Chapter 3

Cooperation in the Space Sciences: The Scientific View

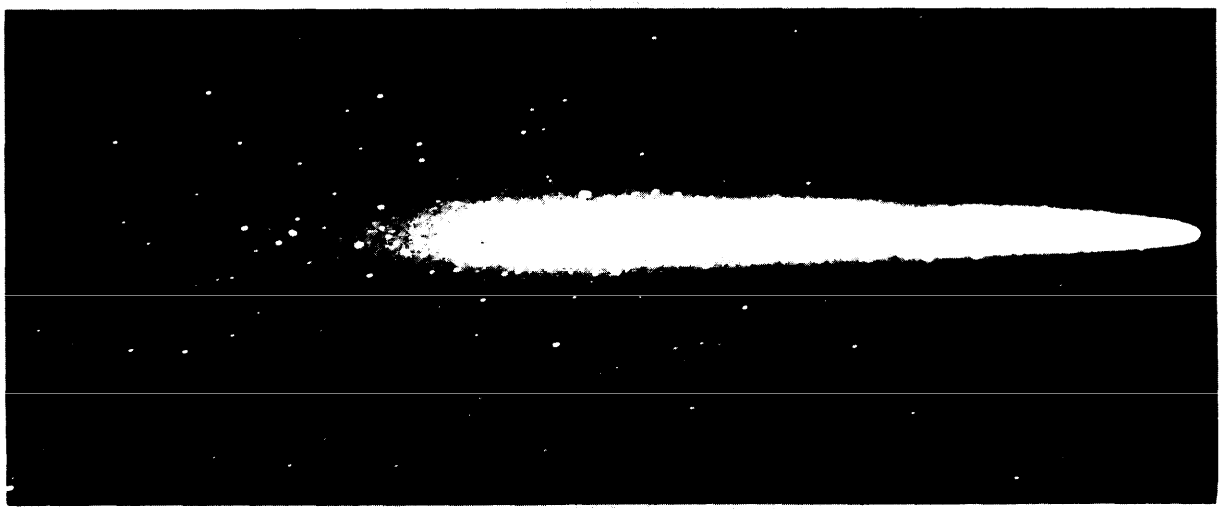


Photo credit: National Air and Space Museum

Halley's Comet, 1910

Chapter 3

Cooperation in the Space Sciences: The Scientific View

INTRODUCTION

As the preceding chapter illustrates, U.S.-Soviet cooperation in space involves a complex, often conflicting mixture of political, scientific, and military issues. These all have a bearing on whether one believes that U.S.-Soviet space cooperation should be pursued and, if so, on the types of projects most appropriate for such activity. These issues and the trade-offs among them are discussed in chapter 5.

In order to clarify some of the specifically scientific and technical issues surrounding cooperation, OTA held a workshop in May 1984 on potential areas for U.S.-Soviet cooperation in the space sciences. Since planetary research and the life sciences are considered the most successful areas of past space cooperation, 13 scientists previously and/or presently involved in cooperative programs with the U.S.S.R. discussed the costs and benefits of past U.S.-Soviet cooperation in the planetary and life sciences and potential areas of such cooperation for the future.

This chapter presents the findings of this workshop in evaluating past and potential U.S.-Soviet space cooperation from a scientific point of view. As illustrated in chapter 2, congressional testimony and other forums have provided evaluations of individual U.S.-Soviet cooperative projects in the past, [1] and several areas outside of the space sciences have been suggested as potentially promising for U, S.-Soviet cooperation for the future, These range from the joint simulated space rescue mission called for in Public Law 98-562 to joint efforts in near-Earth scientific stations, lunar bases, and trips to asteroids, Mars, or the moons of Jupiter. In the area of space applications, COSPAS/SARSAT has been viewed as a successful paradigm which could be used for other types of activities, such as improvements in meteorological coverage, disaster warning systems, and educational satellite telecommunications. OTA discussions with representatives from Third World countries to the United Nations in May 1984 suggested that U, S.-Soviet cooperative efforts, especially in such areas as developing a worldwide disaster warning system, would have some modicum of international support.

The purpose of this chapter is not to evaluate these or other potential cooperative projects, nor is it to make specific recommendations. Instead, the workshop was intended to focus on one area—space science—which has been regarded as a viable area for cooperation in the past, and may well be among the most valuable for the future. By focusing on one broad area, the workshop was designed to highlight the scientific advantages and disadvantages of cooperation with the U.S.S.R. which may be applicable to other areas as well.

