

A Current Perspective On Space Commercialization





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A Current Perspective On Space Commercialization

Removing Barriers to Opportunity

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Foreword

Not far behind the first adventurers into any new frontier have been the real harbingers of civilization: farmers, merchants, businessmen, to harvest and develop its resources. Although space is characteristically unlike the terrestrial frontiers that man has explored, it was clear from the first that the development of space would follow a similar pattern.

Today, a quarter century into the space age, mankind has taken only the first steps toward the commercialization of space, but they have been determined steps and carefully planned. The Space Shuttle and the envisioned Space Station, as well as other ventures by American and foreign entrepreneurs, are positioning man to exploit resources of the new space frontier. But many factors other than technology—numerous legal, regulatory, financial, political, national security and foreign policy issues—cannot be ignored, for they will influence the speed at which commercialization proceeds.

Interest and excitement are building over the commercial potential of space. The National Aeronautics and Space Administration's (NASA) new Office of Commercial Programs has received the first formal proposal from a private company—3M—for investment in the Space Station. With NASA, 3M would develop an industrial chemical research laboratory on board the station. The firm's plan would call for it to utilize as many as 72 Space Shuttle flights through 1995. A newly-formed space consortium which includes aerospace companies, as well as those from other industries, has also submitted a preliminary plan for wide-ranging industrial research on board both the Shuttle and Space Station.

Several aerospace firms have signed memoranda of understanding with NASA expected to lead to joint endeavor agreements in several areas of industrial space processing.

If private firms such as these are to commit themselves increasingly to commercial space ventures, the wide range of issues relating to space will have to be

soon, yet thoughtfully, addressed. Wrong turns, or perhaps worse, failure to act at all will have tremendous impact on how commercialization progresses. The United States must recognize this and proceed accordingly so that this new era in space will offer the greatest opportunity to the United States for leadership in the world market and growth in the domestic economy.

This report by the Aerospace Industries Association (AIA) looks at the potential of space and at what will be required to facilitate its commercialization. It identifies issues of concern and potential barriers to space-based enterprise, space transportation or U.S. participation in the international market for space projects, information or services. It outlines the potential impact of these issues and barriers and identifies alternatives to existing practice which would be most likely to improve space commercialization potential.

Space commercialization is a developing area and events or new policy directions may quickly change the perspective. For this reason, AIA has not attempted a definitive report but rather has chosen to define the range of issues for closer examination. AIA's interest in presenting this report is to stimulate discussion, and assist in the development of consistent, timely policy fostering space commercialization. The alternatives identified are only possible avenues for action and are not AIA recommendations.

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Executive Summary

The rapid commercial success of the satellite communications sector may have raised unreal expectations for a repeat in other space sectors. It is unlikely that this will occur, however, as the defined market that was present in the communications sector does not exist in either the remote sensing or materials processing areas, and exists only to a limited extent in the expendable launch vehicle field. Nonetheless, the development of a space transportation system and the promise of the planned space laboratory have led a diverse range of companies—from large aerospace corporations and non-aerospace corporations to new-start entrepreneurs—to focus attention on space for serious corporate investment. These companies are exploring the potential of the microgravity and vacuum environments of space: (1) to produce entirely new classes of products, (2) to produce existing products more cost-effectively, or (3) to make major advances in ground-based technology research. They are looking at ventures in pharmaceutical processing; electronics; space processed crystals and other materials; advanced space communications; and remote sensing satellites, as well as alternatives to the shuttle transportation system such as commercial launch vehicles.

The commercialization process in sectors other than satellite communications has only just begun. It will require considerable effort and expenditure by the space entrepreneurial community and careful nurturing by government to be implemented successfully. For this to occur, existing regulations must be changed and new legislation, favorable to the long-term development of space, passed. This process has been initiated by the Reagan Administration which is presently developing a long-range space policy. At the administration's urging, the National Aeronautics and Space Administration has outlined a Commercial Use of Space Policy. Continued clarification of U.S. government policy and of uncertainties in international law rank as major prerequisites to the growth of space enterprise.

To ensure that policy is implemented may, however, require greater activity by the aerospace constituency in the public information and political sectors. In addition, a closer degree of cooperation between the private sector and government will be needed to define the different areas and activities of both sectors in space development.

Prerequisite: Identification of Markets

A prerequisite to the involvement of the private business sector in space will be the identification of markets, upon which to base expectations of economic return. A great deal of research and experimentation will have to precede the offering of new products and services, and this will require considerable high-risk investment. A stable business environment will be an important part of the investment equation to which government must give its attention.

From industry, more of a risk-taking stance will be required, and the development of enlarged in-house research and development activities oriented toward potential commercial space ventures. The aerospace industry has traditionally been more concerned, although not exclusively, with providing the infrastructure for potential space commerce than with potential products and services. Genuine opportunities for the development of space products and services markets exist, however, through the medium of joint R&D ventures between aerospace companies and other industries.

A fundamental problem for companies interested in research and experimentation in such a high-risk arena as space is the overall flagging of U.S. innovation and the increasing time required to bring a product from the research stage to market. This could be associated with the high costs involved, and consequent business decisions not to accept such high levels of risk. A different situation exists in many other countries where much of the cost of high-risk R&D activities is born by national governments, not private firms, and this has

damaged the United States competitively. Where space commerce is concerned, the risks of research and experimentation are higher than usual and the difficulties of launching new ventures are consequently increased.

