for International Space Cooperation

Dinner Speaker Roald Sagdeev, University of Maryland

November 19, 2008

9:00 a.m. *Opening Remarks* Charles F. Kennel, Scripps Institution of Oceanography, UCSD

Session 3

9:15 **Cooperation, Competition and National Security**

Moderator Warren M. Washington, National Center for Atmospheric Research
Panelists A. Thomas Young, Lockheed Martin (retired)
Eric Sterner, Consultant

Session 4

11:00 **Cooperation and Collaboration in Space Activities: A Tool for Future Engagement**

Moderator Lennard Fisk, University of Michigan
Panelists Gregory Kulacki, Union of Concerned Scientists
Yoshinori Yoshimura, Japan Aerospace Exploration Agency
Gib Kirkham, NASA Office of External Relations

12:30 p.m. Lunch

1:30 *Parallel Discussion Groups*

Topic 1: International Space Cooperation as a Tool for Engagement with Emerging Space Power

Moderator Charles F. Kennel, Scripps Institute of Oceanography, UCSD

Topic 2: The Role of International Cooperation in the Future of Space Exploration

Moderator Peggy Finarelli, George Mason University

Topic 3: The Role of Earth Observations in Supporting International Efforts in Climate and Sustainability

Moderator Conrad Lautenbacher, NOAA (retired)

Topic 4: New Approaches to Global Space Cooperation in a Time of Limited Resources

Moderator Molly K. Macauley, Resources for the Future

5:30 Adjourn for the day

November 20, 2008

9:00 a.m. Parallel Discussion Groups Reconvene to Finalize Presentations

10:00 Reconvene in Plenary

Review of Parallel Discussion Groups' Outputs

Moderator A. Thomas Young, Lockheed Martin (retired)

11:15 General Discussion

Moderator Ravi B. Deo, Northrop Grumman

12:15 p.m. Summary and Wrap-up

Moderator Charles F. Kennel, Scripps Institute of Oceanography, UCSD

12:30 Adjourn

WORKSHOP PARTICIPANTS

Keynote Speakers, Moderators and Panelists

Mark J. Albrecht, Consultant; former President, International Launch Services
Andrew Aldrin, United Launch Alliance
Mark Brender, GeoEye
Peggy Finarelli, George Mason University
Gib Kirkham, NASA
Gregory Kulacki, Union of Concerned Scientists
Roger Launius, National Air and Space Museum
Conrad Lautenbacher, former Under Secretary of Commerce for Oceans and Atmosphere and Administrator, NOAA
Clay Mowry, Arianespace Inc
Vincent Sabathier, Center for Strategic and International Studies
Roald Sagdeev, University of Maryland
Eric Sterner, Consultant
Jean-Pierre Swings, European Space Sciences Committee
Yoshinori Yoshimura, Japan Aerospace Exploration Agency (Washington Office)

SSB Members

Charles F. Kennel, Scripps Institution of Oceanography, UCSD, *Chair*
A. Thomas Young, Lockheed Martin Corporation (retired), *Vice Chair*
Daniel N. Baker, University of Colorado
Steven J. Battel, Battel Engineering
Yvonne C. Brill, Aerospace Consultant
Elizabeth R. Cantwell, Oak Ridge National Laboratory
Andrew B. Christiansen, Dixie State College and Aerospace Corporation
Alan Dressler, The Observatories of the Carnegie Institution
Jack D. Fellows, University Corporation for Atmospheric Research
Fiona A. Harrison, California Institute of Technology
Klaus Keil, University of Hawaii
Molly K. Macauley, Resources for the Future
Berrien Moore III, Climate Central
Robert T. Pappalardo, Jet Propulsion Laboratory
James Pawelczyk, Pennsylvania State University
Soroosh Sorooshian, University of California, Irvine
Joan Vernikos, Thirdage LLC
Warren M. Washington, National Center for Atmospheric Research
Charles E. Woodward, University of Minnesota

ASEB Member

Ravi B. Deo, Northrop Grumman Corporation

Rapporteur

James V. Zimmerman, President of International Space Services, Inc.

Invited Guests

Marc Allen, NASA
Jacques Blamont, Centre National d'Etudes Spatiales
Lennard A. Fisk, University of Michigan
Lou Friedman, The Planetary Society
Tamara Jernigan, Lawrence Livermore Laboratory
Linda Moodie, NOAA-NESDIS
George Paulikas, Aerospace Corporation (retired)
Ed Stone, California Institute of Technology and COSPAR
Tim Stryker, U.S. Geological Survey
James Van Laak, Federal Aviation Administration, Office of Commercial Spaceflight
James Vedda, Aerospace Corporation
Lyn Wigbels, Center for Strategic and International Studies and Consultant
Jean-Claude Worms, European Space Sciences Committee

National Research Council Staff

Joseph K. Alexander, Senior Program Officer, SSB
Carmela J. Chamberlain, Program Associate, SSB
Dwayne A. Day, Program Officer, SSB
Brian D. Dewhurst, Program Officer, ASEB
Sandra J. Graham, Senior Program Officer, SSB
Lewis Groswald, Lloyd V. Berkner Space Policy Intern, SSB
David Lang, Program Officer, Board on Physics and Astronomy (BPA)
Celeste Naylor, Information Management Associate, SSB
Tanja E. Pilzak, Manager, Program Operations, SSB and ASEB
Robert L. Riemer, Senior Program Officer, BPA
Christina O. Shipman, Financial Officer, SSB and ASEB
David H. Smith, Senior Program Officer, SSB
Marcia S. Smith, Director, SSB and ASEB
Brant Sponberg, Senior Program Officer and Associate Director, SSB
Victoria Swisher, Research Associate, SSB

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Biographies of the Planning Committee, Keynote Speakers, Moderators, and Panelists

PLANNING COMMITTEE

CHARLES F. KENNEL, *Chair,* is a distinguished professor of atmospheric science and director emeritus in the Scripps Institution of Oceanography at the University of California, San Diego (UCSD). Dr. Kennel was the founding director of the UCSD Environment and Sustainability Initiative, an all-campus effort embracing teaching, research, campus operations, and public outreach, and is now chairman of its international advisory board. His research covers plasma physics, space plasma physics, solar-terrestrial physics, plasma astrophysics, and environmental science and policy. He is a member of the National Academy of Sciences (NAS), American Academy of Arts and Sciences, the American Philosophical Society, and the International Academy of Astronautics. He was a member of the NASA Advisory Council from 1998 to 2006, its chair from 2001-2005, and is presently chair of the California Council on Science and Technology. He has had visiting appointments to the International Centre for Theoretical Physics (Trieste), the National Center for Atmospheric Research (Boulder), the Ecole Polytechnique (Paris), California Institute of Technology (Pasadena), Space Research Institute (Moscow), and the University of Cambridge (U.K.). He is a recipient of the James Clerk Maxwell Prize (American Physical Society), the Hannes Alfven Prize (European Geophysical Society), the Aurelio Peccei Prize (Academia Lincei), and the NASA Distinguished Service and Distinguished Public Service Medals. He was the 2007 C.P. Snow Lecturer at Christ's College, Cambridge (U.K.). Dr. Kennel has served on numerous National Research Council (NRC) committees and boards including the Committee on NASA's Beyond Einstein Program: An Architecture for Implementation (co-chair), the Committee on Global Change Research (chair), the Committee on Fusion Science Assessment (chair), the Board on Physics and Astronomy (chair), the Panel to Review the National Space Science Data Center/World Data Center-A for Rockets and Satellites, the Committee on Cooperation with the USSR in Solar Activity, Solar Wind, Terrestrial Effects, and Solar Acceleration (co-chair), the Plasma Science Committee (chair), and the Air Force Physics Research Committee. He is currently chair of the Space Studies Board (SSB).

A. THOMAS YOUNG is a retired executive vice president of Lockheed Martin. Mr. Young previously was president and COO of Martin Marietta Corporation. Prior to joining industry, Mr. Young worked for 21 years at NASA. At NASA, he directed the Goddard Space Flight Center, was deputy director of the Ames Research Center, and directed the Planetary Program in the Office of Space Science at NASA Headquarters. Mr. Young received high acclaim for his technical leadership in organizing and directing national space and defense programs, especially the Viking program. He is a member of the National Academy of Engineering (NAE) and the NASA Advisory Council. Mr. Young is a former member of the NRC Office of Science and Engineering Personnel Advisory Committee, the Committee on Supply Chain Integration: New Roles and Challenges for Small and Medium-Sized Companies, the Committee for Technological Literacy (chair), and the Committee on a New Science Strategy for Solar System Exploration. Mr. Young is currently vice chair of the SSB.

DANIEL N. BAKER is a professor of astrophysical and planetary sciences and director of the Laboratory for Atmospheric and Space Physics at the University of Colorado at Boulder. He is also the director of the

Center for Limb Atmospheric Sounding and is a member of the Center for Integrated Plasma Studies. His primary research interest covers the study of plasma physical and energetic particle phenomena in the planetary magnetospheres and Earth's magnetosphere. He also conducts research in space-instrument design, space-physics data analysis, and magnetospheric modeling. Dr. Baker is a member of SSB.

DAVID GOLDSTON is a visiting lecturer in the Center for the Environment at Harvard University. Prior to joining the Center, he was a visiting lecturer in the Science, Technology and Environmental Policy Program at Princeton University's Woodrow Wilson School of Public and International Affairs. Mr. Goldston was chief of staff of the U.S. House Committee on Science (2001-2006) where he oversaw a committee that has jurisdiction over most of the federal civilian research and development budget, including programs run by NASA, the National Science Foundation (NSF), the Department of Energy, the Department of Commerce, and the Environmental Protection Agency. Prior to becoming staff director, he was legislative director for Congressman Sherwood Boehlert (R-NY) and served as top environmental aide and oversaw the legislative and press operations of the office. From 1985 to 1994, he served on the Science Committee as the special assistant on the Subcommittee on Science, Research and Technology where he oversaw the programs of NSF and National Institute of Standards and Technology. In 1994 and 1995, he was project director at the Council on Competitiveness, a private sector group with members from industry, labor and academia. He is a member of the Aeronautics and Space Engineering Board (ASEB).

JOAN JOHNSON-FREESE is chair of the Department of National Security Decision Making at the Naval War College (NWC). Prior to that, she held positions as chair of the Transnational Studies Department at the Asia Pacific Center for Security Studies, as a faculty member at the Air War College, and as director of the Center for Space Policy and Law at the University of Central Florida. Dr. Johnson-Freese has focused her research and writing on security studies generally, and space programs and policies specifically, including issues relating to technology transfer and export, missile defense, transparency, space and regional development, transformation, and globalization. She has testified before Congress concerning U.S.-Sino security issues concerning space. Dr. Johnson-Freese is a member of the SSB and the Committee on the Rationale and Goals of the U.S. Civil Space Program.

RICHARD H. KOHRS has more than 50 years of experience in systems engineering and integration for NASA's Apollo mission, space shuttle, International Space Station (ISS), and commercial programs. He retired from NASA as director of Space Station Freedom where he had overall responsibility for development and operation of the program. He also served as deputy director for the space shuttle program and before that was responsible for vehicle integration of orbiter, main engines, external tank, solid rocket boosters, and the ground system. From 1997 to 2005, he served as chief engineer of Kistler Aerospace with overall responsibility for technical integration of the seven major subcontractors and systems engineering and integration of the Kistler reusable launch vehicle. From 2006 to 2007, he served as program manager of SAGES (Shuttle/Apollo Generation Expert Services) for SAIC, providing the NASA Constellation Program access to retired senior personnel from Mercury, Gemini, Apollo, and shuttle programs. Mr. Kohrs is a member of the ASEB.

