ECOSPACE AND SOME OF ITS LEGAL IMPLICATIONS***

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A. INTRODUCTION

Ecospace—the economics of outer space—is a controlling factor in the future use of outer space for peaceful purposes for all people. The 1975 Presidential Program of the American Bar Association in Montreal, Canada contained a discussion by a group of distinguished Soviet and United States panelists, including an American astronaut and a Soviet cosmonaut. They reached informal consensus on four matters: (1) an extension of the 1972 U.S.-U.S.S.R. Agreement on Cooperation in Space;[1] (2) the desirability of further joint space programs in the interest of world peace; (3) the desirability of joint space and multilateral space cost sharing; and (4) the desirability of full publicity to bring outer space national benefits to governments, industry, and the individual.

The United States has spent over $80 billion on its combined civilian and military space programs and over half a million people will have been employed directly in American space endeavors.[2] No corresponding data are available from the Soviet Union because of their policies of secrecy in this regard. Nevertheless, experts who have considered the available physical evidence of space activity conclude that in real terms the Soviets have committed a similar amount of resources.[3] The ability of the two leading space powers[4] to continue their space activity depends on the availability of existing resources: finances, manpower, laboratories, factories, launch sites, tracking facilities, and launch vehicles. The critics of expenditures for the space program consistently argue that such resources—especially the billions of dollars and the

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[1]Agreement on Cooperation in Space, May 24, 1972, [1972] 23(1) U.S.T. 867; T.I.A.S. No. 7347. Reproduced in 1 J. Space Law 95 (1973).

[2]Sheldon, United States and Soviet Progress in Space: Summary Data Through 1974 and a Forward Look 1 (Congr. Res. Serv., Library of Congress, 1975).

[3]Hesman, Arms, Men and Military Budgets, 19 Sea Power 154 (May, 1976).

[4]Other nations who have demonstrated earth orbital launch capability include Australia, France, India, Italy, Japan, People's Republic of China, and the United Kingdom. Interview with Dr. Charles S. Sheldon II, Chief, Science Policy Research Division, Library of Congress, August, 1975.

manpower—should be directed to solving man's more immediate and Earthbound problems.[5]

Neither these criticisms nor the glowing incantations on how the conquest of space will benefit mankind show an accurate picture. The space programs of neither the U.S. nor the U.S.S.R. have been "bargains". But a careful and thoughtful look at the goals set, achieved and the benefits derived reveals that they have been the wisest investments these countries have made.

This study purports to set forth some of the intangible benefits of the space program. However, it should be remembered that the intangibles are equally important. Such factors as national pride, international good will, and a nations prestige cannot be measured in dollars and cents, but are invaluable assets. Finally, through the space programs, man has come to realize both the frailty of his own Earth system and the unlimited ability he has, when coupled with the will, to deal with its problems.

B. COST OF THE SPACE PROGRAM

The $80 billion spent thus far by the United States needs to be put into perspective. It is the total amount spent from the beginning of the space program in 1959 by the several governmental agencies involved, such as the National Aeronautics and Space Administration (NASA), the Department of Defense, the Atomic Energy Commission, the Weather Bureau and the National Science Foundation. These expenditures reached a peak of $7.7 billion in 1966,[6] and in 1975 were about $5 billion with $3.2 billion for N.A.S.A. alone.[7] At the peak, the United States was spending close to one percent of the gross national product.[8] Today it is spending *under* 1/2 of one percent.[9] The Soviet Union does not publish space budget data. Because they fly a greater weight of hardware, it is assumed that their program is at least of the same magnitude as that of the United States at its former peak, and may be larger. Their gross national product is thought to be about half that of the United States and therefore they probably spend about two percent of their gross national product on space programs.[10]

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[5]Remarks by Capt. Alan Bean, U.S. Astronaut during the U.S.-U.S.S.R. Aerospace Panel, A.B.A. Presidential Program. A.B.A. Annual Meeting, Aug. 11, 1976 (Montreal, Canada).

[6]Figures taken from U.S. Dept. of Commerce, Bureau of the Census, Statistical Abstract of the United States: 1974 at 224 (94th ed.); Sheldon, United States and Soviet Progress in Space: Summary Data Through 1974 and a Forward Look, *supra* note 2; and interview with Dr. Charles S. Sheldon II, *supra* note 4.

[7]The 1976 N.A.S.A. Budget is for $3.539 million. This is a $300 million increase from 1975, but the effective increase is only about $100 million, or just about 3 percent. This figure should be compared to the current much higher inflation rate. 6 N.A.S.A. Activities 3-4 (Feb. 1975).

[8]*Supra* note 5.

[9]*Id.*

[10]*Supra* note 3.

The manpower commitment has been equally great. In the United States, the NASA program alone at its peak employed about 400,000 people, but now has dropped to about 150,000.[11] This figure does not include the indirect beneficiaries of the space program from the multiplier effect of these expenditures, nor does this figure emphasize the dependence of some regions upon space expenditures. The Soviet Union does not disclose how many people are employed in their space programs. The productivity of this work force in comparison with that of the United States is not known, either. One would like to think that U.S. productivity is higher, but some Soviet attitudes to space development may be simpler than the American approach which incorporates very extensive testing and duplicative facilities in industry.[12] The Soviet work force may be close to 600,000 people because their effort today seems to be at least equal to the U.S. 1966 peak.[13] In short, the Soviet space program is picking up at an accelerating rate just when inflation, Government cutbacks and public apathy are curtailing the American program.[14]