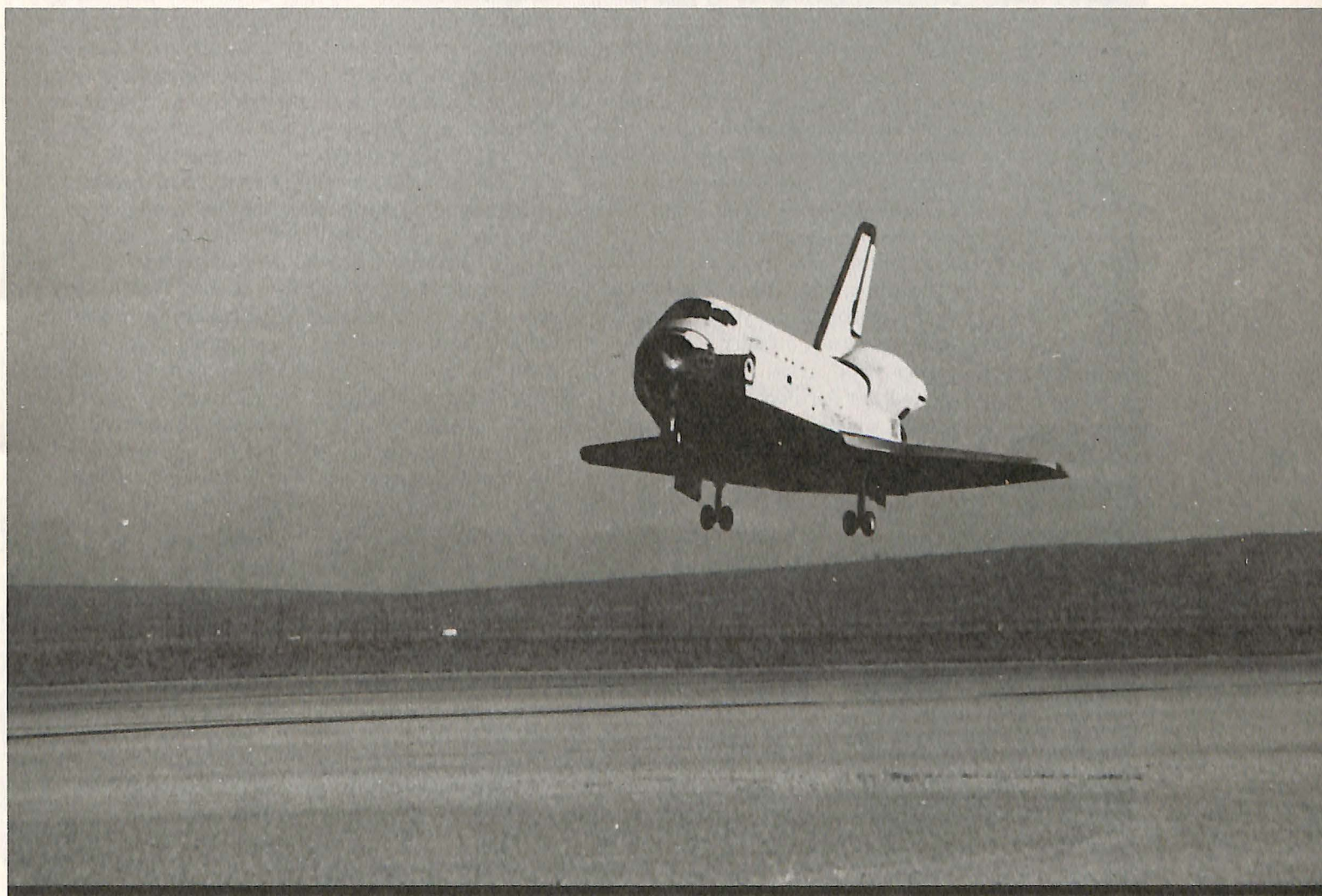
Government's Long-Term Policy Role

The long-term policy role of government comes into play in the stimulation of innovation and in federal incentives for investment and the impact, for example, of the Investment Tax Credit, the Accelerated Cost Recovery System and R&D Limited Partnerships. With certain exceptions, such incentives have not been applied to space ventures, although the Reagan Administration has proposed that space ventures should receive equal treatment with terrestrial enterprise. The administration qualified its initiatives in this respect, however, with the statement that changes would be made "in accordance with decisions on fundamental tax reform

... " Tax reform could thus have a far-ranging impact on the attractiveness of commercial space projects.

There is considerable disagreement concerning the amount of money available for commercial development of space. One industry source has estimated that current growth rates in investment, if extrapolated, would reach approximately one billion dollars per year by 1987. It is felt that most capital for space ventures will come from internally generated funds coupled with outside borrowing. The R&D Limited Partnership concept appears to offer a potent source of outside income.

Several issues at the heart of establishing a definitive commercial space policy center on the government's long-term role in the civilian space program, and the relationship between the civil space program and the military requirements of the nation in space. There is debate over the impact of federal support of the Shuttle program, which some feel makes it difficult for



private firms to compete. Shuttle pricing for full recovery of costs, however, is complicated by the need for the Shuttle to remain competitive with Europe's Ariane and with the need to encourage the user community to invest R&D funds in potential commercial space applications.

There is also concern that NASA's budget and resources have been significantly impacted by Shuttle and Space Station activities, perhaps to the detriment of some areas of space technology development. Some feel that operation of the Shuttle has represented a reorientation of the agency: away from its research functions. At the same time, the Shuttle and the Space Station provide a means of improving the space transportation and operations system, and NASA Shuttle activities provide an assured, stable and improving system with stable pricing, which is beneficial to commercial ventures. NASA's Commercial Space Policy, issued in November 1984, addresses some of the points of concern which have been raised by proposing numerous initiatives that will clarify the agency's role and which represent, in effect, NASA's commitment to the commercialization of space.

Issues surrounding the impact of national security on the process of space commercialization are extremely complex and are endemic in a free society, when both military and civilian sectors share use of the same facilities and systems, e.g., the Space Shuttle. It has been suggested that an alternative to security, scheduling and other potential problems arising from joint civilian and military use of the Shuttle would be for the military to have its own space transportation system. In early March 1985, the issue of a separate military space transportation system was rendered moot, however, when the White House directed the Air Force and NASA to begin studying joint development of a bigger and more powerful Space Shuttle for the 21st century.

The NASA Commercial Space Policy addresses the issue of commercial needs versus military needs by establishing, as a major initiative, efforts to facilitate the

integration of commercial space payloads and to reserve orbiter facilities for commercial ventures.

While some feel that emphasis on military space projects will short-change development of ventures with a civil orientation, it is also possible that there will be a useful synergism between military and civil space technology.

It is yet unclear how investors will gauge the military presence in space, particularly if it includes the introduction of weapons into that arena. It may be perceived by some as additional security, and by others as destabilizing. The question is: will the military presence in space lead investors to perceive the new frontier of space as any more risky than others that businessmen have faced over the centuries?

A number of international issues are perceived as either actual or potential barriers to the commercial development of space. These include areas such as the imprecise nature of international space law, and uncertainties introduced by the regulation and control of many aspects of space by international regulatory agencies attached to the United Nations. Questions also exist regarding the preparation of U.S. delegates to international conferences, and whether commercial factors are taken into account by the State Department when dealing with space issues in international forums.

Additional uncertainties result from the twin issues of international competition and international cooperation. In recent years, foreign nations have rapidly caught up to the U.S. lead in space technology. This, in itself, is of evident competitive concern, but it also introduces questions about U.S. ambivalence toward international cooperation and the sharing of technology and information. These issues will become of greater concern as U.S. and foreign organizations cooperate in developing technologies for increasingly complex projects. They will add to the need for the aerospace industry and government to cooperate in the development of policies regarding these and other areas affecting the short and long-term commercialization of space.

Space Commercialization Issues
— Their Interrelationship —

	ISSUES	NATIONAL			INTERNATIONAL
Legal/Political/ Regulatory	Major government involvement NASA's R&D vs. operational role Poor liaison between private and public sectors Yearly space budget review restrains long-term tech development Lack of organized public support for space	Legal/Political/ Regulatory	Financial & Insurance	National Security	Creates uncertainties over U.S. policies and attitudes toward technology transfer and international cooperation.
Financial & Insurance	Space transport costs high Lack of readily available venture capital Growing R&D costs hurt space commercialization High insurance rates affect space investment Uncertainty about insurance available for ventures	Increased demand for government support of launch services Leads to demand for commercial launch services Increases demand for government support of commercial space ventures & special taxes Increases need for institutional way of handling R&D demonstration May result in pressure to develop government-supplied insurance fund for space ventures			Increases U.S. use of foreign launch vehicles Increases likelihood of joint international ventures Increases opportunity for government-supported foreign inroads
National Security	Prospect of space arms may lead to investor uncertainty Restrictive tech transfer policies impact space investment decisions Military and civilian space priorities differ Government role in space transport operations/marketing	Military use of space vehicles and question of weapons in space create uncertainties regarding consistent government attitudes toward commercial space issues and also role of NASA. Concerns may be weighed against technology improvements/spinoffs, lower costs from higher numbers of launches, potential increased safety of space facilities resulting from military space activities.	Creates uncertainties in minds of investors re safety of space facilities Increases insurance risks		Has adverse effect on international cooperative ventures. Other nations fear that U.S. space facilities will be militarized and also fear U.S. intentions in space. Leads to increased opposition at international meetings, affecting international regulations adversely for U.S.
International	Uncertainty about U.N. space policy decisions Ambiguity about international space laws Upcoming WARC conference decisions on comsats Space may become part of North-South global debate U.S. preparation for space conferences International tech transfer issues	Intensifies government debate over whether international cooperative ventures are barriers or alternatives May reduce possibility of international joint ventures signing JEA's with NASA Raises protectionist instincts and efforts to control technology	Increases difficulty for commercial ventures to raise funds if international companies involved	Increases military concern over technology and information leakage through foreign partners	