MOLLY K. MACAULEY is a senior fellow with Resources for the Future (RFF) where she is director of academic programs. Dr. Macauley's research at RFF has covered studies on economics and policy issues of outer space, the valuation of non-priced space resources, the design of incentive arrangements to improve space resource use, and the appropriate relationship between public and private endeavors in space research, development, and commercial enterprise. Dr. Macauley has served as a visiting professor in the Department of Economics at Johns Hopkins University and in the Woodrow Wilson School of Public Affairs at Princeton University. She was a member of the NRC Science Panel of the Review of NASA Strategic Roadmaps and the Panel on Earth Science Applications and Societal Needs of the decadal survey Earth Science and Applications from Space: A Community Assessment and Strategy for the Future. She is currently a member of the SSB.

BERRIEN MOORE III is the executive director of Climate Central. He is the former director of the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire. Dr. Moore's research focuses on the carbon cycle, global biogeochemical cycles, global change, and policy issues in the area of the global environment. He led the International Geosphere-Biosphere Programme (IGBP) Task Force on Global Analysis, Interpretation, and Modeling prior to serving as chair of the Scientific Committee of the IGBP. Dr. Moore is a member of the SSB and was co-chair of the decadal survey committee for Earth Science and Applications from Space: A Community Assessment and Strategy for the Future.

JOAN VERNIKOS was the director of Life and Biomedical Sciences and Applications at NASA Headquarters from 1993 until September 2000. Prior to this, Dr. Vernikos was on staff at NASA's Ames Research Center and before that, at Ohio State University Medical School where she was assistant professor of pharmacology. While at NASA, she led the research that developed the framework for determining how spaceflight and Earth's gravity affect the human body. After leaving NASA in 2000, Dr. Vernikos began a consulting company, Thirdage LLC. She is a member of the SSB.

WARREN M. WASHINGTON is a senior scientist and head of the Climate Change Research Section in the Climate and Global Dynamics Division at the National Center for Atmospheric Research. Dr. Washington's areas of expertise are atmospheric science and climate research, and he specializes in computer modeling of the Earth's climate. He serves as a consultant and advisor to a number of government officials and committees on climate-system modeling. From 1978 to 1984, he served on the President's National Advisory Committee on Oceans and Atmosphere. In 1998, he was appointed to the National Oceanic and Atmospheric Administration's (NOAA's) Science Advisory Board. In 2002, he was appointed to the Science Advisory Panel of the U.S. Commission on Ocean Policy and the National Academies Coordinating Committee on Global Change. He is a member of the NAE. Dr. Washington's NRC service is extensive and includes membership on the Policy and Global Affairs Committee and the SSB. He is past chair of the National Science Board.

Rapporteur

JAMES V. ZIMMERMAN is the immediate past president of the International Astronautical Federation (IAF). He was elected by the IAF's member organizations to lead the federation in 2004 and has completed his second term as president, a volunteer position. Mr. Zimmerman also serves as president of International Space Services, Inc., a space policy and international business development consulting firm. Before retiring from the U.S. government in 1997, Mr. Zimmerman held several senior executive positions at NASA and other federal agencies. As chief of NASA's International Planning and Programs Office, he was responsible for negotiating NASA's joint projects with space agencies in Africa, the Americas, Asia, and Europe. In 1980 Mr. Zimmerman founded and served as the first director of the International Affairs Office of the National Environmental Satellite Service at NOAA, when NOAA assumed responsibility for the Landsat Earth observations satellite program. From 1982 to 1985 he served as assistant director for export, import and international safeguards of the U.S. Nuclear Regulatory Commission where he was responsible for approving American exports of fuel and reactor components to other countries for nuclear power and research purposes. In 1985 Mr. Zimmerman returned to NASA to become the agency's European representative. During this 12-year assignment he was based in Paris, France, and traveled extensively throughout Europe to represent the U.S. government's civil space interests. He is a fellow of the American Astronautical Society (AAS) and an associate fellow of the American Institute of Aeronautics and Astronautics (AIAA) where he also served as vice president-international. He is a member of the International Academy of Astronautics (IAA) and a co-author of an

Academy cosmic study on "Next Steps in Exploring Deep Space." Mr. Zimmerman was twice awarded NASA's Exceptional Service Medal. In addition he received the European Space Agency's (ESA's) International Space Station Award and the German Space Agency's International Cooperation Award. He also received the AAS's Award for the Advancement of International Cooperation. Mr. Zimmerman received a bachelor of arts degree from Beloit College and a master of arts degree from Johns Hopkins School of Advanced International Studies. He also studied at the Kennedy School of Government, Harvard University, and at universities in Finland, Austria, and Italy.

Staff

IAN PRYKE, *study director,* retired from the European Space Agency in 2003. He is currently a senior program officer (part time) with the SSB, a senior fellow and assistant professor at the Center for Aerospace Policy Research in the School of Public Policy of George Mason University, and also operates as an independent consultant. He joined the European Space Research Organisation [later ESA] in 1969, working in the areas of data processing and satellite communications. In 1976 he transferred to ESA's Earth Observation Programme Office where he was involved in the formulation of the Remote Sensing Programme. In 1979 he moved to the ESA Washington Office, where he was engaged in liaison work with both government and industry in the United States and Canada, taking over as head of the office in 1983. He holds a B.Sc. in physics from the University of London and an M.Sc. in space electronics and communications from the University of Kent.

JOSEPH K. ALEXANDER served previously as director of the SSB, deputy assistant administrator for science in the Environmental Protection Agency's Office of Research and Development, associate director of space sciences at the NASA Goddard Space Flight Center, and assistant associate administrator of the NASA Office of Space Science and Applications. He has also been deputy NASA chief scientist and senior policy analyst at the White House Office of Science and Technology Policy. Mr. Alexander's own research work has been in radio astronomy and space physics. He received a B.S. and an M.A. in physics from the College of William and Mary.

CARMELA J. CHAMBERLAIN has worked for the National Academies since 1974. She started as a senior project assistant in the Institute of Laboratory Animal Resources (which is now the Institute for Laboratory Animal Research in the Division on Earth and Life Studies), where she worked for 2 years. She then transferred to the Space Science Board, which is now the Space Studies Board. She is now a program associate with the SSB.

CATHERINE A. GRUBER is an editor with the SSB. She joined SSB as a senior program assistant in 1995. Ms. Gruber came to the National Research Council in 1988 as a senior secretary for the Computer Science and Telecommunications Board and has also worked as an outreach assistant for the National Academy of Sciences-Smithsonian Institution's National Science Resources Center. She was a research assistant (chemist) in the National Institute of Mental Health's Laboratory of Cell Biology for 2 years. She has a B.A. in natural science from St. Mary's College of Maryland.

KEYNOTE SPEAKERS, MODERATORS, AND PANELISTS

MARK J. ALBRECHT was president of International Launch Services (ILS), the Russian/American joint venture company owned by Lockheed Martin Corporation in collaboration with Khrunichev State Research and Production Space Center, Moscow, from 1999 until 2006. ILS provides the Lockheed Martin-built Atlas and the Russian-built Proton and Angara launch vehicles and associated launch integration services to government and commercial satellite customers worldwide. During his tenure at ILS, Dr. Albrecht has been nominated multiple times for Satellite Executive of the Year by *Via Satellite* magazine. In 2004, he was named by *Space News* as one of the "100 People Who Made a Difference" in space, under the "corporate chieftains" category. Under his leadership, ILS received the Frost & Sullivan Market Engineering Award for Strategic Alliance and Leadership in 2002, as well as the PBI Media PR and Marketing award for the Best Launch Innovation of the Year in 2003. Dr. Albrecht's career at Lockheed Martin included serving as vice president of business development for Lockheed Martin Space Systems. In that position, he was responsible for domestic and international marketing and business development for the space systems operating companies and management of its strategic planning and customer relations. Before joining Lockheed Martin, Dr. Albrecht was senior vice president of Science Applications International Corporation (SAIC). In this capacity, he coordinated all space business activities, including business development, strategic planning, mergers and acquisitions. He joined SAIC in 1992 as its first director of Washington, D.C., operations. He was appointed in 1989 by President George Bush as the executive secretary of the National Space Council, serving in that capacity until 1992. Previously, Dr. Albrecht served as the legislative assistant for national security affairs to Senator Pete Wilson of California, held positions as a senior research analyst for the intelligence community staff in Washington, D.C., and the Rand Corporation, and as a member of SAIC research staff. Dr. Albrecht graduated Phi Beta Kappa from the University of California, Los Angeles (UCLA), and holds a master's degree from UCLA and a doctorate in public policy analysis from the Rand Graduate School.

ANDREW ALDRIN is currently director of Business Development and Advanced Programs for United Launch Alliance. Before that, he served in various positions in Business Development and Strategy at the Boeing Company including: vice president and director of Boeing Launch Services, and director of Business Development for Boeing NASA Systems. Dr. Aldrin's previous career was with leading U.S. policy research institutes, including the Rand Corporation and the Institute for Defense Analyses. He is currently a member of the adjunct faculty at International Space University and has also served as an adjunct professor at California State University at Long Beach as well as the University of Houston-Clear Lake. He holds a doctorate in political science from UCLA, a masters of business administration from Trium, a master's degree in science, technology, and public policy from George Washington University, and a bachelor's degree in political science and international relations from University of California at Santa Barbara. Dr. Aldrin is a corresponding member of the International Academy of Sciences and has written widely on a range of issues related to international security and space exploration.

MARK E. BRENDER joined GeoEye in 2006 after 8 years at Space Imaging as the vice president of communications and Washington operations. Mr. Brender has more than 25 years of experience in public affairs, broadcast journalism, and government relations and is responsible for all communications and marketing, including brand awareness, reputation, and issues management. Prior to joining Space Imaging, Mr. Brender was a broadcast journalist for ABC News where he spent 16 years at the network as an assignment editor and editorial producer. Before his ABC career he served in the U.S. Navy as a public affairs officer and is a retired naval reserve commander. Mr. Brender has an undergraduate degree from Miami University in Ohio and a master's degree in public relations from the School of Business at American University. In 1985 Mr. Brender established the Radio and Television News Directors Association Remote Sensing Task Force to clear the way for high-resolution imagery to move into the commercial sector.

RAVI B. DEO is the director of technology, space systems market segment at Northrop Grumman Corporation's Integrated Systems Sector. He has worked as a program and functional manager for government and company sponsored projects on Cryotanks, Integrated System Health Management, Aerospace Structures, Materials, Subsystems, Avionics, Thermal Protection Systems, and software development. He has extensive experience in roadmapping technologies, program planning, technical program execution, scheduling, budgeting, proposal preparation, and business management of technology development contracts. Among his significant accomplishments are the NASA-funded Space Launch Initiative, Next Generation Launch Technology, Orbital Space Plane, and High Speed Research programs where he was responsible for the development of multidisciplinary technologies. Dr. Deo is the author of more than 50 technical publications and is the editor of one book. Dr. Deo is a member of the ASEB and served on the NRC Panel C—Structures and Materials of the Steering Committee on Decadal Survey of Civil Aeronautics and the Panel J—High-Energy Power and Propulsion and In-space Transportation of the Committee for the Review of NASA's Capability Roadmaps. He has also served on the Scientific Advisory Board to the Air Force Research Laboratories.