[1] See, for example, Joseph G. Whelan, "Soviet Attitude Toward International Cooperation in Space, " in Congressional Research Service, *Soviet Space Programs: 1976 -1980*, prepared for the Senate Committee on Commerce, Science, and Transportation (Washington, DC: U.S. Government Printing Office, 1982), pp. 221 -260: ***East-West Cooperation in Outer Space***, hearings before the Senate Committee on Foreign Relations, Sept. 13, 1984 (Washington, DC: U.S. Government Printing Office, 1984).

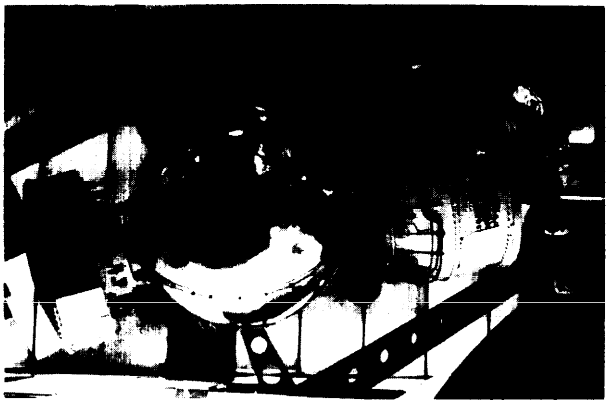
PAST U.S.-SOVIET COOPERATION IN THE SPACE SCIENCES

Two **primary areas of scientific cooperation under the 1972/77 agreement[2] examined in** OTA'S workshop were in: 1) space biology and medicine, and 2) near-Earth space, the Moon, and the planets. Both of these areas of cooperation were regarded as having contributed to scientific knowledge in a way U.S. scientists could not have done alone, although the interchange was not without problems.

Participants viewed the life sciences area as the more substantive and successful, especially in three areas. First was the exchange of flight experimental data regarding human response to spaceflight conditions. Because of the emphasis on extended manned spaceflight in the Soviet space program, of greatest value here were Soviet data on the effects of long-duration flight on bone loss and cardiovascular deconditioning— problems that continue to be of significant concern for manned spaceflight. Data exchanges in this area were particularly valued by U.S. scientists because the Soviets had, in Salyut, the opportunity to conduct an extensive program of repeatable experiments on the response of human beings to long-term stays in space. The U.S. space program had no manned spaceflight from the Apollo-Soyuz Test Project (ASTP) in 1975 to the first Shuttle launch in 1981.

The second area of especially fruitful cooperation was considered to be joint ground-based simulations of spaceflight conditions. For example, participants cited the long-term bed rest studies as a useful example of such joint simulations, and noted that useful joint symposia were held on vestibular problems (1980) and on cardiovascular changes resulting from spaceflight (1981).

Finally, U.S.-Soviet space cooperation has also involved a good deal of animal (biological) research. The joint U.S.-Soviet three-volume work on space biology and medicine,[3] in progress for more than a decade, was published in 1975, and scientific experiments conducted aboard ASTP provided interesting biological data. Perhaps most importantly, the Soviet Cosmos series biosatellites have provided U.S. investigators with a number of opportunities to fly experiments designed to investigate basic biological processes in space, and to exchange information on a range of problems in space biology. The first of several such flight opportunities came in 1975 when the Soviet Union launched Cosmos **782,** a "biosatellite" mission carrying 11 U.S. space biology experiments. Subsequently, in 1977, Cosmos 936 was launched carrying 7 U.S. biological experiments; in 1978, Cosmos 1129 carried 14 U.S. biological experiments; and in 1983, Cosmos 1514 was launched carrying 4 additional U.S. biological experiments. According to workshop participants, American experiments have generally been self-contained and delivered to Moscow by U.S. specialists who provide information on how to care for the package until the time of launch. U.S. experimenters have not been allowed at launch or recovery sites, but according to workshop participants, the Soviets have sometimes been quite helpful in other ways, such as in one case allowing an American experiment to fly overweight.