Space Commercialization Issues Their Possible Impact and Some Possible Solutions

ISSUES	POSSIBLE IMPACTS	POSSIBLE SOLUTIONS
Little public awareness of potential.	Restrains government and public support. Erodes investor confidence.	Public information and education programs. Attention to media coverage.
No overall government policy on space with specific implementation guidelines.	Makes business nervous. Lowers public awareness of space program. Encourages foreign "targeting" of gaps in technology.	Political pressure by space community on Administration and Congress to continue clarifying national space policy and its implementation.
No institutionalized way to bringing basic research to market.	Fall-off in innovation. Loss of technological lead. Strengthens foreign competition.	Increased "In-house" R&D expenditures by companies. More funding of research, development and demonstration projects by universities and small businesses. Greater cooperation between government and industry.
NASA— Shuttle pricing & policy.	Makes investors wary. Reduces entrepreneurial activity. Reduces technological innovation. Changes orientation of NASA.	Pressure Administration and Congress to ensure that NASA and all government agencies conform to Administrative directive forbidding competition with private sector. Review shuttle pricing policy, distinguishing between pricing that encourages Shuttle's use for R&D and pricing to maintain Shuttle's current operational status.
NASA budget and resources significantly impacted by Shuttle and Space Station activities.	Slows space technology development in some areas and may reduce U.S. lead and competitiveness as foreign competition strengthens. Provides assured, stable and improving transportation and space operations system with stable pricing.	Emphasize balance between NASA operations and technology thrusts that will keep U.S. in forefront of space technology development. Congress initiate internal study of future agency directions in response to national needs.
Lack of in-space infrastructure.	Reduces possibility of in-space R&D. Restricts U.S. development of space technology. Reduces corporate and investor interest in space commercialization. Increases foreign competitiveness.	Government/industry cooperation in planning and supplying necessary in-space facilities including free-flying platforms, 25-100 kw power sources, manned space research facilities in LEO and GEO, large antenna platforms, i.e., the Space Station program.
Transportation costs to space too high.	Restrains in-space research. Reduces industry interest and involvement in space. Increases perception of space as "exotic" area not ready for commercial development.	Research and develop new launch vehicles through private sector activities and/or continued government R&D on new launch vehicles.
Tax and other regulatory business incentives do not include commercial space activities.	Restrains investors. Creates uncertainties. Reduces new-start entrepreneurial activities.	Ensure implementation of recent administration initiatives to treat space and terrestrial investments equally.
Space insurance too expensive/too little available.	Reduces space activity. Restrains commercial development. Adds to already high cost of space activity.	Government/industry discussions to ensure sufficient availability of insurance at reasonable cost.
DOD use of civilian space shuttle.	DOD use and priority reduces certainty of launch slots. DOD use makes foreign use less likely. Increases use of foreign competitive launch vehicles.	DOD could procure and operate own space transportation system. DOD could procure own expendable vehicles. But either will increase launch costs to commercial government and other users.
Introduction of weapons into space.	May increase risk to expensive space facilities and reduce investor confidence in commercial development. Orients technology toward military needs. Increases military use of shuttle flights.	Increase awareness of possible effect of military needs on growth of space commerce and promote discussion of ways to resolve potential conflicts.

(Summary Continued)

ISSUES	POSSIBLE IMPACTS	POSSIBLE SOLUTIONS
International competition by foreign government-supported agencies and corporations. Targeting of space sectors by foreign nations.	Reduces U.S. lead in space technology. Has long-term negative economic implications for U.S. Government-subsidized foreign competition makes things very difficult for U.S. space entrepreneurs.	Foster greater government and private investment in space-related R&D. U.S. government should negotiate international agreement on fair and free trade in space products and services.
Uncertainties over international space law and regulations:	Restricts investment and interest in space commerce by U.S. private sector.	Early call by U.S. for international conference to determine precise meaning of regulations governing space resources and to establish right of private companies to function in space arena. State Department, NASA, Department of Commerce could undertake bilateral negotiations to gain support for freedom of action in this area.
e.g. "Common heritage of mankind" clause.	Slows space development, e.g., lunar and asteroidal mining. Poses questions re U.S. support for private sector in international forums.	
e.g. Comsat issues—orbital crowding and control over information from direct broadcast satellites. Private sector competition to Intelsat.	Causes uncertainty re future of satellite communications, especially direct broadcast satellites. Reduces technology driver in comsat field until future more certain.	Industry/government cooperation in formulating new directions in international communications and advanced R&D. Careful joint preparation for WARC '85 and '87.
e.g. Remote sensing issues including right to over-fly and right to use of information by third parties. U.S. ambivalence on issues.	Uncertainties reduce U.S. entrepreneurial activity in this area. Little R&D for future development. Increased foreign competition. Reduced U.S. technological capabilities and lead. Impacts relations with developing nations which are major beneficiaries of Landsat system. Creates internal government-subsidized competition for space entrepreneurs in this field.	Maintain NASA research in remote sensing area. Prepare and carry through long-range international negotiations on remote sensing policy, with particular regard to the goodwill of developing nations, as well as right of private companies to function in space arena. Administration and Congress review attitudes and legislation on privatization of remote sensing, especially regarding degree of public subsidy of operations.
Uncertainty regarding U.S. preparation for international conferences.	Creates unnecessary friction with other nations. Restrains investment in commercial space activities.	Long-term preparation of delegates. Involvement of interested parties in planning. Government support of private sector activities in international affairs and implementation of necessary international negotiations.
Uncertainty regarding U.S. support for commercial space development in international conferences.	Increases lead time before exploitation of space resources will occur. Allows foreign competition to seize initiative in this area.	
Ambivalent U.S. attitude toward international cooperation in space technology development and ventures.	Increases international competition as foreign nations and corporations cannot depend on U.S. Reduces access to foreign technology. Restrains development of cooperative ventures. Increases time and cost of unilateral activities.	Promote understanding in government that information and technology exchange in space field is now a two-way street and U.S. lead has been eroded in nearly all major sectors. Allow private sector to develop joint ventures with other nations and corporations, unless government intends to maintain U.S. tax-payer funded effort across-the-board in space.
Restraint on technology and information exchange.	Slows down pace of commercial activities in space exploration and development.	

Space Commercialization: Introduction and Background

In the quarter century since the orbiting of the first artificial satellite, the development of space has generated a considerable array of direct and indirect benefits. In this brief period, the United States government, based on the technological accomplishments of the aerospace industry, managed to build an extraordinary range of manned and unmanned spacecraft to provide unparalleled access to outer space. These spacecraft resulted in the landing of six two-man crews on the Moon, exploration of the farthest regions of the solar system, and with the advent of the reusable Space Shuttle, the opportunities for manned presence in Earth orbit on a routine basis.

The nation's space program has also generated more direct, practical economic benefits. A multibillion dollar communications and data transfer industry has emerged with enormous impacts on personal and business communications; imaging of the Earth from space (remote sensing) has yielded benefits ranging from improved crop forecasting to more sophisticated exploration of mineral and oil deposits; and the use of the unique attributes of space (vacuum and microgravity) have permitted the investigation of new industrial processes.

The indirect benefits from space technology are nearly impossible to quantify. They encompass well-known "spinoffs" such as miniaturized electronics making possible small computers and heart pacemakers as well as esoteric technologies like energy storage systems and composite materials.

Until recently, the prohibitive costs and sophisticated technologies associated with space exploration meant that the government has been the dominant force in space development. Not surprisingly, space projects were justified on the basis of improving national security (e.g., military surveillance and communication satellites), national pride (e.g., Apollo program), scientific knowledge, and only infrequently, on their long-range economic potential.