Having lost the "race" to the moon, the most immediate national project for the Soviet Union seems to be the development of a long-term laboratory in earth orbit, lofted into space in sections and assembled there as a permanent space station.[15] The Soviets are expected to move to fill the void left in the wake of the U.S. Apollo programs by developing their own space shuttle. It is their practice to make up in volume what they may lack in American-type precision. In 1974 alone, the U.S.S.R. launched 91 objects, or nearly four times as many as the United States and they have already learned how to loft some communications satellites into orbit eight at a time.[16]

To date the United States has made only 770 successful launches compared to the Soviet Union's 934.[17] Five separate programs (Mercury, Gemini, Apollo, Skylab and Apollo/Soyuz Test Project) totalling 31 missions sent 44 U.S.astronauts to log a total of 22,468 hours in space.[18] More importantly, not one American astronaut was

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[11]Remarks by Capt Alan Bean, *Supra* note 5; E. Finch. The United Nations and Earth Resources Satellites, 7 Int'l Lawyer 158-164.

[12]*Id.*

[13]*Id.*

[14]"U.S. Astronauts Report Soviet Program on Rise," N.Y. Times, May 15, 1975, at 86.

[15]Success and experience in long-term space laboratories would give the Soviets the expertise to send a manned mission to Mars. It is also suggested that the Soviets may attempt to beat the U.S. by putting instruments on Mars capable of detecting life, see " 'Race to Mars'—Soviets May Beat U.S.," The Christian Science Monitor, Aug. 19, 1975, at 1.

[16]"End of Apollo Opens Way for the Shuttle," N.Y. Times, July 25, 1975 at 8.

[17]U.S. Bureau of the Census, *supra* note 6; Information provided by Dr. Charles S. Sheldon II, *supra* note 4.

[18]"Manned Space Flight—The First Decade", N.A.S.A. Facts (1973). In terms of manned spaceflight the costs and goals attained may be broken down by program. *See generally,* Canby, Skylab: Outpost of the Frontier of Space, 146 National Geographic 441 (1974); Bergman, A Look Behind the U.S.—Soviet Space Flight, Family Weekly 5 (June 22, 1975; see also *supra* note 16.

lost or injured during a space flight or upon its completion.[19]

C. CORNUCOPIA FROM THE SPACE PROGRAM

The space program has paid for its cost many times over by the scientific perspective it provides—first from the deep insights into the Earth gained from studying other planets, and second from the new knowledge acquired about Earth by looking at it from space.[20]

1. Earth Surveying

In terms of benefits from Earth surveying space activities, the *Landsat* satellites[21] are the outstanding performers. The Soviets calculate their benefits in the range of 5 billion rubles a year in agriculture, geology, geography, and oceanography.[22] A recent report by the U.N. Secretariat listed specific monetary benefits from the earth surveying programs in more than 20 countries.[23]

Of 85 applications studied in the American report for remote sensing information 43 are considered to have valid benefit estimates totalling about $1.4 billion in gross annual benefits. These include: $12.5 million for mapping relative to mineral exploration; $20 million for estimates of crop vigor and yield; $125 million for expediting exploration of petroleum; $326.8 million for improved forecasts of irrigation water availability benefits; $382.9 million for improved timeliness and accuracy of world wheat production forecast benefits.[24]

In addition, requests for *Landsat* information have generated a revenue of their own. The response has been nothing short of phenomenal. The National Aeronautics and Space Administration reports $2 to $2.5 million a year in sales of Earth survey information. This figure has been doubling annually since *Landsat-1* was launched in 1972 and is expected to increase.[25]

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[19]The Soviets lost four cosmonauts on Soyuz I and VI, and U.S. Astronauts Grissom, White and Chaffee were lost in the launch pad fire of Apollo I in 1967.

[20]"Lots of Space Mysteries Still Left to Explore," U.S. News and World Report, May 19, 1975, at 69.

[21]Landsat-1 (formerly ERTS-A) was launched in 1972 and is still in operation, Landsat-2 was launched in 1975, and Landsat-C is scheduled for launch in 1976.

[22]12 Astronautics & Aeronautics 67 (Dec. 1974).

[23]"Summary of Studies on Cost Effectiveness in Remote Sensing," Report by the Secretariat, U.N. Doc. A/AC.105/139, at 11-16 (1975).

[24]*Id.* at 16.

[25]*See* Bylinsky, ERTS Puts the Whole Earth Under a Microscope, 91-1 *Fortune* 117, 130 (Feb. 1975). As a result of sales and activity in earth survey information new publications have appeared (*e.g.* Remote Sensing of Environment, an interdisciplinary journal) and proceedings from annual international symposia on remote sensing have been published (*e.g.* Proceedings on Remote Sensing Symposia, Environmental Research Institute of Michigan).

In the decade ahead, resources issues will have increasing social and economic importance. The danger of famines, depletion of minerals and other natural resources, and permanent changes in the ecology face all nations. Resource decisions need early accurate inventories and projections. In many instances, the real economic problem does not arise in production, but in distribution to those in need. If American plans for *Landsat-C* are cancelled for budgetary reasons, then other governments or the private sector must step in to guarantee a continuity of Landsat-type data. Only a commitment to long-term continuity of service will attract investors and allow realization of the full potential of remote sensing.[26]