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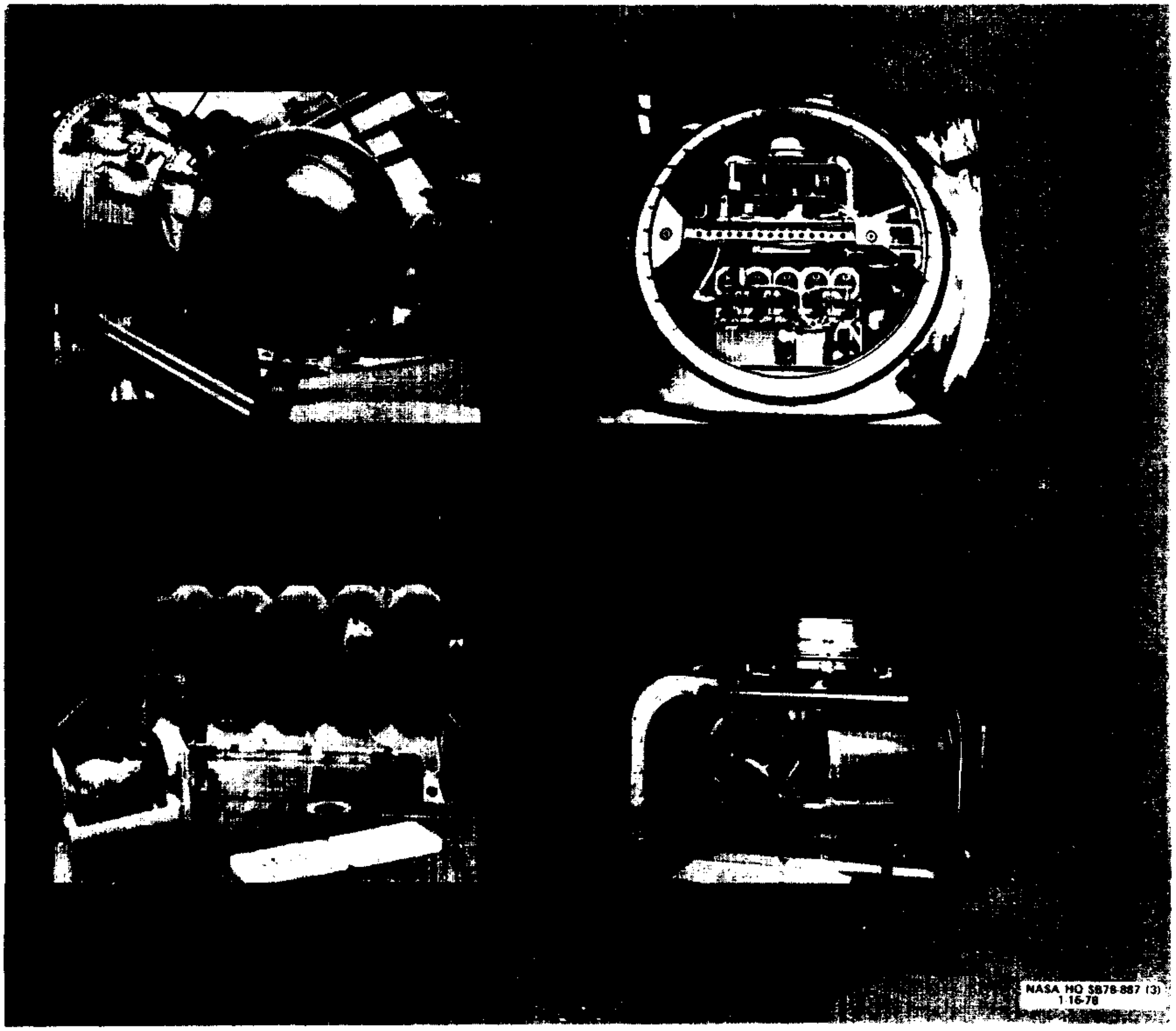
'The Agreement Between the United States of America and the Union of Soviet Socialist Republics Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes, signed in May *1972* and renewed in May 1977.

[3]*Foundations of Space Biology and Medicine,* edited by Melvin Calvin (U. S. A.) and Oleg G. Gazenko (U.S.S.R.), a joint U. S.-U.S.S.R. publication in three volumes (Washington, DC: Scientific and Technical Information Office, National Aeronautics and Space Administration, 197s).