PEGGY FINARELLI is a senior fellow in the Center for Aerospace Policy Research at George Mason University. From 2000-2006, she was the International Space University's vice president for North American Operations. Before that, her career with NASA and other U.S. government agencies focused on strategy development and negotiations in the fields of domestic space policy and international relations in science and technology. At NASA (1981-2000), she rose to the position of associate administrator for policy coordination and international relations. She played a major role at NASA in developing the initial concepts for the international partnerships in the Space Station Freedom (now the ISS). She led the U.S. team conducting the first round of international negotiations in the mid-1980s that resulted in the agreements governing NASA's cooperation with Europe, Japan, and Canada. These agreements established the legal, policy, and programmatic framework for the multi-billion dollar ISS. As an undergraduate at the University of Pennsylvania, she was elected to Phi Beta Kappa and graduated magna cum laude with a B.S. with distinction in chemistry. She also has an M.S. degree in physical chemistry from Drexel University. She was elected to the IAA in 2003, was elected as a fellow of the AAS in 2004, and was elected as an associate fellow of the AIAA in 2005. Ms. Finarelli received NASA's Exceptional Service Medal in 1985, the Presidential Meritorious Rank Award in 1988, NASA's Group Achievement Award in 1989 and 1994, the Women in Aerospace Outstanding Achievement Award in 1989, NASA's Exceptional Achievement Medal in 1991, and the AIAA International Cooperation Award in 2004.

LENNARD A. FISK is the Thomas M. Donahue Collegiate Professor of Space Science in the Department of Atmospheric, Oceanic, and Space Sciences at the University of Michigan, where he also served as chair from 1993 to 2003. Prior to joining the university, Dr. Fisk was the associate administrator for space science and applications at NASA. In this position he was responsible for the planning and direction of all NASA programs concerned with space science and applications and for the institutional management of the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory. Prior to becoming associate administrator in 1987, Dr. Fisk served as Vice president for research and financial affairs at the University of New Hampshire. In this position, he was responsible for the administration of the university research activities and was the chief financial officer of the university. Dr. Fisk joined the faculty of the Department of Physics at the University of New Hampshire in 1977, and founded the Solar-Terrestrial Theory Group in 1980. He was an astrophysicist at the GSFC from 1971 to 1977 and a NAS postdoctoral research fellow at GSFC from 1969 to 1971. He is a member of the NAS and served as chair of its Space Studies Board from 2003 to 2008.

GIB KIRKHAM serves as the director of the Exploration Systems and Aeronautics Research Division in NASA's Office of External Relations. Mr. Kirkham joined NASA Headquarters in 1992, as a presidential management intern. From 1992 to 1995, he served as the lead NASA negotiator on a number of key programmatic, contractual, and policy activities between NASA and its Japanese and Russian partners. Later, as the executive secretary to the Stafford Task Force of the NASA Advisory Council from 1995 to 1997, Mr. Kirkham organized and led initiatives on a broad range of executive-level and interagency international, civil, and national security issues involving NASA's collaboration in human spaceflight with Russia. From 1997 to 2002, Mr. Kirkham served as the NASA attaché to the U.S. Embassy in Tokyo, Japan. Mr. Kirkham received a bachelor of arts in history from the College of Wooster and a master's degree in Japanese studies and international economics from the Johns Hopkins School of Advanced International Studies. In 2004, Mr. Kirkham received a master's of business administration from the International Executive MBA Program of Georgetown University's McDonough School of Business.

GREGORY KULACKI is currently a senior analyst and the manager of the China Project for the Global Security Program of the Union of Concerned Scientists (UCS), a nonprofit partnership of scientists and citizens combining rigorous scientific analysis, innovative policy development and effective citizen advocacy. Since coming to UCS he has been conducting research on the structure and function of the Chinese arms control community, Chinese arms control policy, and China's space program, particularly technologies and strategies related to space security. He has also been administering a professional exchange program that brings Chinese scientific and technical experts together with their U.S. counterparts to conduct research on arms control policy. Formerly the director of academic programs in China for the Council on International Exchange, he has spent nearly 20 years working to promote educational, professional, and governmental exchanges between the United States and the People's Republic of China.

ROGER D. LAUNIUS is senior curator in the Division of Space History at the Smithsonian Institution's National Air and Space Museum in Washington, D.C., where he was division chair from 2003 to 2007. Between 1990 and 2002 he served as chief historian of the NASA. He has written or edited more than 20 books on aerospace history, including *Robots in Space: Technology, Evolution, and Interplanetary Travel* (2008); *Societal Impact of Spaceflight* (2007); *Critical Issues in the History of Spaceflight* (2006); *Space Stations: Base Camps to the Stars* (2003), which received the AIAA's history manuscript prize; *Reconsidering a Century of Flight* (2003); *To Reach the High Frontier: A History of U.S. Launch Vehicles* (2002); *Imagining Space: Achievements, Possibilities, Projections, 1950-2050* (2001); *Reconsidering Sputnik: Forty Years Since the Soviet Satellite* (2000); *Innovation and the Development of Flight* (1999); *Frontiers of Space Exploration* (1998, rev. ed. 2004); *Spaceflight and the Myth of Presidential Leadership* (1997); and *NASA: A History of the U.S. Civil Space Program* (1994, rev. ed. 2001). He is a fellow of the American Association for the Advancement of Science, the IAA, and the AAS. He also served as a consultant to the Columbia Accident Investigation Board in 2003 and presented the prestigious Harmon Memorial Lecture on the history of national security space policy at the U.S. Air Force Academy in 2006. He is frequently consulted by the electronic and print media for his views on space issues, and has been a guest commentator on National Public Radio and major television network news programs. A graduate of Graceland College, he received his Ph.D. from Louisiana State University.

CONRAD LAUTENBACHER is the former undersecretary of commerce for oceans and atmosphere and NOAA administrator. A graduate of the U.S. Naval Academy, Vice Admiral Lautenbacher has served in a broad range of operational, command and staff billets. Staff duties included higher education as well as significant assignments in senior management. Vice Admiral Lautenbacher attended Harvard University receiving M.S. and Ph.D. degrees in applied mathematics. He was selected as a federal executive fellow and served at the Brookings Institution. He served as a guest lecturer on numerous occasions at the Naval War College, the Army War College, the Air War College, the Fletcher School of Diplomacy, and the National Defense University. As a flag officer he served as deputy chief of staff for management/ inspector general on the staff of the Commander in Chief U.S. Pacific Fleet; and as director of force structure, resources, and assessments (J-8) on the Joint Staff, where he contributed to the development of the Base Force and was a prime architect of the Bottom Up Review military force structure. He also served as director, Office of Program Appraisal, on the staff of the Secretary of the Navy, and his last assignment on active duty was as deputy chief of naval operations (resources, warfare requirements and assessments) where he was personally responsible for developing the Navy Future (5) Years Program and a $80 billion annual budget. These positions resulted in the development of significant expertise in federal government processes within both the executive and legislative branches. After transitioning to the civilian sector, he formed his own management consultant business, and worked principally for Technology, Strategies & Alliances Inc. He was president and CEO of the Consortium for Oceanographic

Research and Education, a not-for-profit organization with a membership of 65 institutions of higher learning and a mission to increase basic knowledge and public support across the spectrum of ocean sciences. He joined NOAA in 2001.

LINDA V. MOODIE, in her capacity as senior advisor to NOAA, advises the NOAA assistant administrator for satellite and information services, Mary Kicza, especially in her role as the current chair of the Strategic Implementation Team of the Committee on Earth Observation Satellites (CEOS). Ms. Moodie played a major role in the conceptualization and execution of the first Earth Observation Summit in 2003, which launched the the intergovernmental Group on Earth Observations (GEO). Ms. Moodie advised the NOAA administrator in his capacity as GEO co-chair, advises the NOAA co-chair of the U.S. Integrated Earth Observation System, which is the U.S. contribution to the international system, and participated on the small team that drafted the international GEOSS 10-Year Implementation Plan. Ms. Moodie also represents the United States on its delegation to the Conference of the Parties of the Framework Convention on Climate Change (FCCC) and is the lead U.S. negotiator for research and systematic observation issues. A public servant with NOAA for 20 years, Ms. Moodie is responsible for the international and interagency coordination of collaborative activities undertaken by NOAA in the application of satellite data. Before joining NOAA, she served as deputy director, Bretton Woods Committee, and as public policy analyst and project coordinator, National Council for International Health. Ms. Moodie received her B.A. in economics from the University of Michigan and her M.A. in international affairs from the Johns Hopkins University School for Advanced International Studies.

CLAYTON MOWRY has served as president of Arianespace, Inc., the U.S. subsidiary of Europe's Arianespace launch consortium, since 2001, where he is responsible for sales, marketing, operations, and government relations. Prior to joining Arianespace, Mr. Mowry served for 6 years as executive director of the Satellite Industry Association. He began his career in the space industry as a satellite and launch industry analyst with the International Trade Administration at the U.S. Department of Commerce.

VINCENT SABATHIER is senior fellow and director for space initiatives at Center for Strategic and International Studies. He is also senior adviser to the SAFRAN group and consults internationally on aerospace and telecommunications. He is president of Als@tis, a telecommunications company he founded in Toulouse, France, in 2004. Until 2004, he served as the representative of the French Space Agency (CNES) in North America and as the attaché for space and aeronautics at the embassy of France in Washington, D.C. There, he focused on strengthening bilateral dialogue and cooperation with all branches of the U.S. government involved in aerospace. Mr. Sabathier has served in many roles in the aerospace industry, with the French Ministry of Defense, CNES, and Arianespace, where he was actively involved in the development of Ariane 5. Arianespace selected him to negotiate production contracts for Ariane launchers and later appointed him program manager for follow-on projects they financed. Mr. Sabathier has written more than 50 articles and reports and lectured at a variety of conferences and symposiums. He has also taught space transportation systems at the University Paul Sabatier in Toulouse. He received his degree from École Centrale de Nantes in France and performed research work at the Colorado School of Mines with a grant from Martin Marietta Astronautics. He later specialized in space systems at the École Nationale Supérieure de l'Aéronautique et de l'Espace, Toulouse, and holds an international management degree from ESSEC, Paris. He participated in the Executive Education Program in Strategic Issues in Mergers and Acquisitions at INSEAD, Fontainebleau, France.

ROALD SAGDEEV is a Distinguished University Professor at the University of Maryland. From 1970 to 1980 he served as director of Space Research Institute, Moscow, where he led a number of international space projects, including VEGA (lander and atmospheric balloons to Venus), the joint U.S.-Soviet Apollo-Soyuz mission, and the international mission to Halley's Comet, for which he received the Order of Lenin. He has memberships in Academies in Russia, Vatican, and Tatarstan. He is a foreign associate of the NAS. He served as vice president of COSPAR, and more recently as a member of the

SSB. In 2008, he was elected fellow of the American Philosophical Society (APS). In addition to his scientific career, Dr. Sagdeev played a major political role during the first five years of *perestroika*, serving as an advisor to Mikhail Gorbachev at the Geneva, Washington, and Moscow summits. Mr. Sagdeev has made fundamental contributions to a broad range of fields ranging from plasma physics to planetary science, astrophysics, and arms control. In March of 2001, he was appointed to Intelilabs advisory board. He is co-winner of the 1995 APS Leo Szilard Award for his role in promoting the use of physics for the benefit of society in such areas as the environment, arms control, and science policy.