2. **Communications and Meteorology**

Communications satellites already have more than repaid the cost of their development and launching and, in fact, became commercially profitable within their first decade of operation.[27] This technology application is most obvious to TV viewers. In 1960, one could not send live TV across the Atlantic; by 1965, it became possible but expensive. By 1969, as a result of the space program, the quality has been improved and the cost reduced to one-fifth of the 1965 rate.[28] At present, communications satellites are used largely for transoceanic traffic, providing economical links across the Atlantic, Pacific and Indian Oceans. Before satellites, a West Coast-to-Japan cable circuit cost $15,000 per month; today, the Communications Satellite Corporation (Comsat) offers the same service at a charge of $4,000 per month.[29] In addition, satellites which directly broadcast television to community receivers are demonstrating their potential for delivering educational, medical and other services to remote and hitherto unreachable populations. This could be a tool of immense importance to developing countries seeking to raise the literacy of their people on a mass scale.[30]

It is becoming apparent that satellites will soon handle domestic communications as well as transoceanic traffic. In 1960, there were fewer than 75 million phones in America. There are now about 120 million. In 1960, Americans made about 18 billion calls, this year, about 200 billion.[31] The point is fast approaching where cables will not be able to handle the entire communications load of this country. Our domestic

[26]"Remote Sensing: A good Business Proposition?," 13 Astronautics and Aeronautics 5 (July/Aug., 1975).

[27]"Space Benefits," N.A.S.A. Facts—(1974).

[28]*Id.*

[29]*Id.*

[29]*Id.*

[30]See generally, The Aspen Institute Program on Communications and Society and the Office of External Research of the Dept. of State, Control of the Direct Boradcast Satellite: Values in Conflict (1974).

[31]"Space Benefits," *supra* note 27.

satellite systems should soon offer a whole range of services including low-cost message, data, and television transmission from coast-to-coast and anywhere in between.[32]

Weather satellites, too, yielded almost immediate practical returns from the investment in space research and now provide constant daily information to the National Weather Service, National Oceanic and Atmospheric Administration. The continued improvement in techniques of interpreting data and the improvements in the satellite itself offer the possibility of accurate weather forecasting over vast regions. Space observation of weather patterns on a global scale offers the only hope of understanding weather movement, global temperature, and global wind patterns, which is necessary for long-range forecasts.

An accurate five-day forecast of weather conditions over the United States can provide an estimated annual savings of $6.75 billion when applied to agriculture, lumbering, transportation, retail marketing, and water-resources management. This savings alone would be more than the cost of the U.S. space program in any single year.[33] Accurate long-range forecasts could lead to savings of at least: $70 million annually from flood and storm damage; $1 billion a year to the construction industry; $500 million a year to fuel and electric power industries; $500 million a year to fruit and vegetable producers; $450 million annually to livestock producers.[34] The Soviet Union, usually the most conservative in putting a value to space technology, calculates benefits in the range of 100 billion rubles a year from applying space-based meteorology and communications.[35]

3. **Technology Utilization**

Space technology has a multiplier effect in the economy on individuals and industries that can adapt it for their own problems and uses. The list of benefits from technology generated by the space program is a long one.[36] Space flight technology

[32] Western Union has already launched a satellite for U.S. domestic service. Others are planned by COMSAT by contract with RCA, American Satellite, and AT&T (statement from office of Telecommunications Policy, Sept. 1975).

[33] "Space Benefits," *supra* note 27.

[34] "Space Benefits," *supra* note 27.

[35] 13 Astronautics & Aeronautics 67 (July/Aug. 1975). This issue contains a summary of the 26th International Astronautical Federation Conference.

[36] *See* Staff of Senate Comm. on Aeronautical and Space Sciences, 93d Cong., 1st Sess., Toward a Better Tomorrow With Aeronautical and Space Technology (Comm. Print, 1973); Staff of House Comm. on Science and Astronautics, 93d Cong., 2d Sess., For the Benefit of all Mankind: The Practical Returns From Space Investment (Comm. Print, 1974); Staff of Senate Comm. on Aeronautical & Space Sciences, Space Benefits— The Secondary Application of Aerospace Technology in Other Sections of the Economy, 94th Cong., 1st Sess., (Comm. Print, 1975); N.A.S.A., Technology Utilization Program Report 1974 (N.A.S.A. Publ. SP-5120: 1975). *See generally* 5-6 N.A.S.A. Activities (April 1972-Aug. 1975). For the importance of manned missions in space, see 13 Astronautics and Aeronautics 65 (July/Aug. 1975).

has been used for such diverse purposes as law enforcement equipment systems, pollution control, air transportation, maritime port planning, personal rapid transit, solar energy conservation in housing, and management of natural resources.[37] From this geometric explosion of technology another industry has been spawned—technology utilization.

Technology utilization is the deliberate, structured and planned system for adapting and applying N.A.S.A. technology to industrial, medical, and social problems. Its successful application to such varied and significant public problems as cataract surgery, burn diagnosis and treatment, fire fighting safety, and low-cost household wiring again demonstrates that productivity and quality of life improvements are dividends of the national aerospace investment. In 1974, 4,200 industrial firms throughout the country spent nearly one million dollars for access to space-generated technology through the regionally located Industrial Applications Centers. These users are industries which do not want to "reinvent the wheel" when NASA may have already done so. Over 6,000 technical innovations from the space program are now available for use.[38]

For industry and the individual, this program means access to a data base of more than 3.5 million items, not only generated by N.A.S.A. but from all over the world. One such facility at the University of Connecticut—the New England Research Application Center (N.E.R.A.C.)— has over 3.5 million items and is growing at the rate of about 100,000 pieces of data a month. In 1975 N.E.R.A.C. received about 3,000 requests from about 200 different companies and is growing at the rate of 10 percent a quarter. For as little as $1,700 a company may request the answer to any number of questions if asked one at a time. The answers usually come within five days, 85 percent are processed within ten.[39] With the commitment and efficiency that took man to the moon and satellites to the end of the galaxy, N.A.S.A. technology has been made available to fulfill public and private needs.[40]

4. The Rule of Law in Space

From the birth of N.A.S.A. in October, 1958, the space program of the United States has been dedicated to the concept that space would be the common heritage of mankind and used for peaceful pruposes.[41] Incorporating these and similar ideas put

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[37]The Aerospace Corporation (Annual Report, 1974), at 9-24.