The workshop scientists involved in these and other exchanges believe that the overall success of the collaboration in life sciences can be attributed to several factors:

- a focus on well-defined and specific scientific objectives;
- the selection of areas of complementary capability, providing strong motivation to cooperate;
- the fact that required instrumentation was not generally of a type raising concerns of technology transfer;
- an institutional organization that granted officials on both sides the autonomy to decide on the implementation of plans; and
- the development of mutual confidence, knowledge, and goals among working groups over a long period of cooperation.

In the planetary category, workshop participants identified the strongest areas of cooperation as lunar studies, the exploration of Venus, and solar-terrestrial physics. The exchange of lunar samples and cartographic data provided both sides with a range of information unobtainable

by either program on its own. Although the Soviets shared few significant data from their Mars missions in the early 1970s (possibly due to failures of spacecraft, resulting in little data to be exchanged), the cooperation in the late 1970s and early 1980s between Soviet scientists in the Venera program and U.S. investigators in the Pioneer Venus program was substantial; it extended to the use of Pioneer Venus data to select Venera landing sites and to attempts to intercalibrate instruments. Soviet data from the 1975 Venera landings on Venus were transmitted promptly, providing several surprises regarding the nature of the Venusian surface. The U.S. Pioneer mission to Venus in **1978** profited from details about the Soviet program that would not have been available without the agreement.[4]

[4] *Technology Transfer and Scientific Cooperation Between the United States and the Soviet Union: A* Review, prepared for U.S. Congress, House Committee on International Relations, Subcommittee on International Security and Scientific Affairs (Washington, DC: U.S. Government Printing Office, 1977), pp. 117-118.

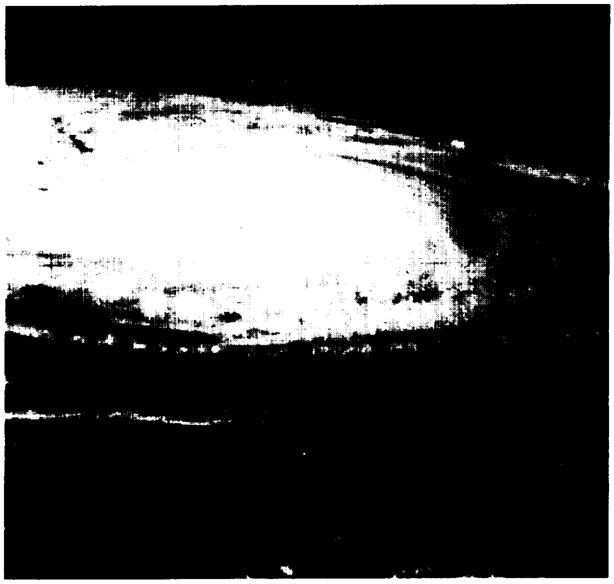
In other areas, data were exchanged on solar-wind phenomena and magnetospheric plasma physics. In the solar-terrestrial area, for example, exchanges of solar wind data obtained by Soviet Prognoz and the International Sun-Earth Explorer (ISEE) spacecraft, developed jointly by the United States and ESA, have been valuable because of differing spacecraft design characteristics. U.S. magnetospheric plasma physics research in space has benefited from cooperation between the two countries in controlled thermonuclear research. Overall, workshop participants noted an evolution toward greater openness in the Soviet planetary program over the past decade.

Finally, workshop participants noted a significant amount of cooperation in astrophysics experiments utilizing detectors mounted on a variety of spacecraft, including Venera and Pioneer Venus, Prognoz, and ISEE. The objective of these experiments was the precise location of gamma-ray bursts by means of simultaneous observations from widely separated spacecraft, with cooperative analysis of resulting data.

Photo credit National Aeronautics and Space Adrninistration

Panoramic views of surface of Mars, from the American Viking spacecraft, and of surface of Venus, from the Soviet Venera spacecraft

The workshop scientists involved in these exchanges believe that cooperation started out slowly but eventually became quite fruitful. Particularly with regard to Venus, the United States gained at least as much information as it provided. However, the interaction in the planetary and solar-terrestrial areas was not as consistently smooth as in the life sciences. There were significant difficulties in acquiring information on mission plans, and in obtaining accurate and complete scientific data. These problems varied in severity through time and across different fields. But workshop scientists believed that the situation was improving noticeably, with regard to both openness and data quality, when the intergovernmental agreement expired in 1982. At that time, U.S. scientists were for the first time being taken into Soviet laboratories and shown instruments, performance data, etc.