ERIC STERNER is a defense and aerospace consultant specializing in areas where high technology and national security intersect. His served as the senior professional staff member responsible for defense policy on the House Armed Services Committee and as the special assistant to the assistant secretary of defense for international security policy, the Honorable J.D. Crouch II. Prior to that, he was a national security analyst for NSR Inc. and for the Strategic and Intelligence Programs Division at JAYCOR, focusing on the strategic impact of emerging technologies. In the areas of civil and commercial space activity, he simultaneously held two positions as NASA's associate deputy administrator for policy and planning and chief of strategic communications. A member of the non-career Executive Service, Mr. Sterner was responsible for institutional management and coordinating the work of NASA's outreach organizations. He served on the staff of the House Science Committee under three different chairs and was the staff director for its Space and Aeronautics Subcommittee at the time of his departure. In the private sector, he was vice president for federal services at TerreStar Networks, Inc., an emerging wireless communications company integrating satellite and terrestrial components. A published author, Mr. Sterner earned his B.A. from American University and two M.A. degrees from George Washington University.

JEAN-PIERRE SWINGS, chair of the European Space Sciences Committee of the European Science Foundation, is an astrophysicist (solar physics, gravitational lenses, large telescopes, both ground and space) with approximately 180 papers published. He has been involved in many international organizations, especially the International Astronomical Society (general secretary 1985-1988), the European Southern Observatory (council member for 17 years, VLT planning, etc.), the European Space Agency (~30 committees), and is a co-founder of the European Astronomical Society. He holds Ph.D. and D.Sc. degrees from the University of Liège, Belgium, where he is an Honorary Professor. He has performed post-doctoral work at JILA, the Joint Research Institute of NIST and the University of Colorado, Boulder, and has served as a Carnegie fellow.

YOSHINORI YOSHIMURA is the director of the Japan Aerospace Exploration Agency Washington Office. Formerly, he was the director of the System Engineering Office at JAXA Headquarters where he was responsible for the coordination of overall JAXA engineering activities to support JAXA's chief engineer and the education planning of JAXA systems engineers. In 1982, he began his JAXA career at the National Space Development Agency of Japan (NASDA) performing satellite structural design. He was also involved in the thermal vacuum tests of satellites at the Tsukuba Space Center. In 1985, he joined the Japanese Experiment Module program as a systems engineer and was stationed at NASA Johnson Space Center as the Japanese representative for the ISS program in 1987. In 1991, he went to the Space Policy Institute of George Washington University to study as a visiting scholar and worked for the House Science Committee Subcommittee on Space as an intern. In 1994, he joined the ISS IGA/Memorandum of understanding negotiations as a member of the Japanese delegation, contributing to the conclusion of the new IGA/MOU in 1998. In 1999, he became the director of international affairs, Office of Research and Development Bureau, Science and Technology Agency of Japan and was responsible for supervising international space cooperation activities both at NASDA and National Aeronautics Laboratory. He received both bachelor and master of engineering degrees from the University of Tokyo.

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Opening Keynote: Scientific and Technological Cooperation and Competition in a Globalizing World

Conrad C. Lautenbacher, Jr.

THE PROPOSITION

The title and topic are rather broad in scope but the time is relatively limited. As a result I have focused my remarks on global Earth and space sciences and on technology as it applies to space and associated areas.

Most of you are well aware that I have been and remain a shameless advocate of international cooperation, interagency coordination, and private and public sector cooperation to meet today's truly difficult societal, economic, and environmental challenges. So, it should be no surprise that I believe:

In today's world, we have unprecedented opportunities to turn competition in space to our advantage and to open a new era of worldwide cooperation in space activities, particularly in regard to building a sustainable future for the human species.

THE MENU

I have structured my remarks to align with the major components of the session title, dividing the whole into:

- Surveying the *Globalizing World,* with a top-level view of globalization and applications to society, the economy, and environment.
- Reviewing the status of *Space Science and Technology,* with emphasis on technology levels, current organizations and status, and the relationship between research and operations.
- *International Opportunities* in Earth observations, space exploration, both manned and unmanned, with emphasis on lessons learned, fiscal and organizational realities, the experience of the Group on Earth Observation (GEO) and the Committee on Earth Observing Satellites (CEOS), and future specific opportunities.

NOTE: At the time of the November 2008 workshop, the author had just left government service on October 31, 2008, as the National Oceanic and Atmospheric Administration (NOAA) administrator and under secretary of commerce, and so participated in the workshop as a private citizen. Views expressed in this paper are strictly personal and not official NOAA pronouncements.

GLOBALIZATION

The General Situation

Globalization is a permanent part of the world order. The ever-increasing connections among all parts of the world and with multiple disciplines affect every part of our lives. The examples are many and graphic. To begin, national economies are intertwined. One has only to review the business page each day and see the results of 24 hours of continuous trading occurring somewhere in the world. Preceding the opening of the stock markets, futures markets influence the specific trading that goes on in the stock and commodities markets. As surely as day turns into night and back again somewhere in the world, the impacts are connected, and on some days very unsettling.

The current economic crisis has affected (or infected) the entire world. Financial systems are connected. We have only to look at the current meetings of the world's leaders as they ponder the size and effect of various remedies, essentially working together to cope with a worldwide recession and potential depression based on the globalization of bad debt and tightening on the credit markets. This high-level connection rolls down to average citizens around the world affecting their jobs, their standard of living, and potential for the future. No one is immune!

Goods and services are globally connected as never before. The automobiles we drive are composed of parts made by the lowest bidders around the world, assembled in different user countries, and profits returned to the parent nations of international corporations. We call the help desk for our computers and information technology (IT) systems, and many times talk with someone on the other side of the globe including countries such as India. Retail industry products and profits are affected daily by the connection to a global supply chain and a global consumer market.

Global technology development enables the connections that bind our corporations and economies in endless cycles of development and technological improvements that show up almost simultaneously in all parts of the world. The safeguarding of intellectual property rights (IPR) has become a high-priority topic of concern among the developed nations of the world. National leaders work continuously to ensure that technology transfers take place under recognized rules and protocols, with due respect to those that provide the seed corn for progress. In spite of our concerns for safeguarding IPR, technology travels to all parts of the world legally or not, enabled by expanding IT networks and the rapid movement of ideas.

Global organizations are likewise ubiquitous, beginning with a large family of high-level United Nations (UN) organizations that run the gamut of purposes from policy and governance to science, agriculture and environment, to name only a small sample. Likewise there are regional affiliations among nations, private sector organizations, industries, and charitable groups. Every conceivable cause seems to have advocacy groups, again enabled by IT and the ever growing flow of information.

Perhaps the easiest example of globalization for scientists to understand is the relationship that has always existed within the environment and among Earth and space sciences. The planet is and always has been connected—physically, chemically, and biologically; the Earth ecosystem is essentially a "system of systems." With expanding globalization in other parts of life, it has become even more important to recognize and understand the synergy created by rampant globalization. Such visible environmental manifestations as global disease transmission can occur with the speed of modern aircraft. With people and goods as carriers, vector diseases can move around the globe in not much more than 24 hours. Invasive species circle Earth in the ballast tanks of ships or the cargo holds of planes, transforming the landscape at their new location and severely impacting the ecological balance.

Natural disasters caused by Earth-related phenomena such as hurricanes and earthquakes are clearly common worldwide and affect the biosphere in similar ways around the world. Resource shortfalls in water, energy, and food are global and are the cause of significant global efforts at mitigation, adaptation, and easing of human suffering. In such situations, political boundaries are irrelevant, and in most cases cannot limit the extent of the situation and may even hinder response and recovery efforts.

Today's Status

While I believe that most of us accept globalization as very real and influential on the course of business, government, and daily living, what are the specific conditions occurring today that will affect our deliberations with regard to international cooperation in space and space-related disciplines?

Clearly we are in the beginning, or midst, depending on your prognosis, of a worldwide economic recession. The recent high-level meetings among national leaders led to the discussion of general and specific remedies which to be effective seem to beg for more international cooperation. It also seems clear that we will see increased interest in stimulus packages, as well as tighter federal budgets, and increased monitoring and regulation. Rising expenditures and budget shortfalls will perhaps become even more acute than we normally experience.

National security concerns remain a worldwide priority. Globalization also includes such negative influences as nuclear arms and terrorism. The concept of "rogue states" is alive and well, and their global impact remains unsettling. Long entrenched antagonisms based on religious, ethnic, territorial, and cultural differences within and among nations remain as major drivers of national security policies. These trends will continue to push us apart, with the result that political boundaries remain highly relevant.

While it is arguable that there may not be any significant increase in technological and industrial competition among nations, worldwide recession tends to reinforce the status quo. In this country we see the adverse effects of our laws regarding a topic known as International Traffic in Arms Regulations (ITAR)—something I know we will be talking about during the next two days. I will leave this topic to the experts for further analysis. But there remains a significant force in place, one that supports protectionism of both national industries and technology development. Achievement in space always has been, and will continue to be, a sensitive topic in national diplomacy.

However daunting the current situation appears, there exist significant forces and conditions that encourage the need for more international cooperation. The growing worldwide concern over the effects of global climate change and the broader category of global change are causing political agendas everywhere to include calls for action and a search for cost-effective solutions.

Resource shortfalls lead to competition, to be certain, but they also presage cooperation, particularly as worldwide shortages become more common and fiscal resources become even scarcer. The search for affordable, clean energy and water become projects of a magnitude that go far beyond what any individual nation can afford to take on alone.

Food security has always been a significant issue. The world trade organization has worked for many years to develop a worldwide trade regime for agricultural products that is fair and equitable; but there has never been any doubt that trade in foodstuffs is a global issue. Fisheries management becomes even more compelling. The sea provides on the order of 20 percent of the world's protein, and the extension of political boundaries into the world ocean becomes even more problematic. International cooperation in fisheries management is a must and is recognized as such today.

The need to improve the lot of developing nations is a significant force. Economic development is a priority that drives the dynamics of international organizations from the Food and Agriculture Organization (FAO) to the United Nations Framework Convention on Climate Change (UNFCCC), for example. It is a factor that continues to play a role in almost every international diplomatic issue discussion.

Another important factor from my personal experience is that U.S. leadership remains real and significant. As I have traveled and held discussions with counterparts around the world (the National Oceanic and Atmospheric Administration, NOAA, is a significant player in Earth sciences around the world), I have found that there is a strong sentiment to work with the United States and to cooperate in solving our economic and environmental challenges. The goal is to convert this continuing desire to have strong bilateral relations with the United States into broad acting multilateral initiatives with the expertise and resources needed to solve significant worldwide challenges.

Bottom Line

International cooperation is not only feasible but necessary for progress on the challenges we face. However, we must understand the current factors driving international relations. We must work around many of these conditions, because waiting for them to change means inaction and lack of forward motion. The attitude must be that the cup is at least half full if success is the goal!