[38]N.A.S.A., Technology Utilization Program Report 1974 (N.A.S.A. Publ. SP-5120: 1975, at i. 1-4). Another organization which attempts to speed the movement of new ideas and processes from the laboratory to the market place is the M.I.T. Development Foundation, Inc. "M.I.T's. Hothouse for New Ventures," N.Y. Times, Aug. 24, 1975, sec. 3 at 5.

[39]Interview with Dr. Daniel U. Wide, Dirctor of N.E.R.A.C., Aug. 1975.

[40]See N.A.S.A., *supra* note 38 at iii.

[41]National Aeronautics and Space Act, Sec. 102, 42 USC 2451 (1974), 72 Stat 426.

forth by the Soviet Union,[42] a United Nations General Assembly resolution was passed which recognized outer space, its peaceful uses and exploration to be the common interest of "mankind" with benefits for states "irrespective of the stage of their economic or scientific development"[43] The resolution which seeks to avoid obstructing national rivalries, emphasizes "international cooperation for peaceful purposes."[44] There was to be a mutual exchange and dissemination of information on outer space research and these basic tenets became "the principles of outer space." The 1967 Outer Space Treaty, now adhered to by more than 70 nations incorporates these tenets and adds the denial of national sovereignty in outer space and the freedom peacefully to use, explore, and investigate there for all states.[45] Variations and elaborations on these principles are found in each subsequent space treaty: 1968 Agreement on the Rescue and Return of Astronauts,[46] 1972 Liability convention[47] and the 1975 Registration Convention.[48]

Today the United Nations including the General Assembly, the Secretariat, the specialized agencies, and especially the Committee on the Peaceful Uses of Outer Space (hereinafter Outer Space Committee), continues to promote the rule of law in outer space and to study the technical and legal problems likely to arise in space exploration.[49] The Outer Space Committee, at the conclusion of its 18th Session in June 1975, noted its future work to be such matters as the draft of a Moon treaty, remote sensing of the Earth from space, and direct broadcasting by satellite.[50]

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[42]See generally, A Piradov (ed.), International Space Law (Moscow, 1974); V. Vereschchetin, Space, Cooperation, Law (Moscow, 1974; N.A.S.A. Translation); S. Lay and H. Taubenfeld, The Law Relating to Activities of Man in Space (1970; J. Fawcett, International Law and the Uses of Outer Space (1968); Dembling and Arons, The Evolution of the Outer Space Treaty, 33 J. Air L. & Comm. 419 (1967).

[43]G. A. Res. 1721, 17 U.N. G.A.O.R. Supp. 17 at 6, U.N. Doc. A/5026 (1962).

[44]*Id.*

[45]Treaty on Principles Governing the Activities of State in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, [1967] 18 (3) U.S.T. 2410;T.I.A.S. No. 6347.

[46]Agreement on the Rescue of Astronauts, The Return of Astronauts, and the Return of Objects Launched Into Outer Space (1968), 18 (3) U.S.T. 2410, T.I.A.S. No. 6599.

[47]Convention on International Liability for Damage Caused by Space Objects, [1973] 24(2) U.S.T. 2389; T.I.A.S. No. 7762.

[48]Convention on Registration of Objects Launched Into Outer Space, U.N. Doc.A/RES/3235/XXIX (Nov. 26, 1974), reproduced in 3 J. Space L. 99 (1975).

[49]The technical, economic and social implications of space endeavors and technology utilization are usually studied by the Scientific and Technical Subcommittee of the Outer Space Committee, the Secretariat, and the U.N. expert in charge of space applications. The legal aspects of space utilization are usually studied by the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space.

[50]Report of the Committee on the Peaceful Uses of Outer Space, 13 U.N. G.A.O.R. Supp. 20, U.N. Doc. A/10020, at 4-6 (1975).

Reflecting a recognition of the fact that Space Shuttle craft will mean permanent lunar missions and space stations, the Legal Subcommittee of the Outer space Committee must resolve questions of the Moon's natural resources, the scope of a Moon treaty and the information to be furnished on missions to the Moon. Remote sensing of the Earth from space poses several legal puzzles as to national sovereignty.[51] A consensus has been reached that their solution will depend on the answer to the fundamental question of whether a state has sovereign rights over the dissemination and use of information pertaining to its natural resources.[52] Similarly, principles to govern direct broadcast satellites will turn on considerations of whether a state has sovereign rights to control absolutely the flow of information into its territory.[53] As the quantity of space activity increases, a consensus must be reached on matters relating to the definition and delimitation of outer space and outer space activities.

The Outer Space Committee and the United Nations will continue to provide the most optimal forum for airing exploration of space. The precedent is commendable—no satellite has been destroyed in space by other than the launching state. As long as the mission is for peaceful purposes, it is now recognized that any interference would violate principles of international law and treaty obligations.