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SCIENTIFIC BASIS FOR FUTURE COOPERATION

Workshop discussions resulted in a number of general observations and specific recommendations regarding the content and possible mechanisms for future U. S .-Soviet cooperation in space,

One point of consensus was that such cooperation must be scientifically substantive, with clear scientific objectives, in order to be successful. The Soviet Union has enough to offer scientifically, participants argued, that cooperation for purely political reasons is not, in their view, an adequate rationale for U.S. participation. Areas of complementarily, they stressed—such as that represented by American orbital capability and Soviet lander capability—must be found so that cooperation will be mutually beneficial on a scientific and technical level.

Participants agreed that the simplest levels of exchange—joint discussions, cooperative data analyses, and joint planning of separate missions—would be the most workable. Hosted U.S. experiments on Soviet spacecraft (as well as the reverse) were also viewed as practicable, although it was emphasized that official U, S. concerns about technology transfer have introduced considerable complexity into some of these interactions. Participants agreed that the introduction~ of hardware into the exchange would invariably be a complicating factor. The difficulty of working together would reach its highest point, they said, in the case of full-scale joint missions, where both hardware and many layers of official participation would be involved.

Based on past successes in planetary, solar-terrestrial, and astrophysics areas of cooperation, it was suggested that should future cooperation be pursued, the concept of coordination and tracking of separate spacecraft be added to joint mission planning. The advantage of this would be to maximize scientific return while minimizing problems of hardware exchange and technology transfer. A second recommendation was to include U.S.-Soviet co-investigators within the framework of cooperation.

Finally, participants also addressed the question of which new areas of scientific exchange currently hold promise for U. S .-Soviet cooperation. The workshop itself represented a somewhat different breakdown of disciplines than the categories included under the previous agreement. Most notably, astrophysics and heliospheric studies were broken out as separate disciplinary groups. One promising new area was regarded as the field of “global habitability, ” which includes a wide range of integrated Earth environmental observations. The vast size of the Soviet Union makes that country’s participation in this field especially important.

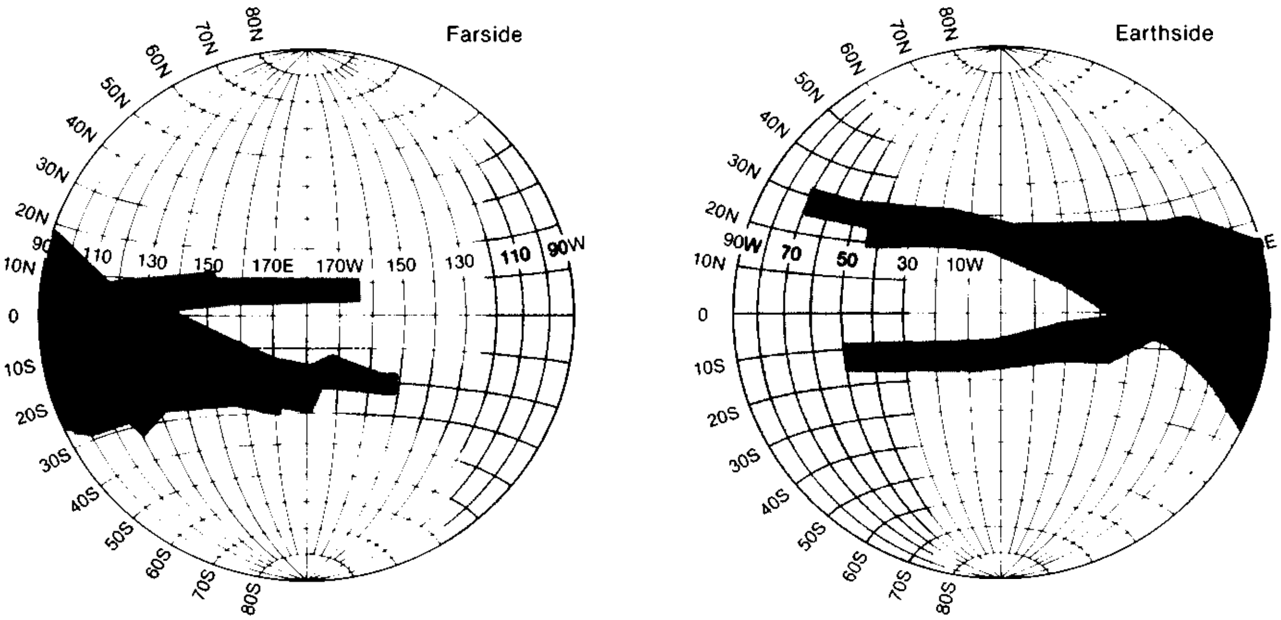
In the life sciences area, the field of exobiology (i.e., nonterrestrial biology and biochemistry) was viewed as one promising area for future cooperation. Workshop participants believed that studies in this area might include search for extraterrestrial intelligence (SETI), or joint collection and analysis of Antarctic meteorites. Global biology would be an important aspect of the global habitability studies just described. Another suggestion was the joint demonstration and testing of advanced life support systems, including those of the “closed,” or bioregenerative, type.