SPACE SCIENCE AND TECHNOLOGY

Now let us take a global look at the level of and value of science and technology, particularly with regard to space. While the space age is in the grand scheme of things a small blip in the history of the planet, there have been many notable achievements which include celebrating 50 years of NASA as well as orbital flight. Space technology has achieved a level of maturity that allows us to stimulate our imaginations as well as to demonstrate its value across many disciplines and economic sectors.

There are Earth-orbiting satellites too numerous to mention that provide, on a routine basis, communications connectivity around the globe. Environmental satellites ring Earth, providing valuable meteorological, oceanographic, and terrestrial information that forms the basis of a developed nation's industry and economy. Earth-observing satellites play a pivotal role in providing the basis for approximately one third of our nation's economic activity.

Research satellites focusing on Earth's climate are providing insights that have never before been available to scientists and decision makers alike. A major example of operational space science success is the Global Positioning Satellite (GPS) system that has spawned an unending number of valuable applications driving economic value and quality of life improvements around the world.

We have explored our solar system with satellites and have put humans into orbit. As we sit here today, the International Space Station orbits Earth as a major example of international cooperation and space research. So much has happened in the past few decades that space is taken for granted at this point. Alas perhaps too much!

We have learned that the contribution of space to activity on Earth increases many times when combined with in situ information. The World Weather Watch is a perfect example of the use of information obtained from both space- and Earth-bound assets combined together to provide critical environmental information for human activity and early warning of potential disasters. The world is a much safer and more productive place thanks to observation from space.

In addition to the need to combat complacency in the public arena, the generation of space scientists and engineers that took us to the Moon and that created this marvelous source of development on Earth is now retiring. We must invest and nurture the next generations of engineers and technicians that will provide steady and dramatic improvements in our ability to use space to improve the human condition. This is not a single event, but one that is going to require improved institutionalization of academic and career development now and for the foreseeable future. It is also an international imperative!

International cooperation requires more than just a strong desire to study and do research in space, it requires serious organization. There is probably no more difficult task than organizing large numbers of our individualistic species into large-scale, efficient, and productive organizations. Fortunately we have many examples of international organizations, some that are very effective and others less so. There really is no end to the list of organizations formed to serve every conceivable purpose. However, there are relatively few high-level international organizations that incorporate and use space.

A key to successful international organizations is a successful organization schema at the national level. National interagency cooperation precedes effective international cooperation. To understand some of the impediments to successful organizational structure, we have to look no further than our own national government. Although beyond the scope of this presentation, we could certainly become more effective as a space-faring nation in cross-disciplinary and cross-agency management of national space issues.

When viewing the level of space technology and applications to societal benefits, there needs to be a greater understanding of the difference between research and operations when it comes to space and space-technology applications. We need to understand and support robust space research activities as well as those space activities that have reached the "operational" threshold.

Space research organizations such as NASA, the European Space Agency (ESA), and the Japan Aerospace Exploration Agency (JAXA), to name just a few, around the world have become well established, highly proficient, and have worldwide stature. On the other hand, operational space organizations that operate constellations of satellites for applications to industry, government, and the economy are less well understood and supported. Organizations such as NOAA, the United Stated Geological Survey (USGS), and the European Meteorological Satellite (EUMETSAT) organization serve as important examples of the growing number of organizations that have made commonplace the use of information gained from space assets in critical pubic and private decision making.

We are in the infancy of building worldwide operational space organizations and agencies, and we must work at developing the proper organizational structures as well as joint planning mechanisms for funding cutting edge research and then transitioning the most effective and proven research results into operations for the benefit of society.

INTERNATIONAL OPPORTUNITIES

With that rapid survey of the situation, let's turn now to the opportunities for international collaboration, taking into account the lessons learned both in competition and collaboration. There are different ways to examine the various categories of space technology and development, but for simplicity, let us divide the field into two major categories: Earth observation and space exploration (including space science), each of which subdivides broadly into manned and unmanned categories. Manned missions are certainly connected mostly with exploration, but I believe most will admit to the proven value of manned missions to Earth observation as well.

Given the time allowed, once again I will state up front that international collaboration currently exists in manned space exploration, the International Space Station (ISS) being a prime example, and much more can be done to improve the mechanisms and partnerships that would provide quantum leaps in space discovery with larger scale international efforts. In fact, the large-scale interplanetary exploration missions cry out for international collaboration.

Given that the workshop agenda includes ample time to examine the potential for space exploration initiatives, I will focus my remarks on Earth observation, the area with which I am most familiar and one that is deserving of attention in this workshop given the recent successes in international organization and partnerships that have occurred within the past decade.

Lessons Learned

Fiscal realities will drive us toward renewed emphasis on collaboration versus competition. Budgets around the world are constrained. Here at home, for example, the U.S. research agency, NASA, has an annual budget of approximately $17 billion, two of the operational agencies, NOAA and USGS, have much less at $4 billion and $1 billion. Of those overall totals, only about $1 billion within NOAA and a small fraction within USGS are spent on space operations. Given the state of the world economy, there is little or no margin for much expansion at this time, even though the need for, and value of space to society is great.

Compounding the fiscal problem is the rising cost of space research and technology development. Almost every large space program sponsored by the U.S government has and continues to experience significant cost growth. Unlike much in our economy that is reasonably predictable, space technology really is "rocket science"! In addition to growing requirements and resulting instrument complexity, many believe that the loss of experienced manpower has also contributed significantly to over optimistic resource estimates. National priorities in a world with recession on its mind and a landscape of terrorism tend to exclude strong emphasis on space issues.

Remember that space from the very beginning has been considered an area of competition as nations vie for international standing and prestige. Space achievement has been viewed as a symbol of national pride and technological supremacy. This situation is ripe for change!

Organizational realities: The truth is that effective, large-scale organizations are necessary for developing, funding, and executing large-scale projects. Complexity is one word that comes to mind when examining current organizational realities. From a governmental view, national cooperation and focus is critical to success in international cooperation. Such agencies as NASA, NOAA, USGS, and the Department of Defense (DOD), for example, must have a coherent unified agenda; White House offices such as the Office of Science and Technology Policy (OSTP), the Council on Environmental Quality (CEQ), the National Security Council (NSC), and the Domestic Policy Council (DPC) must take an active role in fostering interagency collaboration and integration, and supporting a truly national space agenda.

Congressional priorities and oversight roles are significant parts of the picture. Obstacles to overcome include the maze of committees and subcommittees, each of which tends to focus on the internal political priorities of their members. Our election cycles emphasize short-term success when everyone knows that space research and development usually takes on the order of at least 5 to 10 years for large and significant projects.

Specific Example

Having described some of the lessons learned in organization from a very general viewpoint, let us take stock of lessons learned by using a currently successful example, GEO in the area of Earth observation, that is dependent on space assets for ultimate success.

The motivation for the formation of GEO and its importance can be reviewed succinctly in a recent Center for Strategic and International Studies (CSIS) report, *Earth Observations and Global Change,* in which it is noted that "the ability to observe, understand, and subsequently adapt to our world is a key requirement for civilization."[2]

In essence, Earth observations are fundamental to the economy and society and to advancing knowledge in Earth science areas. Cooperating with regard to Earth observations represents a clear-cut win-win situation. No single nation can understand and predict the global environment! Benefits include the ability to be proactive versus reactive in our approach to global change, resource management, and disaster response and recovery.

A small but not unimportant point is the name itself, "Earth observation," which is apolitical and nonthreatening in a policy sense. Designed from the very beginning to include an "end-to-end" mechanism to provide decision-quality information to the public and national leaders, the name provides no bias as to what those decisions should or should not be. The choice of a neutral title is critical to gaining wide support!

Another important factor is that GEO was formed with the concept of societal and economic benefits as the prime motivation. It was not set up with the goal of creating another scientific research system, but rather to provide direct benefits to the economy by delivering useful information to the decision makers of the world. Those reasons are codified in the GEO organizational structure as Societal Benefit Areas (SBAs). There are nine specific areas that the nations of the world agreed were imperatives for a sustainable future. In summary they are health, disasters, weather, climate, water, energy,

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[2] L. Wigbels, G.R. Faith, and V. Sabathier, *Earth Observations and Global Change:Why? Where Are We? What Next?,* Center for Strategic and International Studies, Washington, D.C., July 2008, p. 1.

agriculture, ecosystems, and biodiversity. It is important to think of the GEOSS as a system that will improve the ability of the human species to manage within the nine SBAs for concrete economic and societal benefits, not solely to build a bigger and better research tool.

With regard to national leadership, there has been strong White House involvement. The OSTP created a relevant interagency coordination body under the Committee on Environment and Natural Resources named the U.S. Group on Earth Observation (USGEO) to develop the U.S. contribution to GEO, which is known as the Integrated Earth Observation System (IEOS). There is coherence in the national effort that dovetails with strong U.S. leadership internationally.

Internationally, the United States has been both sensitive to the needs of other nations and involved in early efforts at the 2002 World Summit on Sustainable Development (WSSD). The United States led efforts at the subsequent G-8 meeting to gain multilateral support for the GEO initiative. Significant emphasis was placed on bilateral conversations with developed and developing nations alike to scope the interest and requirements for leading a new multilateral international effort. Bilateral relationships are much easier to build and maintain, but Earth observation is by definition a multilateral activity.

Internal U.S. political realities were taken into account in the matter of UN versus non-UN. GEO was envisioned to begin as a non-UN organization, but with the significant involvement by the many UN organizations that either operate or use Earth observation data and to which all of the GEO member nations belong. Today, 5 years after the original organizing Earth Observing Summit I, there are 75 member nations and the European Commission, as well as 50 UN and intergovernmental organizations united in the GEO effort.

Such important bodies as the World Meteorological Organization, the Intergovernmental Oceanographic Commission, Committee on the Peaceful Uses of Outer Space, the Intergovernmental Panel on Climate Change, to name a very small number, are participating organizations and bring with them the various international observing systems that support the work plans that have been tailored to achieve the agreed upon "10 Year Implementation Plan."

CEOS is the primary international Earth observation from space organization within GEO, and with 28 members with satellite programs and 20 associate members, is responsible for many important tasks in the work plan. GEO was created at the ministerial level and provided direct access to, and involvement by, the highest leadership of all the member nations. It includes scientific as well as diplomatic and political representation and makes provision for private sector involvement, although this effort to capture the extraordinary entrepreneurial value of the worldwide private sector is in its infancy.

The organizational structure takes into account the different "business models" under which governments work—the extremes of which can be described as total government subsidy of all Earth observation information on one hand and on the other charging all customers for any information gathered. The definitions can be shortened by thinking of these as "public-good data" or "pay for play." The GEO premise is that there needs to be some level of public-good data freely available to all nations, or what is known as an open data policy. The GEO 2007 Ministerial Declaration for Implementation of Data Sharing Principles by the planned 2010 Ministerial is a significant statement of recognition of this policy by the member nations and a key to the success of the 10-year implementation plan.

International collaborative space program opportunities abound within the GEO arena. The building of the U.S. IEOS a is strong incentive for effective national long-range planning among NOAA, USGS, and NASA. It has also served as an important example to many other nations who now have also begun to build the important collaborative interagency structures that will serve in the development of the GEOSS.

With regard to specific programs, internationally much progress has been made in the drive to make the JASON series of altimetry satellites continuous and join the current family of operational space assets. The benefits of space-based altimetry to the understanding of the effect of climate change have been documented in a recently published paper that indicates sea-level rise has doubled since 1993. Such calculations would be impossible without the maturation of altimetry from space and will fail in the future without continuity of the space assets.