Accordingly, with the exception of the communications satellite sector, the aerospace industry's role in space was limited to fulfilling the national security, political and scientific needs of government. However, in the past few years that situation has been rapidly changing. A diverse range of industries, from Fortune 500 aerospace and non-aerospace corporations, to new-start entrepreneurs, are treating space as a target for serious corporate investment. These companies are being drawn to space by the potential of using the microgravity and vacuum environments of space: (1) to produce entirely new classes of products, (2) to produce existing products more cost-effectively, or (3) to make major advances in ground-based technology research.

Such ventures generally fall into one of several major categories: pharmaceutical processing (e.g., exploring the possibility of using the space environment to develop cancer treatments and cures for diabetes); electronics (e.g., producing purer forms of semiconductor materials to significantly increase computer power); space processed crystals (such materials might generate a whole new industry of light-powered, ultra-fast computers); advanced space communications; remote sensing satellites; and commercial launch vehicles. *Aviation Week & Space Technology*, a leading aerospace trade journal, recently quoted analysts as saying that by the year 2000, "commercial space operations could generate \$65 billion in annual gross revenues, which in turn could generate some \$13 billion in annual tax revenues."¹

This transition from public to private participation in space has raised a number of issues regarding how the government can best encourage large-scale private investment in space. These issues are made more complex in the present case because of the difficulty and

¹Craig Couvaut, "Unique Products, New Technology Spawn Space Business," reprint of *Aviation Week & Space Technology*, June 25, 1984, p. 4.

high cost of getting into space, coupled with the enormous investment already made by the U.S. taxpayer.

In addition to those barriers that are to be expected in the opening of any new frontier, space offers other and sometimes unexpected difficulties. Some of these are due to the all encompassing totality of space, its global impact. Data from remote sensing satellites offer man, for the first time in his history, a new way of understanding and managing his environment. The use of this revolutionary tool has only just begun, its full flowering will require the establishment of new institutions and ways of obtaining, processing and delivering the data in a form and time-frame acceptable to the end user. The establishment of such institutions and a cost formula that is acceptable to provider and customer, all within the framework of international as well as national regulation, provides a new challenge to the commercial sector.

Equally important, space offers man a limitless future in a limitless frontier. The full impact of that perception has yet to come, but it is this promise more than any other factor that offers a challenge to the private sector. In the lifetime of some now living, it may be possible to obtain a new and virtually limitless supply of resources from the Moon and asteroids. Possibilities such as this make space different from all other frontiers and of so much interest and concern to all the world's nations.

This international interest and concern provides new and complex issues for U.S. commercial interests. Compared to terrestrial law, space law is still very much in a nascent stage. Four multinational treaties, drafted and signed under United Nations auspices, constitute the body of space law today.*

These treaties are essentially oriented toward establishing an international protocol dictating obligations between nation-states. Thus, the displacement of government by private enterprise challenges this network of understandings. Among other consequences, the emergence of private actors in space "raises a potential

realignment of rights and obligations between the United States and the international community, between the United States and such private sector entities, and between those entities themselves."²

Thus, a high degree of political uncertainty is added to the already uncertain milieu in which commercial development will occur, making it even more difficult for private corporations to obtain the enormous funds necessary to open this new frontier. At the same time, it is widely perceived by other nations that space is the next area of man's development, and they are positioning themselves accordingly. In large measure this accounts for the aggressive government space programs of many foreign nations: the Soviet Union, members of the European Space Agency, Japan, China, India, Brazil, and others. Competition is nothing new or unexpected for corporations, but competition from governments introduces formidable problems, especially when the rules and regulations are established by the United Nations subject, as it is, to the political pressures of 168 member states.

Foreign competition, more than anything else, will require close cooperation between the U.S. government and the private sector if the latter is to play the role it should in opening up this new frontier. It is in at least partial recognition of this fact that on July 20, 1984, President Reagan announced major initiatives (which will be examined later) intended to minimize national governmental barriers to industry involvement in space.

Communication Satellites - Background

It is sometimes overlooked that one sector of space development—communications—has been commercialized from the very beginning of the Space Age. In 1945, Arthur C. Clarke first suggested the concept of worldwide communications by means of three satellites placed in geosynchronous orbit (an orbit 36,000 kilometers—23,250 miles—high, in which a satellite orbits in space at exactly the same speed as the Earth rotates, thus appearing to remain stationary over one spot on the surface).³ Clarke foresaw that it would be fifty years or more before such satellites would be in existence. Less than 20 years later, however, in 1963, NASA introduced the Syncom series of communications satellites. Syncom III, launched in August of that year, was the

*Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and other Celestial Bodies, January 27, 1967.

Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space, April 22, 1968.

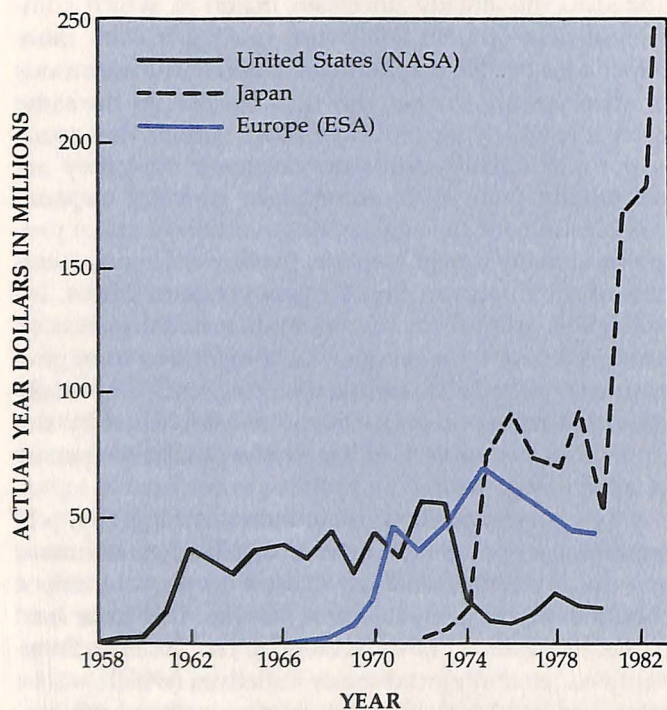
Convention on International Liability for Damage Caused by Space Objects, March 29, 1972.

Convention on the Registration of Objects Launched into Outer Space, January 14, 1975.

²Congressional Research Service, *Policy and Legal Issues Involved in the Commercialization of Space*, September 23, 1983, p. 42.

³Arthur C. Clarke, "Extraterrestrial Relays," in *Wireless World*, February 1945, reprinted in: *Voices From the Sky*, N.Y., Harper & Row, Appendix, pp. 229-239.

FIGURE 1
Budgets for Communications Satellites
(Government-Sponsored R&D)



SOURCE: NASA

first geostationary satellite. In 1965, Early Bird, developed by the Communications Satellite Corporation and launched by NASA, became the precursor of today's global satellites, the first in a series to provide the worldwide coverage foreseen by Arthur Clarke.

Today, another twenty years later, we have become so accustomed to instantaneous global communications that we hardly give the means a thought. Yet, the figures show the enormous progress that has been made during this short period: in 1965, the international satellite communications system consisted of 240 voice and one TV circuit. In 1982, this had increased to 40,000 voice and 10 TV circuits. During this period, Intelsat (the International Telecommunications Satellite Organization) had grown from 11 to 108 member nations serving a total of 170 countries, while annual space segment charges had fallen from \$32,000 to \$4,680.⁴

⁴Joseph N. Pelton, "Intelsat: Making the Future Happen," *Space Communication and Broadcasting*, Vol. 1, No. 1, April, 1983, Table 2, pp. 38-39 and p. 40.