In solar-terrestrial physics, workshop participants noted a complementarily in American and Soviet research plans, suggesting that mission coordination and data exchange would yield substantial scientific benefits for both countries. Integration of Soviet data into the online data processing and exchange program now being developed for the International Solar-Terrestrial Physics Program, they believed, would be especially valuable.

Astrophysics, the participants also noted, offers several promising opportunities for complementary and mutually advantageous cooperation. In the radio area, they believed that joint missions in very long baseline interferometry (VLBI) could be undertaken using independent U.S. and Soviet spacecraft, with collaborative planning for the orbits and frequencies to be used. They suggested that U,S, Spacelab experiments involving large-scale equipment such as X-ray detectors of large collecting area could be reflown on the Salyut for long-term exposure. In the first example, two essentially free-standing missions enhance one an-

Figure 3-1 .—Photographic Coverage of the U.S. Apollo and Soviet Zond Spacecraft (example of informal information exchange between U.S. and Soviet scientists)

Coverage of Apoflo and Zond Mapping Pictures



Soviet Zond photographic coverage   U.S. Apollo photographic coverage

Note Base map courtesy of National Geographic Society

SOURCE Merton Dawes

Photo credit National Aeronautics and Space Adrninistration

The Moon

other by proper coordination and planning; in the second, the scientific potential of expensive experiments is realized more fully by a longer time for making observations in orbit.

Possibilities for cooperative ventures in the planetary field, participants underlined, are numerous, including: lunar geochemical orbiters, continued lunar sample exchange, joint Venus missions (studies of the atmosphere as well as long-lived surface missions); coordination of separate Mars missions or even a joint Mars sample return mission; comet rendezvous and sample return; and outer planet exploration.

A final concern was the relative merit of continuing low-level exchange, as against initiating a high-visibility “spectacular,” such as a joint Mars sample return or a joint “Starprobe” mission to the Sun. Workshop participants stressed that large-scale missions would have little lasting sig-

Box 3B.—Nongovernmental Initiatives for U.S.-Soviet Space Cooperation

Quite apart from other issues affecting U.S.-Soviet cooperation in space, the scientific benefits of such cooperation have been viewed as positive in many disciplines. Despite the lapsing of the bilateral U.S.-Soviet agreement in 1982, a number of initiatives have been taken by U.S. scientists and nongovernmental institutions to sustain or expand certain U.S.-Soviet cooperative efforts.

Because of the complementarily of lunar data from the Soviet Zond and U.S. Apollo missions, for example, one scientist has received lunar data and photographs from Moscow, and is pursuing the possibility of joint U.S.-Soviet analysis to determine the geodetic control network of the Moon—creating a selenographic coordinates system encircling the Moon, and building a unified photogrammetric grid based on pictures from Apollo 15, 16, and 17, and Zond 6 and 8 (see figure 3-l). Photographs from the Soviet Venera 15 and 16—mapping high latitude regions of Venus not well covered by the U.S. Venus Radar Mapper mission—have been shared with American scientists, and U.S. scientists have continued to participate in data analysis and some aspects of planning for Soviet planetary missions; working largely through third-party agreements, several American scientists are now collaborating on the Soviet VEGA mission, in data analysis, image processing, and other areas.