5. International Cooperation and Exchange of Information

Until the successful "handshake in space" during the Apollo/Soyuz Test Project (A.S.T.P.), international cooperation in space had been a more subtle legacy of our space program. Starting with the International Geophysical Year in 1958 to the 1974-75 Global Atmospheric Research Program,[54] the United States has joined other nations in a solid history of effective and productive international cooperation in space sciences. In addition, N.A.S.A. has current international cooperative programs with West

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[51]*See*, Background Paper by the Secretary-General Assessing United Nations Documents and Other Pertinent Data Related to the Subject of Remote Sensing of the Earth by Satellites, U.N. Doc. A/AC.105/118 (1973); Finch, The United Nations and Earth Resources Satellites, 7 Int'l. Lawyer 158 (1973); Dalfen, The International Legislative Process: Direct Boradcasting and Remote Earth Sensing by Satellite Compared, 10 Can. Y. B. Int'l L. 186 (1972); Packard, International Legal and Political Aspects of Earth Reources Surveying by Satellite, American Institute of Aeronautics and Astronautics Paper No. 70-331 (1970).

[52]Moore, Earth Resource Satellites, A Puzzle for the United Nations, 16 Harv. Int'l. L. J. 649 (1975).

[53]See Aspen Institute, *supra* note 30. Am. Soc. of Int'l Law, Direct Broadcasting from Satellites: Policies and Problems, Studies in Transnational Legal Policy No. 7 (1975); and Gotlieb, Dalten, and Katz, The Transfer of Information by Communications and Computer Systems: Issues and Approaches to Guiding Principles, 68 Am. J. Int'l L. 227 (1974).

[54]Scheel, GATE: Doing Something about the Weather, *Sea Power* 25 (March 1975).

Germany, Japan and the Soviet Union.[55] For global problems, it is obvious that only systematic, organized global efforts can hope to discover solutions.

N.A.S.A. continues its policy of launching, on a reimbursable basis, payloads for industry and other nations.[56] In 1974, the majority (9) of the payloads launched by N.A.S.A. were international in character. They were launched jointly with, or for, the United Kingdom, France, Germany, and the Netherlands. The only *caveat* is that the purpose of the mission must be in line with the Outer Space Treaty.[57] The Landsat program involves participation of more than 35 countries and various international organizations, educational institutions and private industry.[58] Our manned flights, from Gemini to Skylab and A.S.T.P., performed experiments the results of which were used by international principal investigators. This practice will continue in connection with the Space Shuttle and appropriate invitations to governments, international organizations, agencies and individuals to propose experiments for particiation in life sciences investigations have already been issued.[59]

The United States has been committed from the start of its space efforts to the free release of all scientific and technical results from its missions, as well as open coverage of all N.A.S.A. launches.[60] Now, in the second decade of space exploration, these principles have guided all of N.A.S.A.'s programs and have influenced other space powers.

The national policy on remotely sensed information was announced before the U.N. General Assembly in 1969. *Landsat* and the Earth Resources Experimental Package (E.R.E.P.), which flew on Skylab, were "dedicated to produce information not only for the United States, but also for the world."[61] The United States would "share both the adventures and the benefits of space....the effort marked by the same spirit of fraternal cooperation that has so long been the hallmark of the internatinal community of

[55]See Robinson, N.A.S.A.'s Bilateral and Multilateral Agreement—A Comprehensive Program for International Cooperation in Space Research, 36 J. Air L. & Comm. 729 (1970), containing a fairly detailed discussion of the effectiveness of N.A.S.A.'s past bilateral and multilateral cooperative undertakings. N.A.S.A.'s current international efforts are summarized in N.A.S.A., Aeronautics and Space Report of the President: 1974 Activities 7-40, 79-83 (N.A.S.A., 1975).

[56]Remarks by Capt. Alan Bean, U.S. Astronaut, *supra* note 5.

[57]*Cf. supra* note 41.

[58]Finch, The United Nations and Earth Resources Satellites, 7 Int'l. Lawyer 158-164 (1973); NASA, ERTS (NASA publ., 1972).

[59]Interview with Dr. Charles Sheldon and Mr. Stephen Doyle, NASA Headquarters, Wash., D.C., Aug. 1975.

[60]J. Barbour, Footprints on the Moon 42 (1969), (quoting President Kennedy); *See also* National Aeronautics and Space Act, *supra* note 41, § 102(c).

[61]President Nixon's address before the U.N. General Assembly, "Strengthening the Total Fabric of Peace," 61 Dept. State Bull. 297-301 (Oct 6, 1969).

science."[62] America has more than fulfilled this promise—selling all remote sensed data at minimal cost; offering the services of specialists to aid in their interpretation; hosting panels, workshops and instructional seminars; providing the Outer Space Committee with copies of *Landsat* raw data; and supporting efforts to establish an international regional data storage and dissemination center for the informatin from receiving stations here and in Canada, Brazil, Italy, and Iran.[63]

The United States took the initiative in developing international agreements on space and space law.[64] Bilateral agreements with Mexico, Brazil, and Canada set ground rules for the cooperative efforts in research and utilization of data from earth resources surveys by aircraft and spacecraft.[65] A 1971 U.S.-U.S.S.R. Agreement on Space Cooperation between N.A.S.A. and the Soviet Academy of Sciences set up schedules for the exchange of scientific data and for cooperation in the study and coordination of experiments.[66] The 1972 memorandum of understanding set in motion the joint space effort that culminated in Apollo/Soyuz.[67] It is this 1972 memorandum that should be extended as noted above. Formal extensions would enable outer space international law and science to advance together. The United States also has completed an agreement with the member governments of the European Space Research Organization (E.S.R.O.),[68] and N.A.S.A. has signed a memorandum of understanding with E.S.R.O., now the European space Agency (E.S.A), for a cooperative program concerning the development, procurement and use of the space laboratory to be flown by Space Shuttle.[69] To this end, E.S.A. has already committed more than $400 million.[70] Canada is also participating by developing and manufacturing the remote manipulator system, or "mechanical arm", at a cost of about $30 million.[71]

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[62]*Id.*

[63]*Id.*

[64]*Id.*

[65]*But see,* A Piradov (ed.) International Space Law (Moscow, 1974), setting forth the proposition that the Soviet Union acted alone.