Similar spectacular growth has occurred at the regional and national levels. Excluding the Soviet Inter-sputnik and Molynia satellites, there are 15 international and regional systems in operation, with a total of 46 satellites. North America has 20 domestic systems with 108 satellites; other nations have 13 domestic systems with 40 satellites, while there are an additional 13 direct broadcast systems worldwide, with 40 additional satellites. This makes a grand total of 65 systems and 271 satellites. In addition, the Soviets, by 1980, had launched 18 satellites into geosynchronous orbit and a further 78 Molynia satellites into 12-hour orbit.⁵

It is estimated that by 1985 the global satellite market will be worth a total of \$4 billion. Even more rapid growth is predicted for the coming years: an additional 16 billion dollars by the turn of the century which will mean a launch market of a further \$10 billion, and a ground station market estimated at \$24 billion.⁶ These figures show that satellite communications has become big business.

Communication Satellites - Commercialization Issues

Quite evidently, the space communications sector has already been rapidly and successfully commercialized. In fact, its very success has created troublesome issues such as overcrowding of the geosynchronous orbit, and who controls the information being broadcast by the new direct broadcast satellites. (These will be examined in more detail later). In addition, although evolutionary technology has permitted new commercial ventures to challenge the monopoly of Intelsat in the provision of international telecommunications, it also poses a threat to the long-term development of the satellite communications field itself through the evolution of ground-based fiber optic systems.^{7,8}

⁵Figures extracted from Walter L. Morgan and Margaret Petronchak, "1984 Satellite Performance Reference Chart," *Satellite Communications*, Vol. 8, No. 3, March 1984, insert.

⁶Robert R. Lovell, "Giant Step for Communication Technology," *Aerospace America*, Vol. 22, No. 3, March 1984, p. 55.

⁷Two U.S. corporations: Orion Satellite Corp., and International Satellite Inc., have proposed private trans-Atlantic systems. Articles by spokespersons for Orion, Intelsat and International Satellite may be found in *Satellite Communications*, February, March, April 1984.

⁸The competition between fiber optics and communication satellites has already begun. A new trans-Atlantic cable is being prepared for earliest possible operation while, recently, AT&T and other carriers endorsed an immediate start on a similar trans-Pacific cable. This was over the vocal objections of Comsat who complained that if the cable was placed into operation prior to 1991 it would leave only the thin routes to satellites, thus making them economically unattractive. See *Satellite Week*, August 6, 1984, pp. 7-8.

The greatest impact of the rapid development of communication satellites, however, lies in the expectations it has created about the possibility of equally rapid payoffs in other space sectors. Unfortunately, such expectations may not be easily realized. The other sectors have neither the established market nor the infrastructure (e.g., pricing structure, a network of users) that existed in the communications sector.

Expendable Launch Vehicles - Background

Once NASA decided to concentrate entirely on the Space Shuttle and phase out the expendable launch vehicles (ELV's) which it had previously used, several aerospace corporations indicated their interest in commercializing these vehicles (Titan, Atlas Centaur, Delta). In addition, two newly-started entrepreneurial companies invested in the design and development of new cost-effective launch vehicles—one a modified Minuteman and the other a water-launched vehicle. Both of these ventures helped to bring about government interest in the regulation of commercial space transportation.

The Titan and the Atlas Centaur vehicles are now being offered commercially by their builders (Martin Marietta and General Dynamics), while the Delta (built by McDonnell Douglas) is being operated by a newly formed company, TransSpace Carriers Inc. A number of other launch vehicles are reported to be under development by still other companies, but whether any of these will become operational is not known at this time.⁹

The Space Shuttle is limited to an orbit some three hundred miles above Earth. If a higher orbit is desired, such as Clarke's geosynchronous orbit, a trans-orbital vehicle must be used. This has encouraged a market for such "upper stages" and a number of companies have already entered this field.¹⁰ Competition is growing quickly in this area, made more complex by the larger satellite manufacturers, who are now offering such transfer stage motors as an integral part of their new designs.¹¹

The first U.S. company attempting a launch of its own vehicle was Space Services Inc. of Texas, which developed the Conestoga. It took them nearly two years

and hundreds of thousands of dollars to clear the regulatory hurdles that they found in their way, involving eighteen separate federal agencies. This matter was brought to the attention of the Administration, which, late in 1983, appointed the Department of Transportation (DOT) as lead agency for this new field.

According to the executive order establishing DOT as lead agency, the department's mandate was to be a facilitator of the licensing process. Rather than attempt to change or do away with existing regulations, the department would instead assist the applicant through the licensing process. The designation of DOT as lead agency was one of the more visible institutional indications that the government intended to help in the development of the commercialization process.

Congress concurred with the importance of this action and in the closing days of the 98th Congress passed the Commercial Space Launch Act, which went beyond the President's Executive Order by providing DOT with substantive authority (versus being limited to a facilitator role) to expedite the licensing process for commercial launch operators.

Expendable Launch Vehicles - Commercialization Issues

A major difficulty that stands in the way of the commercial development of launch vehicles is the size of the market and competition for that market from both the Space Shuttle and launch vehicles built and operated by other countries.

Developed with a considerable expenditure of taxpayers' money, the Shuttle is expected to pay its way in operation as soon as possible. According to a recent report by the Office of Technology Assessment (OTA), initial shuttle flights have been heavily subsidized,¹² leading some of the newly-formed expendable launch vehicle companies to complain of unfair competition from their own government. OTA acknowledges that this is a two-edged issue: on the one hand, subsidized shuttle rates ensure that the Space Shuttle will remain competitive with the European Space Agency's Ariane, and encourage R&D investment in emerging industries and technologies. On the other hand, subsidized rates endanger the Reagan Administration's policy encouraging a domestic launch service industry. OTA emphasizes that the federal government must find a way to resolve the two seemingly inconsistent policies of making the Shuttle competitive with Ariane and more easily

⁹See *The Commercial Space Report*, July 1984, for names and activities of these companies.

¹⁰Orbital Science Corp. is building two upper stages of their own design and Astrotech International is building one for the Shuttle based on the Delta second stage. See *Space Calendar*, July 2-8 and 9-15, 1984.

¹¹See articles by Susan Frutkin and Judith Johansen on new satellites from Ford Aerospace and Hughes Aircraft with integral upper stages, *Satellite Communications*, February 1984.

¹²Congress of the United States, Office of Technology Assessment, *Civilian Space Policy and Applications*, Washington, D.C., 1982, p. 223.

available to entrepreneurs while encouraging private launch services.

Shuttle pricing is probably the single most important issue for space commercialization in the next 10 to 20 years since transportation costs will dominate and the Shuttle pricing policy will, to a large extent, dictate transportation costs. Clearly, there are conflicting policy goals of promotion of space commercialization ventures (products and services to a terrestrial marketplace) and space commercialization infrastructure (transportation to serve these ventures) and resolution satisfactory to the interests of entrepreneurs in both areas will not easily be achieved. However these issues are resolved, a major goal—benefitting both product-oriented ventures and potential launch service enterprises—is long-term policy stability. This is particularly important in an area where business risk is far beyond the ordinary.

In August 1984, the Reagan Administration directed NASA to address the Shuttle pricing issue and to develop a pricing schedule policy that would provide eventual full cost recovery on shuttle flights. The White House Senior Interagency Group for Space has yet to announce final actions on NASA's recommendations. A major area of concern is what it actually costs to send a business payload into orbit. Another is the impact of Shuttle pricing on the commercial market.

Some have suggested that the conflicting interests of international competitiveness and the encouragement of private space launch ventures be addressed through a two-tier pricing structure for the Shuttle. A subsidized price would apply to those involved in R&D work for which use of the Shuttle is required. Full cost recovery would be charged to commercial and foreign satellite owners who are currently benefitting from subsidized prices. There are those who contend that subsidizing Shuttle prices poses an unfair burden on the taxpayer and represents a major economic disincentive to the nascent commercial launch field. On the other hand, others believe that going to full cost recovery too quickly will simply inhibit the expansion of the payload market. However, to the extent that Shuttle charges at full cost recovery place the Shuttle at a competitive disadvantage with Ariane, the extension of U.S. Export-Import Bank loans, credits and guarantees to potential customers could be explored.