On the institutional side, an agreement between California Institute of Technology and Moscow State University, signed in the late 1970s, has allowed for continued joint theoretical work in gravitational physics, 30 to 40 percent of which is directly space-related (such as the recent design of a gravitational wave detector). The Planetary Society—an independent organization, with Roald Sagdeyev, Director of the Soviet Institute for Space Research, on its Board of Advisors—has been sponsoring conferences and other forums among Soviet, American, and European space scientists, and is encouraging formal cooperation in areas such as Venus radar data exchange, a joint mission to Mars, and scientist exchanges on forthcoming missions.

The experiences of all of these individuals and groups have varied markedly. Many have noted a decisive shift in Soviet openness since approximately 1983. Despite the lapsing of the bilateral agreement, they note that the Soviets have been sharing data and photographs with Westerners, and have tended to be more open in discussing plans for future missions, whether to Venus, the Moon, or Mars. While recognizing more openness on the Soviet side, other scientists stress the still essentially closed nature of Soviet scientific and technical programs, and the difficulties Soviet scientists may have working through their own political bureaucracies. For tracking the data of the upcoming VEGA missions, for example, both Soviet and American scientists organized a world wide network of tracking stations; but according to scientists involved, Soviet security has precluded Soviet scientists from sharing the exact location of their tracking stations, limiting the utility of the Soviet data for mathematical calculations. Both American and Soviet scientists, however, have stated that they are limited in the extent to which they can cooperate without a U.S.-Soviet bilateral agreement.

Few Americans truly understand the role of different Soviet people or organizations in establishing and maintaining cooperation in space with the United States, or the Soviet decisionmaking process and mechanisms to deal with space-related issues. Few American scientists have been immune to the difficulties of working with Moscow, in terms of difficulties in making arrangements, obtaining visas, corresponding with Soviet counterparts, and dealing with a high level of government secrecy.

But continuing efforts on the part of both American and Soviet scientists to share research and knowledge are testimony to the scientific value which both communities place on such interchange. Both scientific communities believe that such interchange would be greatly eased with the signing of another bilateral agreement. But both communities must deal with broader government apparatuses where other calculations have become the subject of debate, and where science is but one concern.

nificance if they did not include substantial scientific content. The consensus was that, given the . difficulties inherent in large-scale joint missions, it would be wise to begin with simpler exchanges of the type now underway, perhaps holding the possibility of such a large-scale mission as a long-term goal.

SOVIET COOPERATIVE PRIORITIES

Shortly after the space science workshop, OTA discussed the workshop results with leading scientists in the U.S.S.R. These interviews, conducted in the Soviet Union, indicated a high degree of commonality with U.S. scientists concerning the most promising areas for future cooperation in space science. The Soviet scientists interviewed by OTA not only listed areas of study, but enumerated projects within fields in order of cooperative appeal. Levels of cooperation, however, were not specified.[5]

Briefly, their suggestions were as follows. (Asterisks indicate projects not mentioned by U.S. scientists at the OTA workshop.)

‘N. Lubin, OTA, interviews in Moscow, June 1984.

- Planetary:
  - —Study of asteroids, * comets, and interplanetary dust
  - —Study of Mars, including sample return
  - —Continuation of Venus study
  - —Study of planetary moons and Saturn’s rings,
- Life sciences:
  - —Human and animal responses to spaceflight factors
  - —Standardization of research methods and data collection techniques*
  - —Further ground-based simulation studies.
- Solar-terrestrial physics / astrophysics:
  - —General interest in cooperating in these fields.

SUMMARY AND CONCLUSION

Participants in OTA’S workshop underlined that past interactions with the Soviet Union in space science have benefited U.S. scientific programs, and believed that such interactions would again be fruitful, given an appropriate official framework.

According to workshop participants, Soviet capabilities now present an opportunity for a substantive, broad-based exchange that is equally balanced on both sides. In addition to renewing previous areas of scientific exchange, future cooperation could include new areas of joint work (e.g., astrophysics and global studies) that take advantage of our respective strengths and meet mutual needs. A dramatic joint mission to Mars or the Sun could be considered as a long-term goal, to be reached through successive cooperative steps. Types of cooperation, they noted, should be flexible. For example, joint coordination of separate missions could be an effective way to maximize scientific return while minimizing problems of technology transfer and mission management.

This is not to suggest, participants stressed, that cooperation should offset the development of our independent space capabilities. A key point of the workshop was that the United States must continue to have a strong, active space program of its own in order to be viable as a cooperative partner—whether with the Soviet Union or others. But such cooperation, they argued, can in turn greatly enhance U.S. knowledge and capabilities, and should therefore be carefully designed to assure maximum scientific benefit.