[66]*See* Earth Resources Agreement with Brazil, Sept. 10, 1968, [1968] 19(5) U.S.T. 6066, T.I.A.S. No. 6569; Earth Resources Agreement with Mexico, Dec. 20, 1968, [1968] 19 (6) U.S.T. 7809, T.I.A.S. No. 6613; Letter plus annex from Marcel Cadieux (Ambassador of Canada) to the U.S. Secretary of State, May 14, 1971.

[67]Agreement on Cooperation in Space, *supra* note 1.

[68]Agreement Between the Government of the United States and Certain Governments, Members of the European Space Research Organization, reproduced in 2 J. Space L. 53 (1974).

[69]Memorandum of Understanding Between N.A.S.A. and E.S.R.O., Hearings before the Committee on Aeronautical and Space Sciences of the U.S. Senate on Space Missions, Payloads and Traffic for the Space Shuttle Era, 93d Cong. 1st Sess., pt. 1 at 121-134 (Oct. 30, 1973), reproduced in 2 J. Space L. 40 (1974).

[70]Interview with Dr. Charles S. Sheldon III and Mr. Stephen Doyle, N.A.S.A. Headquarters, Washington, D.C. (Sept. 1975).

[71]Interview, *supra* note 59.

With Apollo/Soyuz, the U.S.S.R. allowed foreign media representatives to view a launching for the first time. Before that only American astronauts and technicians were allowed to visit their space operation headquarters and become familiar with the Soyuz spacecraft.[72] In addition to being a necessary element for the success and safety of the Apollo/Soyuz mission, these precedents provide a foundation for continued exchanges and a more open policy by the Soviet Union toward the rest of the world concerning its space activities.

After the successful conclusion of the Apollo/Soyuz linkup, it is hoped that the flow of information—scientific, technical, economic—will be more balanced. The pattern of bilateral and multilateral agreements have successfully promoted cooperation in outer space, and has kept it open for peaceful uses. Similar cooperation in other areas would certainly aid in relieving tensions in the world and facilitate the quest for solutions to national as well as global problems.[73]

D. THE CHALLENGE OF THE FUTURE

A four-year pause in manned space flights has begun. Operating within a fixed budget of slightly more than $3 billion a year, N.A.S.A. will continue during this period a large program of launching unmanned communications and scientific satellites into orbit around the Earth and sending vehicles toward Mars, Venus, Jupiter, and Saturn. For the first time a N.A.S.A. budget has no new project starts.[74] In terms of immediate impact, the significance of this fact is alarming. For the future it will mean an eventual "drying up" of the expertise, manpower and equipment that should have been committed five or ten years earlier. The technology now being utilized so successfully did not grow in a vacuum but from clearly defined national goals. A new commitment and new goal definitions will be mandatory for the already extensive benefits to accrue and continue to increase in the future.

Rising costs have affected other space programs as well. International cooperation with a sharing of equipment and knowledge is the necessary key to future exploration.[75] The catalogue of possible subjects for joint, international endeavors includes an International Solar System Decade, energy from space, space manufacturing, Earth resources, direct broadcast satellites, space shuttles and space stations, space colonization, voyages outside the planetary system, scientific experiments that can only be done in space, and space medicine.[76] In the spirit of the Outer Space Treaty, any

[72] J. Bergman, A Look Behind the U.S.-Soviet Space Flight, Family Weekly, June 33, 1975 at 5; U.S. Newsmen Visit Soviet Space Center, N. Y. Times, May 14, 1975, at 8.

[73] Waldheim, Space Can Unite Nations, 13 Astronautics and Aeronautics 21 (Sept. 1975).

[74] "U.S. Aide Forecasts Huge Rise in Solar Panel Energy", N.Y. Times, April 30, 1976, Sec. D, p. 17. See also Hessman, *supra* note 3.

[75] Statement of the Soviet space expert Viktor Bayov, N.Y. Times, July 20, 1975, at 48.

[76] 12 Astronautics and Aeronautics 69 (Dec. 1975).

combined missions would reflect a truly international effort to explore space and celestial bodies for peaceful purposes and man's benefit. Rising costs make it mandatory that the billions in expense be shared not only by the major space powers but also by other states.

1. **The Space Transportation System**

N.A.S.A., of course, has not abandoned manned space flight. The Space Shuttle era will begin approximately 20 years after our first venture into space, the launching of Explorer I on January 31, 1958. Since that date, unmanned satellites have probed the near and distant reaches of space, and manned systems have been used to explore the lunar surface. In order to serve the future needs of space science and its applications, technological and operational experiences underlying these accomplishments are being applied to the development of the Space Shuttle.[77] This vehicle is the basic element in a space transportation system which includes a sortie lab and space tug and will open a new era of routine operations in space.[78]

The first American satellite, *Explorer I,* cost more than $100,000 a pound to place in orbit.[79] When the largest present launch vehicle (*Saturn V*) is used, the cost is less than $1,000 a pound.[80] By avoiding the cost of a launch vehicle and recovery at sea, Space Shuttle should reduce space flight costs to about one-tenth of the presnt level.[81] It is estimated that by using the Shuttle the cost of placing a payload in near earth orbit could be as little as $1 per pound, and of placing a payload on the moon could be as little as $5 per pound.[82]

2. **Space Contamination and Pollution**

It is anticipated that, in the future, contamination, both forward and back, will pose a problem for manned and unmanned space flights.[83] Forward contamination

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[77]End of Apollo Opens Way for Shuttle, N.Y. Times, July 25, 1975, at 8; M. Mallzivo, Space Shuttle: The New Baseline, 12 Astronautics and Aeronautics 62 (Jan. 1974); N.A.S.A., Environmental Statement for the Space Shuttle Program (N.A.S.A. publ., 1972); Space Benefits, *supra* note 27; Interview with NASA Information Officer, NASA Headquarters, Wash., D.C., Aug. 1975.