Another difficulty in increasing private sector involvement in space faces those companies attempting to commercialize former Government ELV's, necessitating the use of government-owned facilities, tooling and services. Negotiations to transfer the operation and management of launch vehicle facilities and equipment to the private sector have been lengthy and protracted. Issues such as 'fair price' for such equipment and 'addi-

tive cost' for use of tracking and radar have proven particularly troublesome.

A barrier to commercial success in the ELV field is also created by NASA's intention to market the Shuttle, through a private company, with the goal of 75 percent of the world's launch market. Given the tremendous difficulty launch firms are currently facing in obtaining payloads (e.g., there is a dearth of comsat companies willing to sign launch contracts before 1987), NASA's plans will impact the commercial payload market.

It is issues such as this which make space a highly complex policy area. There are no quick and easy answers to many of the barriers that are presently slowing down the commercialization process.

Materials Processing in Space - Background

It was evident from the beginning of the space program that this new area offered a unique environment for the development of new materials. Microgravity and high vacuum, both properties of the space environment, are difficult to produce on Earth for any length of time. A few early experiments during the Apollo moon program offered tantalizing glimpses of the possibilities of using these environmental features to produce new materials in space.¹³

Skylab, the world's first large in-space workshop provided additional opportunity. It could have offered much more, if the time had been available to properly plan the program. But as it was, during the 172 days the three different crews were in the workshop, a total of 15 experiments and nine demonstrations in materials growth and processing were carried out. These included work in crystal growth, metal composites, eutectics, welding and brazing, fluid effects, and combustion processes.¹⁴

In 1975, the joint Soviet-American, Apollo-Soyuz flight offered another opportunity. A total of 12 processing experiments and three demonstrations in crystal growth, electrophoresis, and materials processing were carried out during the flight.¹⁵ Several were verifications and/or refinements of the Skylab investigations. Two were in the field of electrophoretic separation of biological specimens, a process invaluable for the pro-

¹³Five MPS experiments were carried out on Apollo flights, see National Academy of Sciences, *Materials Processing in Space*, Washington, D.C., 1975, p. 27.

¹⁴For a description of experiments aboard Skylab, see, Philip Bono and Kenneth Gatland, *Frontiers of Space*, N.Y., Macmillan, rev. ed., 1976, pp. 119-134.

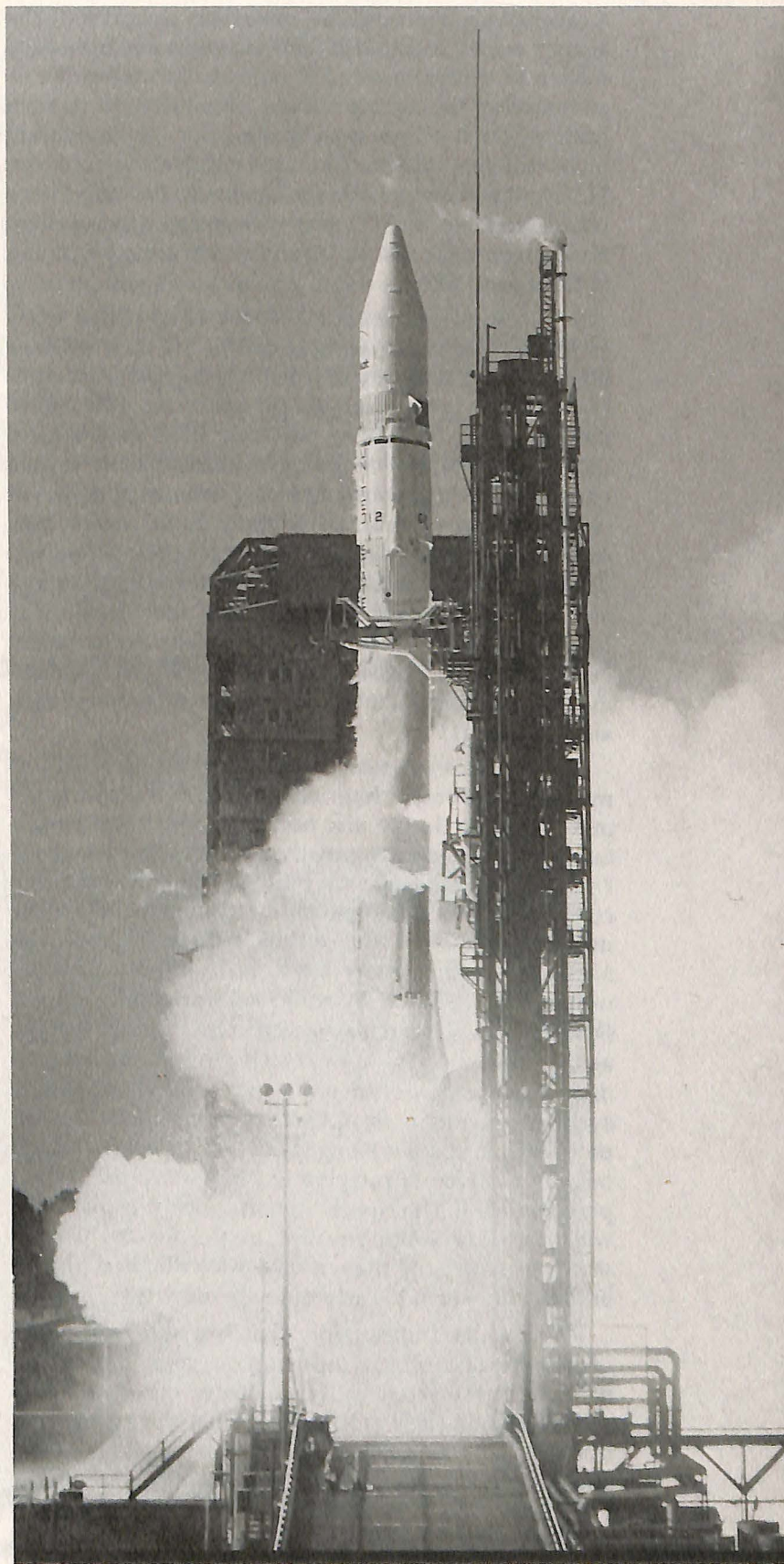
¹⁵For a detailed account of ASTP, see NASA, *Zero-G Technology*, Apollo-Soyuz Pamphlet No. 8, U.S. Government Printing Office, NASA-EP1401976, 59 p.

duction of drugs but sometimes made difficult, or impossible, on Earth because of gravity-induced effects preventing the proper separation of the materials. All the experiments produced interesting results, although some were questionable due to the design of the experiments, which was often hurried, or designs were built to fit a particular space which did not allow proper operation. This led the Space Applications Board of the National Research Council to question the entire concept of materials processing in space. Having found little of interest in any of the crystal growth or electrophoresis experiments, their report concluded that "... the Committee has not discovered any examples of economically justifiable processes for *producing* materials in space and recommends that this area of materials technology not be emphasized in the NASA program."¹⁶

Despite such pessimistic findings, the scientists at McDonnell Douglas and Johnson and Johnson decided to proceed with plans to cooperate in the design and development of an operational electrophoresis facility to fit on the Space Shuttle. Under a Joint Endeavor Agreement (JEA) with NASA, this was flown free of charge for the first five trial flights. The experiments proved so successful that the first batch of drugs to be produced in space for use on Earth was processed on Shuttle flight 41-D in August 1984, and returned to Earth for testing by the Food and Drug Administration. The earlier tests showed that the space environment allowed 700 times the productive capability, and five times the purity of terrestrial facilities for the drug manufactured. The two companies anticipate sales of the first drug to be in the region of \$1 billion annually by the early 1990's. In the mid-nineties they will be manufacturing three drugs, and by the late nineties, 10 drugs.¹⁷

Materials Processing - Commercialization Issues

Other materials processing possibilities have been slower in attracting commercial attention. NASA had held high hopes in the late seventies that once the Shuttle was in operation, a number of companies would quickly take advantage of the opportunities offered for experimentation in this area. It was felt that the results of the crystal growth experiments, in particular, would attract corporate funds, and in its 1980-84 five-year plan the agency forecast higher expenditures in this area, in order to keep up with the anticipated demand for additional research and other services. The expected cus-



¹⁶Space Applications Board, Academy of Engineering, National Research Council, *Materials Processing In Space*, Washington, D.C., National Academy of Sciences, 1978, p. 5.