* * * * *

The early *scientific* rationale for cooperation in space activities, following the spirit of the 1957-**58 International Geophysical** Year (IGY), was that space exploration was too vast and expensive an area of exploration for any one country to under-

Table 3-1.—Potential U.S./U.S.S.R. Collaborative Activities: From OTA Workshop, May 1984

Sun-Earth (Heliospheric):
- Joint meetings to develop space plasma theory
- Joint coordination and data exchange in solar terrestrial physics—specifically for International Solar-Terrestrial Program (U.S./ESAlJapan)
- Exchange of co-investigators
- Hosted instruments (detectors)
- Joint Starprobe mission to the Sun (very long range)

Astrophysics:
- Joint planning for:
  - — Gamma-ray burst studies using Gamma Ray Observatory and other spacecraft
  - — Very long baseline interferometry (complementary orbits of spacecraft)
- Data exchange regarding contamination of cooled surfaces (infrared telescopes) and plasma glow problems (ultraviolet telescopes)
- Co-investigators on Space Telescope, Gamma Ray Observatory, and Advanced Astronomical X-ray Facility
- Mounting of Spacelab experiments on Salyut for long-term exposure

Planetary:

Venus:
- Joint planning or joint missions as part of a sequence to investigate the properties of the atmosphere of Venus
- Joint planning/missions for "long-lived" Venus surface studies

Mars:
- Coordinated planning for Mars missions ca. 1990 (Phobos lander and Mars Geochemical Climatological Orbiter (MGCO))
- Joint planning/missions for Mars sample analysis or return

Moon:
- Lunar geochemical orbiters
- Continued lunar sample exchange

Comets:
- Soviet contribution to instrument design for U.S. mission to Comet Kopf (1990) [possibly a hosted experiment]
- Coordinated or joint cometary sample return missions

Outer Planets:
- Joint orbiter/probe missions to Saturn, Uranus, or Neptune [after the NASA/ESA Cassini mission to Saturn and Titan, Uranus is the next cooperative opportunity here]

Life Sciences:

Effects of long-duration spaceflight:
- Data exchange and joint or hosted flight experiments, especially on problems of (human) bone loss, radiation effects, life support, and countermeasures
- Joint ground-based simulations (e. g., long-duration bed rest)
- Joint (or hosted) biological experiments aboard Cosmos biosatellites and/or Spacelab, using various animal and plant species

Exobiology:
- Joint unmanned missions or data exchange to further investigate the question of life on Mars
- Joint meetings and/or data exchange regarding search for extraterrestrial intelligence (SETI)
- Joint collection and analysis of Antarctic meteorites

Global biology:
- Earth observations data exchange

Life support systems:
- Joint ground-based demonstration and flight testing of life support systems (including bioregenerative type)

SOURCE Office of Technology Assessment

Table 3-2.—Participants in May 8 Workshop on Possible Future U.S.-Soviet Space Cooperation

Bernard Burke, *Workshop Chairman*
Department of Physics
Massachusetts Institute of Technology

Donald De Vincenzi
NASA Headquarters

Thomas M. Donahue
Department of Atmospheric and Oceanic Sciences
University of Michigan

Paul Gorenstein
Center for Astrophysics
Harvard University

James W. Head
Department of Geological Sciences
Brown University

Martin Israel
Department of Physics and McDonnell Center for the Space Sciences
Washington University at St. Louis

Charles Kennel
Department of Physics
University of California at Los Angeles

Eugene Levy
Lunar Planetary Lab
University of Arizona

Harold Masursky
U.S. Geological Survey

David Morrison
University of Hawaii

Tobias Owen
Earth and Space Sciences Department
State University of New York at Stony Brook

Fred Scarf
Space and Technology Group
TRW

Gerald Wasserburg
California Institute of Technology

SOURCE Office of Technology Assessment

take alone. According to the scientists at OTA'S workshop, 25 years of independent space efforts have not discredited that rationale.

OTA'S workshop highlighted the belief that cooperation with the U.S.S.R. has been, and can continue to be, mutually beneficial in many areas of scientific research. The following two chapters discuss how the scientific and technical concerns must be integrated with other issues in making decisions today—first, as illustrated in another Western country, and then in the context of issues facing policy makers in the United States.