[78]*Id.* For example, the Large Space Telescope (LST) scheduled to be lifted into orbit by the Space Shuttle in the early 1980's is intended greatly to extend the range of man's vision into the universe. *See* 7 Industrial Research 18 (Aug. 1975); American Insitute of Aeronautics and Astronautics, Large Space Telescope (AIAA publ., 1975).

[79]Space Benefits *supra* note 27.

[80]*Id.*

[81]*Id.*

[82]See Sheldon note 3 *supra.*

[83]Robinson, Earth Exposure to Martian Matter: Back Contamination Procedures and International Quarantine Regulations, Proc. 18th Colloquium on the Law of Outer Space 134 (1976).

could be carried to a planet. Billions of bacteria were deposited on the Moon from manned exploration. Fortunately, the Moon's surface—exposed to extreme heat and cold and hard radiation—is self-sterilizing. But Mars is not. If there is life on Mars, then manned exploration there might produce some problems for the Martians,[84] and if there are Martian micro-organisms, for the astronauts and for us on their return.[85] The attempt to protect the Earth from contact with lunar samples failed repeatedly because of laxity in the enforcement of quarantine procedures.[86] If the Moon had harbored virulent micro-organisms, it is believed there might have been a plague on Earth. With a planet such as Mars, the danger is greater.[87]

If sufficient concern and attention are not given at the outset to all aspects of reducing the risk of back contamination in the Mars surface sample return mission, establishment of technologically viable, politically sensitive, and legally responsible back contamination programs will suffer.[88] The possibility of introducing to Earth's biosphere an alien life form or toxic substance, either of which might cause an insidious low-grade infection or a catastrophic biological accident, is a serious risk that must be addressed responsibly not only by scientists but also by lawyers.

The simple economics of the Mars surface sample return mission make international cooperation and involvement essential. It is infinitely easier to obtain governmental and citizen support if these costly undertakings are shared internationally, and there already exists a broad international scientific interest in Mars surface samples.[89] Precisely what constitutes an acceptable level of risk of biological, vector or toxic contamination in returning Martian surface samples to Earth will involve weighing the views of persons from disciplines, including scientists, engineers, public health officials, legislators, economists, lawyers and general public opinion.

The large number of flights scheduled for an operational Space Shuttle may result in environmental problems of its own. The amount of nitrogen oxide and sulfur oxide released from supersonic transport flights, subsonic planes, and space launchings presents serious possibilities for reducing the ozone layer around the Earth, thereby letting in harmful ultraviolet light and changing climatic conditions.[90] Traced by

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[84]*Cf.* H. Wells, The War of the Worlds (1848), describing a fictional invasion of the earth that was stopped when earth bacteria infected Martian invaders; *cf.* also M. Clichton, The Andromeda Strain (1969), depicting a fictional epidemic caused by alien bacteria brought to earth on unmanned space probe.

[85]Robinson, *supra* note 83.

[86]*Id.*

[87]*Id.*

[88]Two methods for returning Martian surface samples are described in Robinson, *supra* note 83.

[89]*Id.*

[90]National Academy of Sciences, Environmental Impact of Stratosphere Flight 8 (1975); 107 Science News 220 (1975).

sounding rockets, these noxious gases stay mostly in the upper atmosphere, where they may stagnate for three years while diffusing laterally all around the world. The problem is obviously global, requiring international regulation on airflight, fuel, and aircraft engines.[91]

3. **Solar Power Satellites**

Current estimates are that in the year 2000 this country alone will need at least 85,000 megawatts per year of new generator capacity.[92] One of the newest methods being considered for meeting this rising demand is to collect solar energy and relay it to Earth for conversion into electricity.

The basic idea is a large array, either of solar cells or of turbogenerators, located in geosynchronous orbit, about 25,000 miles high, always over a fixed point on the surface of the Earth. There, solar energy would be available more than 99 percent of the time. Solar energy is converted into microwave power, and transmitted from a phased-array antenna, of about 1,000 meters diameter, driven by a large number of small amplifying tubes. At a fixed receiving antenna on the ground about 90 percent of the beam power is contained within a width of about seven kilometers. An overall transmission efficiency of about 56 percent has been demonstrated in tests. The target figure is from 63 to 70 percent which seems close to realization. The cost estimated for a first satellite power station is about $9.37 billion.[93]

Increased utilization of the radio frequency presents the problem of user conflict with navigation, communications, and meteorological satellites.[94] Careful study will have to be made to (1) insure the integrity of the other systems using the geostationary orbit; (2) investigate the environmental and economic impact of such systems; and (3) provide equal access by the less-technologically advanced nations to this energy source. At the same time, the energy needs of Earth will be growing and the need for a "clean" alternative energy source must be met.[95]

4. **Space Manufacturing Research**

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[91]*Id.* at 88-90.

[92]O'Neill, Summary of Session on Application and Developments, Space Manufacturing Facilities Conference, Princeton University, May 7-9, 1975.