¹⁷*Aviation Week and Space Technology*, June 25, 1984, pp. 52-56.

tomers did not materialize, however; as a result, the agency cut its anticipated 1984 expenditures from \$100 million to approximately \$20 million. This raises the issue whether the agency should not undertake its own basic research rather than waiting for expressions of interest from others. One recommendation of the NASA Task Force on Space Commercialization Policy established late in 1983 was to increase concentration and budget expenditures again in this area, beginning in fiscal year 1986.

This over-estimation by NASA of corporate interest in carrying out space research in the early eighties highlights the difficulty of a publicly-supported institution trying to understand the private sector. Few corporations would be able to persuade their stockholders that sufficient knowledge is available about crystal growth in space to warrant placing millions of dollars at risk in such a venture, particularly as the nation was experiencing a recession during most of the period under review. This, coupled with a reluctance to commit to any in-space research activities until the Shuttle was fully operational, does much to explain the apparent lack of corporate interest in even discussing the possibility of negotiating a Joint Endeavor Agreement in materials processing.

The JEA is an excellent tool devised by NASA to make the extremely high cost of space transportation more bearable during any necessary initial experimentation period in crystal growth or other such endeavors. Under a JEA, the agency offers free flights for those companies undertaking such experimentation, on the understanding that the results will be shared with NASA on a proprietary basis. NASA has negotiated numerous JEA's but, by mid-1984 only one company (Microgravity Research Associates) had signed such an agreement with NASA for crystal growth research. Today, other companies are or have concluded negotiating such agreements with NASA, showing that materials processing in space is being taken seriously. What is still missing is a way of carrying out long-term *manned* experimentation. The Space Station, once it is available, will provide this opportunity. In the meanwhile, researchers have only the ten-day, power-limited Shuttle orbiter with which to carry out experiments.

The general uncertainty that has surrounded the entire issue of commercializing space has evidently contributed to the seeming reluctance of corporations to enter this field. It is only recently that the administration has taken an active interest in the question of commercial space development. The announcement by the President in July 1984 of a National Policy on the Commercial Use of Space will most likely result in increased

interest in this area, provided that it is followed-up by the requisite legislation.

Another boost for the commercialization process resulted from deliberations of the Senior Interagency Group on Space which, at the request of President Reagan, prepared a National Strategy for Space policy statement. The strategy announcement in August 1984 reaffirmed some earlier stated goals and directed implementation of a number of initiatives including the identification of new, major long-range national space goals. The administration also directed NASA to submit a plan for full Shuttle cost recovery. The Office of Management and Budget was directed to submit an analysis on the competitive pressures between the Shuttle, U.S. commercial expendable launch vehicles and foreign vehicles such as the European Space Agency's Ariane. These are promising steps. As long as the new policy reflects support for and an understanding of industry's desire for an assured, stable and predictable investment environment, it can only help with the long-range commercial development of space.

Meanwhile, the Congress, disturbed by the apparent lack of direction in the nation's space program, enacted legislation requiring the President to establish within ninety days a National Commission on Space. Within twelve months, the Commission would prepare a long range plan for U.S. civilian space activities and recommend appropriate legislation to support it. Although the President announced the establishment of the Commission in October 1984, there was a delay in the appointment of members until the spring of 1985.

Once the Commission is operational, it is assumed that it will undertake a number of studies into various space sectors. The commercialization process is almost certain to be one. Provided that its recommendations are acted upon, the Commission could do much to provide a long-range planning and public education function. From the viewpoint of the commercialization process, the Commission's findings could act as a catalyst to ensure that the necessary adequate and supportive regulations are passed to help with its initiation.

Remote Sensing - Background

Very early, it was realized that space offered a new and potentially valuable vantage point from which to view the Earth and to obtain data useful for managing its resources in a more rational manner. Between 1964 and 1978, NASA flew seven successful Nimbus research earth sensing satellites. Nimbus was the forerunner of several generations of weather satellites (TIROS, ESSA, NOAA, GOES), the experimental Applications Technology Satellites (ATS) series, and today's Land-

sats.¹⁸ Major advances in land remote sensing—development of the multispectral scanner and associated return beam vidicon, and the thematic mapper—were developed through programs that followed Nimbus.

Although the Administration at one time proposed the private operation of the weather satellite system, the proposal ran into heavy opposition in the Congress and was subsequently withdrawn. Only the Landsat system is now being considered for privatization.

A distinction must be made here between "privatization" and "commercialization." The first term refers to a process in which the private sector takes over the operation of a system which was originally developed and operated by the government. Very often, at least in the initial stages, some form of subsidy, or market guarantee is included. Commercialization, on the other

hand, refers to a process or product developed and operated by the private sector with its own funds.

The Landsat system is made up of two remote sensing satellites equipped with special instruments that "read" the "signature" reflected by all objects on the ground. It is difficult for lay people to appreciate just how much information the trained eye can glean from these images, and the multiple uses to which the information is put by scientists in government, industry, and other organizations, and by users around the world.¹⁹ The accompanying table enumerates some of the academic disciplines involved, but does not do justice to the scope and magnitude of the day-to-day applications of this data.