NPOESS is a prime example of international cooperation between the United States and Europe, with each operating it own satellite systems in different orbits but sharing the data, which significantly reduces the cost for each party.

The geostationary meteorological satellite support agreements that the United States has with Europe and Japan could easily be extended to the family of nations that provides worldwide meteorological coverage from geostationary orbit.

The initiation of the GEONETCast system of direct broadcast of Earth-observation data from space to the world, now being sponsored by China, Europe and the United States, could easily be expanded with other nations and data providers joining the effort.

The United States and Japan are studying a partnership involving the sharing of instruments and data using current and future satellites.

One of the most exciting opportunities for multilateral development and cooperation in Earth-observing space assets involves the CEOS effort to build "virtual constellations." A virtual constellation is essentially a postulated group of existing or future satellites, accompanying instruments, and ground segments designed for coordinated operation and exploitation. Such an effort would provide consistent guidance for design standards and future development that would allow coherent operation of the entire constellation.

Opportunities would include shared experience in algorithm development, standardized data and measurements, timely exchange of and access to products, and facilitation of new mission planning. Combining the outputs with in-situ observations (which is essential) to support end-user customers would demonstrate on a large and efficient scale the critical worldwide contribution of space agencies to the "value-chain" of an end-to-end system.

Six constellations have now been approved for analysis, as follows:

- Constellation for Atmospheric Composition (ACC) designed for monitoring ozone, air quality, and climate, directly serving the SBAs of disasters, health, energy, climate, and ecosystems;
- Constellation for Land Surface Imaging (LSI) designed for serving the SBAs of disasters, energy, climate, water, ecosystems, agriculture, and biodiversity, and incorporating LANDSAT, SPOT, CBERS, and ALOS-PRISM;
- Constellation for Ocean Surface Topography (OST) for Systematic Observation from basin-scale to meso-scale phenomena and serving the SBA's of disasters, climate, water, and weather;
- Constellation for Precipitation (PC) designed for multi-satellite global precipitation missions and serving the SBAs of disasters, climate, water, and weather; and
- Two recently approved constellations for Ocean Color Radiometry (OCR) and Ocean Surface Vector Wind (OSVW).

While the examples described are relatively well defined, other opportunities for collaboration not so far into the conceptual stage also exist. To mention a few, there is a critical need for a Global Climate Observing System (GCOS) to support potential worldwide agreements on mitigation and adaptation to climate change. Integral to that effort would be a Global Carbon Monitoring System (GCMS). There can be no effective solutions to the climate change issue without the ability to monitor worldwide effects of any regulatory or control regimes that might be put into place. Certainly, with the cost of changes to the world energy and natural resource use patterns, we may only get one chance to do this correctly. As an example of the difficulty, the effect of changes in land cover, including deforestation, must be quantified.

While space assets can provide unique information, normally the combination of observation from space with data from in-situ sensors is required to provide useful information to decision makers. The recognition that space is part of a much larger picture and planning accordingly is a message that needs emphasis. Most of the world's 21st century challenges will require a multidisciplinary approach with space playing a significant role.

Private sector and public sector involvement is critical as well. Government can provide regulations and rule sets for the economy, but the ability to develop and build large-scale hardware and software is the business of the private sector around the world. Exclusion of private-sector ingenuity and entrepreneurial expertise from the future of space enterprises would be a big mistake.

The ability to build effective partnerships across organizational boundaries can lead to synergistic solutions to some of the most challenging problems.

CONCLUSION

Based on the above review I would emphasize and restate my opening premise as follows: There are enormous opportunities for collaboration on the horizon today, both nationally and internationally. Rising costs, economic priorities, technological and scientific needs, and expanding benefits combine to make collaboration both appealing and necessary. In particular with regard to Earth observing, we must continue to demonstrate that we can work together at the science and technology level as well as the governing political level. We must raise public understanding of the need for investment in space applications to improve the economy in an increasingly globalized system and to build a cooperative international framework for a sustainable future. I do believe that these same tenets apply to space exploration.

To that end, I will close by offering four principles that I believe underpin successful collaborations both nationally and internationally:

- The objective of the collaboration should be clearly relevant to high-priority economic and social needs;
- All parties must work together to create a unified and much larger public voice in support of the mission;
- There must be coherent, realistic planning for the continuity of successful research results to continuous future operations; and
- Success is much more likely when the project is supported by high-level (ministerial) involvement!

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Session 1 Keynote: Governmental Space Cooperation and Competition During and After the Cold War—Lessons Learned

Roger D. Launius
National Air and Space Museum
Smithsonian Institution
Washington, D.C.

INTRODUCTION

In many respects, the history of U.S. cooperation and collaboration in space activities mirrors the larger story of how the United States and its allies have interrelated since the conclusion of World War II. If one were to characterize it accurately throughout the last 50-plus years, the undeniable conclusion is that both parties have enjoyed an uneasy relationship in which they have recognized that they were better off cooperating rather than competing, and in which they constantly jockeyed, even while cooperating, for a superior position vis-à-vis the other nations in partnership. Certainly, that has been the case among senior officials of the United States—many over the years viewing the nation's effort in non-military space activities at a fundamental level as a program aimed, at least in part, at ensuring foreign policy objectives. If securing those objectives required cooperative relations in space, such was most assuredly acceptable and supportable as a national objective.[1]

Having said that, it is important to note that in the first part of the 21st century U.S./European cooperative efforts in space have been overall quite successful. I conclude that, despite the very real difficulties encountered in the various projects undertaken and the many twists and turns in the geopolitical climate. Indeed, the process of collaboration has continued nearly unabated, notwithstanding significant political, cultural, economic, social, and technological changes on both the European and the North American continents. These efforts have survived the rise and fall of the Cold War, budget pressures in the various space-faring nations, questions of national sovereignty, the replacement of ideological with economic competition, and the rise of the global community. Both the United States and their partners in space have learned from each other and advanced the cause of space exploration and use beyond the dreams of all but the most idealistic advocates. Perhaps most important, the decades of cooperative ventures in space have prompted into being a fellowship of scientists, engineers, and managers who have a global vision of spaceflight for the benefit of humanity that is on the verge of full realization.

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[1] A.W. Frutkin, *International Cooperation in Space,* Prentice-Hall, Englewood Cliffs, N.J., 1965; J.M. Logsdon, "U.S.-European cooperation in space science: A 25-year perspective," *Science* 223:11-16, 1984; U.S. Senate, *United States International Space Programs: Texts of Executive Agreements, Memoranda of Understanding, and Other International Arrangements, 1959-1965*, Senate Document No. 44, 89th Congress, 1st session, U.S. Senate Committee on Aeronautical and Space Sciences, July 30, 1965.

COOPERATION IN AN ERA OF COMPETITION

For years the issue of international competition and cooperation in space has dominated much space exploration policy. Indeed, it is impossible to write the history of spaceflight without discussing these themes in detail.[2] The U.S. space exploration program for its first decade and a half was dominated by international rivalry and world prestige, and international relations have remained a powerful shaper of the program ever since. Indeed, all of NASA's human spaceflight projects, from the creation of the agency until the present—the Apollo program, the space shuttle, and the space station—have enjoyed as major reasons for their conduct the furtherance of U.S. foreign-policy goals.

At first there was the Moon race—intensely competitive—in which the two superpowers locked in Cold War struggle sought to outdo each other. No cost seemed too high; no opportunity to "best" the other seemed too slight. The astronauts planted the American flag on the surface of the Moon when the great moment came in 1969, not unlike the Spanish flag planted by Columbus in America, although they did not claim the Moon for their nation. The irony of planting that flag, coupled with the statement that "we came in peace for all mankind," was not lost on the leaders of the Soviet Union who realized that they were not considered in this context a part of the "all mankind" mentioned.

The Cold War context in which the U.S. civil space program arose in 1958 ensured that foreign policy objectives dominated the nature of the activity. This naturally led to the need for cooperative ventures with other nations. The U.S. Congress said as much in the National Aeronautics and Space Act of 1958, the legislation creating the National Aeronautics and Space Administration (NASA). In this chartering legislation, Congress inserted a clause mandating the new space agency to engage in international cooperation with other nations for the betterment of all humankind. This 1958 legislation provided authority for international agreements in the broad range of projects essential for the development of space science and technology in a naturally international field. The United States has a variety of methods for accomplishing such objectives: treaties, executive agreements, agency-to-agency agreements, memoranda of understanding, and letter agreements. NASA's charter provided the widest possible latitude to the agency in undertaking international activities as the means by which the agreed goal could be reached. The scope of NASA's international program has been fortified since that time by repeated involvement with the United Nations, bilateral and multilateral treaties, and a host of less formal international agreements.[3]

But with the successful termination of the Apollo program, everyone realized that the United States was the unquestioned world leader in scientific and technological virtuosity, and continued international competition seemed pointless. Certainly President Richard M. Nixon, who took office in January 1969, made it clear that there would be during his leadership no more Apollo-like space efforts. Couple this with the great desire of those working for a continuation of an aggressive space exploration effort, and the result could only be the search for a new model. While successfully continuing to tie space exploration to foreign relations objectives, now the linkage would be based more on cooperation with allies rather than competition with the nation's Cold War rival. The exploration of space increasingly emphasized visible and exacting international programs. All of the major human spaceflight efforts, and increasingly as time progressed minor projects, have been identified since the 1970s with international partnerships.

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[2] Representative works include Frutkin, *International Cooperation in Space,* 1965; R. Handberg and J. Johnson-Freese, *The Prestige Trap: A Comparative Study of the U.S., European, and Japanese Space Programs,* Kendall/Hunt Publishing Co., Dubuque, Ia., 1994; D.L. Harvey and L.C. Ciccoritti, *U.S.-Soviet Cooperation in Space,* Monographs in International Affairs, Center for Advance International Studies at the University of Miami, Miami, Fla., 1974; J. Johnson-Freese, *Changing Patterns of International Cooperation in Space,* Orbit Books, Malabar, Fla., 1990; R.M. Bonnet and V. Manno, *International Cooperation in Space: The Example of the European Space Agency,* Harvard University Press, Cambridge, Mass., 1994.

[3] J.M. Logsdon, moderator, *The Legislative Origins of the National Aeronautics and Space Act of 1958: Proceedings of an Oral History Workshop,* Monographs in Aerospace History, No. 8, Washington, D.C., 1998, pp. 58-59.

For years such issues have affected the relations of the United States and its partners, as the various national organizations jockey and cajole each other and seek to gain advantage—competitive or otherwise—in space activities. John Krige has explained this issue in the context of the nations involved in the European Space Agency (ESA):

> Any collaborative venture involves a partial loss of sovereignty for a nation. Inevitably, the question arises as to whether the benefits accruing from working with others outweigh the costs. Generally speaking, European governments have four main motives for collaborating scientifically and technologically:
>
> 1. The field of science is worth pursuing.
> 2. The technology developed is of importance for their industry.
> 3. Material need (the savings in human and financial resources deriving from pooling efforts).
> 4. Political advantage.[4]

Such issues have prompted various nations to go their own way in space, notably in ESA's decision in the 1970s not to accept the offer in toto of NASA to cooperate in a post-Apollo human space program.[5]

APOLLO: PRIDE AND PRESTIGE

Central to any discussion of Apollo is its role as an engine of national pride and international prestige for the United States in the context of Cold War rivalries. Prestige, for all of its ubiquitousness in the literature of human spaceflight, is an imprecise term, and it perhaps obscures more than it illuminates. At sum it signifies a demonstration of U.S. superiority. But this superiority has many facets and audiences. It elicits both a "gut-level" reaction and calls for a more sophisticated explication. It is driven by politics of many sorts—international, bureaucratic, and domestic—none of them sufficient on their own to explain the primacy of human spaceflight in American culture, but all complexly intertwined.