[93]Arthur D. Little, Inc. would use solar cells while Boeing Aerospace Co., as an alternate would use turbogenerators. Dr. O'Neill's summary includes a comparison and criticism of both concepts and their respective costs. O'Neill, *supra* note 92.

[94]The International Telecommunications Union World Administrative Radio Conference in 1977 (WARC-ST) will be considering allocation of the 11.7-12.2 GHZ band and weighing the competing users, present and future.

[95]A phased development program for a satellite solar power station (SSPS) started in 1975 could not result in an operational system until 1977. A flight experiment will be done by 1985, with a prototype by 1992. Arthur D. Little, Inc., Press Release (1975).

Project Skylab marked the highlight and completion of the first chapter in the history of materials processing under weightlessness. It demonstrated dramatically that elimination of gravity may lead to different and often superior products, as well as to many operations virtually impossible on the surface of the Earth.[96]

Crystals grow larger and purer under zero gravity. Such crystals could make feasible substantial reductions in the size of the components in computers, television sets, and other electronic devices and great improvement in memory capacity. Glass may be produced essentially perfect, without scratches or flaws, thereby solving the problem of tension failure.[97] In the energy-rich environment of outer space, an energy- intensive process such as electrolysis is an economically viable way for obtaining aluminum from the lunar rock plagioclase. The same is true for reducing ilmenite (lunar rock) to titanium and oxygen.[98]

Studies have identified about 50 different research and development topics including, *inter alia,* metals and alloys, composite materials, semiconductor crystals, glasses, and biological substances.[99] The new techniques learned may also find application on Earth as the rich ores that need only simple processes run out. Taking advantage of the unique qualities of the space environment to produce materials which might be more economical to process in space or impossible to produce on Earth will present fascinating new problems for lawyers. Such areas as contracts, licensing agreements, labor law, or, more broadly, the policy decisions on private and public funding of space enterprises will need close examination.[100]

5. Habitats in Space

The dream of 10,000 people working and living in outer space now has firm financial and technical foundations. In recent seminars on the feasibility of space stations it was concluded that space colonies have a future and could be operating by early in the twenty-first century.[101] Reports have been made on specific topics such as

[96]*Cf.* NASA, Aeronautics and Space Report of the President: 1974 Activities, at 4 (NASA publ., 1975); Stuhliner, Materials Processing in Space: A Look Towards the Future, 13 Astronautics and Aeronautics 20 (May, 1975); Bredt and Montgomery, Materials Processing in Space: New Challenge for Industry, 13 Astronautics and Aeronautics 22 (May, 1975).

[97]Hibbs, Summary of Presentations, Space Manufacturing Facilities Conference, Princeton Univ., May 7-9, 1975.

[98]*Ibid.*

[99]Stuhliner, *supra* note 96 at 20.

[100]Robinson, Legal Problems of Sustaining Manned Space-Flights, Space Stations and Lunar Communities Through Private Initiative and Non-Public Funding, 7 Int'l Lawyer 455 (1973).

[101]This idea is based on fabricating totally manmade communities or facilities in stable orbit in earth-moon space. It differs from prior conceptions of "space colonization," *i.e.* the idea of colonizing the Moon or Mars or some other planet. *See generally,* "Princeton Gathering Makes Detailed Assessment of Problems in Establishing a Colony of 10,000 in Space. N.Y. Times, May 12, 1975 at 54; "Space Colonies Getting to be Serious Dreams," N.Y. Times, June 1, 1975, Sec. 4, at 9; "Plan Space Colonies for Next Century," Industrial Research 30-38 (Aug. 1975); "Scientists Consider Space Living Plans," The Christian Science Monitor, Aug. 5, 1975, at 6.

location of the orbiting colonies, materials to be used in their construction, basic supplies of raw materials for the orbiting colonies, means of producing food for their thousands of inhabitants, and legal and social structures for the colonies. Solar heat is to be the main power source for these space structures. According to one scheme, a major project of the first group of settlers would be to construct a vast solar energy satellite that would convert solar heat to electricity and then to microwaves, which would then be beamed down to Earth for reconversion to electric power. Revenue from this activity would finance expansion of the colony. Lunar raw materials would make the construction economically feasible and in view of this the terms of a new Moon treaty take on added significance.[102]

Legal and social regimes would have to be created for this unique command-control situation without depriving the inhabitants of basic rights and freedoms. The question of granting governmental or ultimately statehood status to these colonies is to be seriously considered. International law will have to restructure its Earth-bound criteria when applying the rule of law in space.

E. CONCLUSION

When President Kennedy called for a manned lunar landing and safe return by the end of the decade, he characterized the effort as a leading accomplishment in space achievement which may hold the key to our future on Earth. His words have proved to be most prophetic.

Space programs have produced talented men and women everywhere with technical inventiveness and capacity to deal with global problems. Such knowledge and ingenuity can vastly improve and enhance the condition of all humanity. To continue this impetus, the economics of space demand international cooperation as envisioned in the 1972 U.S.-U.S.S.R. Space Cooperation Agreement. Space activity eventually may pay for itself. Until then, the investment and cooperation by nations of the world hold the future for man's continued peaceful existence on his own planet and his successful exploration of new frontiers.

President Ford and Chairman Brezhnev have both come out strongly for the advancement of outer space for the benefit of all mankind. Now the nations of the world are on the threshold of increasing opportunities to restore the Earth and its environment for the increasing population on this planet. This era has become known as the Space Age—it can become a "Golden Age" bridging the twentieth and twenty-first centuries.

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[102]For details, see *supra* note 101.