Vernon Van Dyke's 1964 book, *Pride and Power: The Rationale of the Space Program* epitomized this perspective, making the case with scholarly detachment that there were only five reasons for the United States to undertake an expansive Moon landing effort.[6] In the words of reviewer John P. Lovell,

> Van Dyke classifies these reasons as "military security," "peace," "progress in science and technology," "economic and social benefits," and "national prestige." Without impugning the sincerity of those who profess such rationales, Van Dyke marshals convincing evidence in support of the thesis that "national pride" has served as the goal value most central to the motivation of those who have given the space program its major impetus.[7]

Although his research is certainly dated, Van Dyke's conclusions hold up surprisingly well after the passage of more than 40 years. At a fundamental level U.S. presidents have consciously used these

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[4] J. Krige, "The politics of European collaboration in space," *Space Times: Magazine of the American Astronautical Society* 36(September-October):4-9, 1997, p. 4.

[5] L. Sebesta, "The politics of technological cooperation in space: U.S.-European negotiations on the post-Apollo programme," *History and Technology: An International Journal* 11:317-341, 1994; R.D. Launius, "NASA, the space shuttle, and the quest for primacy in space in an era of increasing international competition," pp. 35-61 in *L'Ambition Technologique: Naissance d-Ariane,* E. Chadeau, ed., Institute d-Histoire de l'Industrie, Paris, France, 1995.

[6] V. Van Dyke, *Pride and Power: The Rationale of the Space Program,* University of Illinois Press, Urbana, Ill., 1964.

[7] J.P. Lovell, "Review of *Pride and Power: The Rationale of the Space Program,*" in *Midwest Journal of Political Science* 9:118-120, 1965, p. 119.

activities as a symbol of national excellence to enhance the prestige of the United States throughout the world.[8]

There may well be four distinct attributes of the pride and prestige issue in Apollo, as follows:

- Prestige on the international stage—using Apollo as a means for enhancing the attitudes of others towards the United States;
- Pride at the national level—drawing the nation and its many peoples, priorities, and perspectives together;
- Defining national identity—offering important ingredients into the national narrative celebrating exceptionalism among all else in the world; and
- Embracing the idea of progress—using the Apollo program as a symbol for U.S. forward-thinking.

This application of prestige is a classic application of what analysts often refer to as "soft power." Coined by Harvard University professor Joseph Nye, the term gave a name to an alternative to threats and other forms of "hard power" in international relations.[9] As Nye contends:

> Soft power is the ability to get what you want by attracting and persuading others to adopt your goals. It differs from hard power, the ability to use the carrots and sticks of economic and military might to make others follow your will. Both hard and soft power are important . . . but attraction is much cheaper than coercion, and an asset that needs to be nourished.[10]

In essence, such activities as Apollo represented a form of soft power—the ability to influence other nations through intangibles such as an impressive show of technological capability. It granted to the nation achieving it first an authenticity and gravitas not previously enjoyed among the world community. At sum, this was an argument buttressing the role of spaceflight as a means of enhancing prestige on the world stage.

There is no question that the Apollo program in particular, but also all of the human spaceflight efforts of the United States, was firstly about establishing U.S. primacy in technology. Apollo served as a surrogate for war, challenging the Soviet Union head-on in a demonstration of technological virtuosity. The desire to win international support for the "American way" became the raison d'etre for the Apollo program, and it served that purpose far better than anyone imagined when the program was first envisioned. Apollo became first and foremost a Cold War initiative and aided in demonstrating the mastery of the United States before the world. This may be seen in a succession of Gallup polls conducted during the 1960s in which the question was asked: "Is the Soviet Union ahead of the U.S. in Space?" Until the middle part of the decade, about the time that the Gemini program began to demonstrate U.S. prowess in space, the answer was always that the United States trailed the Soviets. At the height of the Apollo Moon landings, world opinion had shifted overwhelmingly in favor of the United States.[11] The importance of Apollo as an instrument of U.S. foreign policy—which is not necessarily identical with national prestige and geopolitics but is closely allied—should not be overlooked in this discussion. It served, and continues to do so, as an instrument for projecting the image of a positive, open, dynamic American society abroad.

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[8] See R.D. Launius and H.E. McCurdy, eds., *Spaceflight and the Myth of Presidential Leadership*, University of Illinois Press, Urbana, Ill., 1997, especially Chapters 2, 3, 6, and 7.

[9] The term was coined in J.S. Nye, *Bound to Lead: The Changing Nature of American Power,* Basic Books, New York, N.Y., 1990. See also J.S. Nye, *Soft Power: The Means to Success in World Politics,* PublicAffairs, New York, N.Y., 2004.

[10] J.S. Nye, "Propaganda isn't the way: Soft power," *The International Herald Tribune*, January 10, 2003.

[11] Gallup polls on October 1, 1957; August 1, 1958; December 1, 1959; December 1, 1960; May 1, 1961; August 1, 1962; February 1, 1963; June 1, 1963; May 1, 1964; June 1, 1965; July 1, 1969; and May 1, 1971.

OBJECTIVES OF U.S. COOPERATIVE SPACE VENTURES IN THE COLD WAR

The central question for the United States has always been how best to use space exploration as a meaningful foreign-policy instrument, and at times an odd assemblage of political, economic, and scientific/technological objectives emerged to guide the development of international programs. First, there were the overarching geopolitical considerations—without them there would have been no space exploration program at all, much less a cooperative effort. Four unified features have informed this political decision to cooperate in space projects with European nations. Cooperative projects in space:

- Create a positive image of the United States in the international setting. In the early years of the space age this was very much related to the larger battle to "win the hearts and minds" of the world to the democratic/capitalistic agenda. More recently it has been mobilized to help ensure continued good will between the United States and the European community.[12]
- Encourage both European unity and U.S. relations to collective European entities.[13]
- Reinforce the perception of U.S. openness to outside nations and collective organizations. This was especially important during the Cold War when American openness could be juxtaposed to Soviet secrecy.[14]
- Expand the use of space technology as a tool of diplomacy to serve broader foreign-policy goals for the United States.

Equally important, the United States pursued two overarching economic objectives with its cooperative space efforts. First, cooperative projects expanded the investment for any space project beyond that committed by the United States. Kenneth S. Pedersen, NASA director of international programs in the early 1980s, opined that "by sharing leadership for exploring the heavens with other qualified space-faring nations, NASA stretches its own resources and is free to pursue projects which, in the absence of such sharing and cooperation, might not be initiated."[15] Second, cooperative projects might help to improve the balance of trade by creating new markets for U.S. aerospace products.[16]

Finally, there is a set of important scientific and technological objectives that have motivated the United States' international cooperative efforts in space. In this context cooperation:

- Enhances the intellectual horsepower applied to any scientific question, thereby increasing the likelihood of reaching fuller understanding in less time.
- Helps to shape European space projects along lines compatible with U.S. efforts and limits European efforts in space that are competitive with U.S. efforts.
- Encourages the development of complementary but different experiments from European scientists.
- Ensures that multiple investigators throughout the international partnership make observations contributing toward a single objective.[17]

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[12] Frutkin, *International Cooperation in Space*, 1965, p. 73; H.E. McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice*, The Johns Hopkins University Press, Baltimore, Md., 1990, p. 101.

[13] Frutkin, *International Cooperation in Space*, 1965, p. 78.

[14] A.W. Frutkin, NASA's associate administrator for international programs for many years, made the observation that "when NASA was organized . . . the keystone of Government space policy was to give dramatic substance to the claim of openness—and, at the same time, to seek credibility for the nation's assertion that it entered space for peaceful, scientific purposes. This was done . . . most importantly, by inviting foreign scientists to participate extensively and substantively in space projects themselves" (A.W. Frutkin, *IEEE Spectrum* 20(9):70, 1983).

[15] K.S. Pedersen, testimony to Senate Subcommittee on Science, Technology, and Space, March 18, 1982, NASA Historical Reference Collection, NASA History Division, Washington, D.C.

[16] S.M. Shaffer and L.R. Shaffer, *The Politics of International Cooperation: A Comparison of U.S. Experience in Space and Security,* University of Denver, Graduate School of International Relations, Denver, Colo., 1980, p. 17.

[17] *Ibid*., pp. 17 and 50; Logsdon, "U.S.-European cooperation in space science," 1984, p. 13.

In light of these macro-national priorities, NASA has always wrestled with how best to implement the broad international prospects mandated in legislation and polity. NASA leaders developed very early a set of essential features that have guided the agency's international arrangements with European partners. These features remained in place until the partnership to build the International Space Station (ISS) in the early 1990s:

- Cooperation is undertaken on a project-by-project basis, not on an on-going basis for a specific discipline, general effort, and so on.
- Each cooperative project must be both mutually beneficial and scientifically valid.
- Scientific/technical agreement must precede any political commitment.
- Funds transfers will not take place between partners, but each will be responsible for its own contribution to the project.
- All partners will carry out their part of the project without technical or managerial expertise provided by the other.
- Scientific data will be made available to researchers of all nations involved in the project for early analysis.[18]

From the point of view of U.S. leaders, moreover, cooperative projects offered two very significant advantages to the agency in the national political arena. First, at least by the time of the lunar landings, they recognized that every international partnership brought greater legitimacy to the overall project. This important fact was not lost on NASA administrator Thomas O. Paine in 1970, for instance, when he was seeking outside sponsorship of the space shuttle program and negotiating international agreements for parts of the effort.[19]

Second, although far from being a coldly-calculating move, agreements with foreign nations could also help to insulate space projects from drastic budgetary and political changes. U.S. politics, as notoriously rambunctious and short-sighted—looking not much beyond the next scheduled election—as it is, is also enormously pragmatic. Dealing with what might be a serious international incident resulting from some technological program change is something neither U.S. diplomats nor politicians relish, and that fact could be the difference between letting the project continue as previously agreed on or dickering with it in Congress and thereby changing funding, schedule, or other factors in response to short-term political or budgetary needs. The international partners, then, could be a stabilizing factor for any space project, in essence a bulwark to weather difficult domestic storms.[20]

Perhaps Fritjof Capra's representative definition of a social paradigm is appropriate when considering the requirements for space projects in the United States in the aftermath of the Apollo Moon landings. While Apollo had been an enormous success from a geopolitical and technological standpoint, NASA had to contend with a new set of domestic political realities for its projects thereafter, and a radical alteration had taken place in the "constellation of concepts, values, perceptions and practices shared by a community, which forms a particular vision of reality that is the basis of the way the community organizes itself."[21] International cooperative projects helped NASA to cope with that changing social paradigm.

[18] S.M. Shaffer and L.R. Shaffer, *Politics of International Cooperation,* 1980, p. 18.

[19] A. Galloway, "Does the space shuttle need military backing?" *Interavia* 27:1327-1331, 1972; R. Gillette, "Space shuttle: A giant step for NASA and the military?" *Science* 171:991-993, 1971.

[20] This has clearly been the case with the Space Station *Freedom* program of the 1980s. See J.M. Logsdon, *Together in Orbit: The Origins of International Participation in Space Station Freedom,* NASA Contractor Report 4237, Washington, D.C., 1991.

[21] F. Capra, "Paradigms and paradigm shifts," *ReVision* 9(Summer/Fall):11, 1986. Capra's definition was closely related to T.S. Kuhn, *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago, Ill., 1970, especially pp. 175ff.

POST-COLD WAR ISSUES FOR U.S. INTERNATIONAL SPACE COOPERATION

In the 1990s the United States collaborative space policy entered an extended period of transition from the earlier era of Cold War, one in which NASA has been compelled to deal with international partners on a much more even footing than ever before. This was true for several reasons. U.S. preeminence in space technology was coming to an end as ESA developed and made operational its superb Ariane launcher, and other nations developed ancillary space capabilities that made it increasingly possible for them to "go it alone."[22] U.S. commitment to sustained "preeminence" in space activities also waned and significantly less public monies went into NASA missions.[23] U.S. political commitment to cooperative projects seemingly waned as well. The United States refrained from developing a probe for the international armada of spacecraft that were launched toward Comet Halley and withdrew support from the controversial International Solar-Polar Mission.[24]

Of those cooperative projects that remained, NASA increasingly acceded to the demands of collaborators to develop critical systems and technologies. This overturned the policy of not allowing partners onto the critical path, something that had been flirted with but not accepted in the shuttle development project. This was in large measure a pragmatic decision on the part of U.S. officials. Because of the increasing size and complexity of projects, according to Kenneth Pedersen, more recent projects have produced "numerous critical paths whose upkeep costs alone will defeat U.S. efforts to control and supply them." He added, "It seems unrealistic today to believe that other nations possessing advanced technical capabilities and harboring their own economic competitiveness objectives will be amenable to funding and developing only ancillary systems."[25]

In addition to these important developments, the rise of competitive economic activities in space has mitigated the prospects for future collaborations. The brutal competition for launch business, the cutthroat nature of space applications, and the rich possibilities for space-based economic activities have created a climate in which international ventures may once again become the exception.[26] John Krige astutely commented of late that "collaboration has worked most smoothly when the science or technology concerned is not of direct strategic (used here to mean commercial or military) importance. As soon as a government feels that its national interests are directly involved in a field of R&D, it would prefer to go it alone." He also noted that the success of cooperative projects may take as their central characteristic that they have "no practical application in at least the short to medium term."[27] I would add that the sole exception to this perspective might be when nations decide that for prestige or diplomatic purposes it is appropriate to cooperate in space.[28]

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[22] Sebesta, "The politics of technological cooperation in space," 1994, pp. 317-341.

[23] W.J. Clinton, "National Space Policy," September 29, 1996, NASA Historical Reference Collection.

[24] J.M. Logsdon, "International cooperation in the space station programme: Assessing the experience to date," *Space Policy* 7:35-45, 1991; W.D. Kay, "Where no nation has gone before: Domestic politics and the first international space science mission," *Journal of Policy History* 5:435-452, 1993; J. Johnson-Freese, "From Halley's Comet to solar terrestrial science: The evolution of the Inter-Agency Consultative Group," *Space Policy* 8:245-255, 1992; J.M. Logsdon, "Missing Halley's Comet: The politics of big science," *Isis* 80:268-270, 1989.

[25] K.S. Pedersen, "Thoughts on international space cooperation and interests in the post-Cold War world," *Space Policy* 8:217, 1992.

[26] See R. Handberg, *International Space Commerce: Building from Scratch*, University Press of Florida, Gainesville, Fla., 2006.

[27] Krige, "The politics of European collaboration in space," 1997, p. 6.

[28] A superb example of this is the effort beginning in 1997 to shift U.S. launch operations to the private sector by contracting out the majority of activities at NASA Kennedy Space Center to the USA Corporation. For an excellent account of the process whereby commercial activities were initiated, see W.D. Kay, "Space policy redefined: The Reagan administration and the commercialization of space," *Business and Economic History* 27(Fall):237-247, 1998.

INTERNATIONAL SPACE COOPERATION AND THE CLASH OF CIVILIZATIONS

Perhaps the hardest part of spaceflight is not the scientific and technological challenges of operating in an exceptionally foreign and hostile environment but in the down-to-Earth environment of rough-and-tumble international and domestic politics. But even so, cooperative space endeavors have been richly rewarding and overwhelmingly useful from all manner of scientific, technical, social, and political perspectives. Just as surely as the Apollo program helped the United States from a foreign policy standpoint, so too have the many international collaborations in space activities in the post-Cold War world.[29]

With international tensions remaining, even as the Cold War ended, collaborative space ventures may prove just as important in the quest to maintain U.S. hegemony—political, technological, and economic—in the world as Apollo had been at the height of the Cold War. Since the collapse of the Soviet Union a different set of priorities has replaced the powerful secular ideologies of democracy, communism, nationalism, fascism, and socialism that dominated international politics since the Enlightenment. These were not so much new priorities as ancient traditions based on ethnic, religious, kinship, or tribal loyalties that reemerged full-blown in the 1990s as all the great ideologies, save democracy, collapsed worldwide—and even democracy was none too stable outside the West.[30]

Harvard political scientist Samuel P. Huntington developed a powerful thesis to explain what has happened in the world since the collapse of the Soviet Union and the end of a bipolar world. The thrust of Huntington's argument rejects the notion that the world will inevitably succumb to Western values. On the contrary, Huntington contends that the West's influence in the world is waning because of growing resistance to its values and the reassertion by non-Westerners of their own cultures. He argues that the world will see in the 21st century an increasing threat of violence arising from renewed conflicts among countries and cultures basing their identities on long-held traditions. This argument moves past the notion of ethnicity to examine the growing influence of a handful of major cultures—Western, Orthodox, Latin American, Islamic, Japanese, Chinese, Hindu, and African—in current struggles across the globe. In so doing, Huntington successfully shifts the discussion of the post-Cold War world from ideology, ethnicity, politics, and economics to culture—especially to the religious basis of culture. Huntington rightly warns against facile generalizations about the world becoming one, so common in the 1990s, and points out the resilience of civilizations to foreign secular influences.[31]

In the clash of civilizations of the 21st century, such collaborative ventures as the ISS offer a test-bed for civilizational alliances. At some level this has already begun. From the beginning the West adopted the ISS project and brought in a second great civilization in Japan. In 1993 the Orthodox civilization, using Huntington's terminology for Russia and other Slavic peoples, joined the program. Perhaps the difficulty of working with the Russians has been largely the result of these strikingly different civilizations. Brazil and other nations of the Latin American civilization also want to join the program, as does India. China has also made overtures about the desire to become a part of the effort. Despite the very

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[29] R.D. Launius, "Perceptions of Apollo: Myth, nostalgia, memory or all of the above?" *Space Policy* 21:129-139, 2005.

[30] On the reorientation of world politics in the 1990s, see J.L. Gaddis, "Toward the post-Cold War world," *Foreign Affairs* 70(Spring):101-114, 1991; J. Goldstein and R. O Keohane, eds., *Ideas and Foreign Policy: Beliefs, Institutions, and Political Change,* Cornell University Press, Ithaca, N.Y., 1993; F. Fucayama, "The end of history," *The National Interest* 16(Summer):3-18, 1989; M. Singer and A. Wildavsky, *The Real World Order: Zones of Peace, Zones of Turmoil,* Chatham House, Chatham, N.J., 1993; J.M. Goldgeier and M. McFaul, "A tale of two worlds: Core and periphery in the post-Cold War era," *International Organization* 46(Spring):467-491, 1992; K.N. Waltz, "The emerging structure of international politics," *International Security* 18(Fall):44-79, 1993; Z. Brzezinski, *Out of Control: Global Turmoil on the Eave of the Twenty-first Century,* Scribner, New York, 1993; D.P. Moynihan, *Pandemonium: Ethnicity in International Politics,* Oxford University Press, New York, 1993; W.S. Lind, "North–South relations: Returning to a world of cultures in conflict," *Current World Leaders* 35:1073-1080, 1993; D.J. Puchala, "The history of the future of international relations," *Ethics and International Affairs* 8:177-202, 1994.

[31] This provocative thesis is illuminated in S.P. Huntington, *The Clash of Civilizations and the Remaking of World Order,* Simon and Schuster, New York, N.Y., 1997.

real challenges that would result from incorporating these new partners into a collaborative space program, their inclusion would advance the cause of creating alliances with other civilizations. This could serve ultimately as a means of closing the gap between nations rather than widening it. At a fundamental level, space collaborations could serve the larger objectives of U.S. foreign policy better than many other initiatives that offer fewer prospects for success.[32]

All the promise held out for spaceflight in gaining scientific knowledge, advancing technology, and creating a hopeful future through exploration of the solar system may well pale in comparison to the very real possibility of enhancing cross-civilizational relations through this one act of working together to tackle an enormous challenge. The same may be true of the very real costs involved; it is a small price to pay for better international relations, and spending a larger share of the public treasury for the space exploration is eminently better than spending it for weapons of destruction. For all the difficulties involved in working with a large group of international partners, the knowledge gained in large-scale cooperative programs will serve the United States and the West well in the inter-civilizational rivalries of the 21st century.

CONCLUSIONS

One of the key conclusions that we might reach about both the course of international cooperation between the United States and its international collaborators in space is that it has been an enormously difficult process. I am reminded of the quote from Wernher von Braun, "We can lick gravity, but sometimes the paperwork is overwhelming."[33] Even so, cooperative space endeavors have been richly rewarding and overwhelmingly useful, from all manner of scientific, technical, social, and political perspectives. Kenneth Pedersen observed in 1983, "International space cooperation is not a charitable enterprise; countries cooperate because they judge it in their interest to do so."[34] For continued cooperative efforts in space to proceed into the 21st century it is imperative that those desiring them define appropriate projects and ensure that sufficient national leaders judge them as being of interest and worthy of making them cooperative.

The past 50 years have provided a wealth of experience in how to define, gain approval for, and execute the simplest of cooperative projects. Even those have been conducted only with much trial and considerable force of will. For those involved in space exploration in both the United States and other nations it is imperative that a coordinated approach to project definition, planning, funding, and conduct of future missions be undertaken. Only then will we be able to review the history of our international programs and speak with pride about all of their many accomplishments while omitting the huge "but" that must follow as we consider all of the challenges encountered in space cooperation.

[32] Ibid., pp. 266-98; *Voice of America News,* "China publishes plans for space exploration," November 22, 2000; M. Boucher, "Shenzhou 2 launch imminent, Chinese manned space program targets the Moon," October 30, 2000; People's Republic of China, The Information Office of the State Council, "China's space activities," November 22, 2000, all available in NASA's Historical Reference Collection.

[33] A.S. Levine, *Managing NASA in the Apollo Era*, NASA SP-4102, Washington, D.C., 1982, p. v.

[34] K.S. Pedersen, "International Aspects of Commercial Space Activities," speech to Princeton Conference on Space Manufacturing," May 1983, NASA Historical Reference Collection.