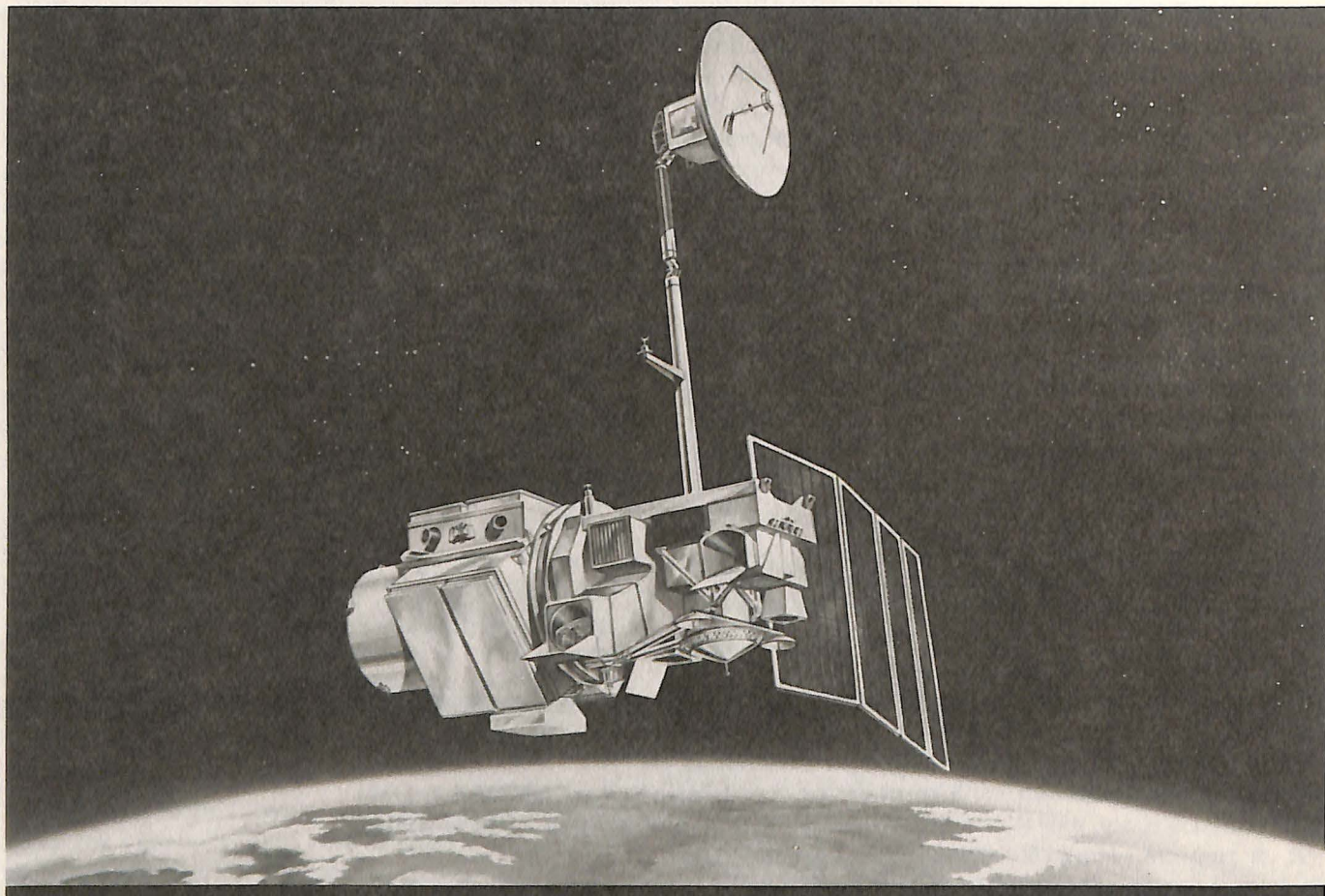
Some observers believe Landsat to be one of the great technological developments of all time. Two writ-

¹⁸A description of these satellites and their operation may be found in U.S. Department of Commerce, National Environmental Satellite Service, *Catalog of Products*, Washington D.C., third ed., 1980, 120 p.

¹⁹For a brief outline of Landsat technology and some applications, see, U.S. Department of the Interior, Geological Survey, *Studying the Earth from Space*, Washington D.C., 1977, 26 p., pp. 1-7.

TABLE 1
Summary of Applications of LANDSAT Data
in the Various Earth Resources Disciplines

Agriculture, forestry, and range resources	Land use and mapping	Geology	Water resources	Oceanography and marine resources	Environment
(1) Discrimination of vegetative types: Crop types Timber types Range vegetation	(1) Classification of land uses (2) Cartographic mapping and map updating (3) Categorization of land capability	(1) Recognition of rock types (2) Mapping of major geologic units (3) Revising geologic maps	(1) Determination of water boundaries and surface water area and volume (2) Mapping of floods and flood plains	(1) Detection of living marine organisms (2) Determination of turbidity patterns and circulation (3) Mapping shoreline changes	(1) Monitoring surface mining and reclamation (2) Mapping and monitoring of water pollution (3) Detection of air pollution and its effects
(2) Measurement of crop acreage by species	(4) Separation of urban and rural categories	(4) Delineation of unconsolidated rock and soils	(3) Determination of areal extent of snow and snow boundaries	(4) Mapping of shoals and shallow areas	(4) Determination of effects of natural disasters
(3) Measurement of timber acreage and volume by species	(5) Regional planning	(5) Mapping igneous intrusions	(4) Measurement of glacial features	(5) Mapping of ice for shipping	(5) Monitoring environmental effects of man's activities (lake eutrophication, defoliation, etc.)
(4) Determination of range readiness and biomass	(6) Mapping of transportation networks	(6) Mapping recent volcanic surface deposits	(5) Measurement of sediment and turbidity patterns	(6) Study of eddies and waves	
(5) Determination of vegetation vigor	(7) Mapping of land-water boundaries	(7) Mapping landforms	(6) Determination of water depth		
(6) Determination of vegetation stress	(8) Mapping of wetlands	(8) Search for surface guides to mineralization	(7) Delineation of irrigated fields		
(7) Determination of soil conditions		(9) Determination of regional structures	(8) Inventory of lakes		
(8) Determination of soil associations		(10) Mapping linears (fractures)			
(9) Assessment of grass and forest fire damage					



ers recently noted: "Historians of the future may well compare its development to that of the wheel, so revolutionary and so basic may become its ultimate impact on society."²⁰ The United States, from the outset of the program, made the data from Landsats available at cost to all comers. This proved a boon to the developing nations, which in many cases were able for the first time to measure the extent and location of their resources, as well as to map their countries.

Remote Sensing - Commercialization Issues

Providing remote sensing data at cost proved, however, to have a double-edge. Although the United States insisted that the satellites were only experimental, a growing body of users quickly developed around the world. These users were and are interested in the continuation of the data on an ongoing operational basis. Successive U.S. governments have tried, but have

never successfully dealt with this dilemma. The Reagan Administration finally decided that the system should be handed over to a commercial venture for development and operation.

Immediately, however, came the question of how a company could make an adequate return from a system which had been heavily subsidized by the government. Obviously, it would either have to raise the price of the data substantially or receive an ongoing operational subsidy. Toward the end of July 1984, the government announced that it would provide a subsidy of \$70 million for the year 1985, with additional amounts in the following years. It placed a cap of \$250 million on the total subsidy. Two companies were then in the competition for Landsat, but one group (Kodak/Fairchild) later withdrew, leaving only Earth Observation Satellite Company, or Eosat (a joint venture of RCA and Hughes Aircraft, with Computer Sciences Corp. and Earth Satellite as major subcontractors) as a candidate.

It had originally been expected that the federal subsidy involved in the privatization of Landsat would total nearly \$1 billion over six years, with a payout at approx-

²⁰William D. Nixon and Richard E. MacCormack, "Landsat: A Tool for Your Classroom," *Social Education*, Vol. 41, No. 7, November-December, 1977.

imately \$150 million per year. The much lower amount of \$250 million was apparently a compromise reached between Commerce Secretary Malcolm Baldrige and Office of Management and Budget Director David Stockman. The White House reportedly agreed to the plan only after a discussion of whether the lower amount would be seen to conflict with the President's enthusiastic endorsement of the privatization of Landsat.²¹ There is some reason for White House concern because, unless customer charges are increased (very difficult under congressional legislation governing the privatization of Landsat—see below), it would appear most unlikely that a company could make sufficient profit to maintain ongoing research and development and to operate the system.

At the end of October, 1984, however, the government plan to privatize Landsat had stalled over a failure of Congress to appropriate the initial subsidy funds before adjournment. The Office of Management and Budget had ruled against such a request to Congress at this time. The delay in the transfer of Landsat to commercial operation may lengthen the anticipated interruption of transmission of pictures of Earth from Landsat, expected to degrade by 1987. Meanwhile, SPOT Image Corporation, a French-controlled company, will launch its own Earth-imaging satellite in 1985, which, with higher resolution capabilities, will be in strong competition with any American effort.

Some of the losers in the earlier bidding for Landsat, it was reported, intended to offer alternative systems of their own. They may find this a losing proposition in view of the congressional legislation that has been passed governing the use and distribution of remotely sensed data.²² The legislation states that data scanned by sensors on U.S.-made spacecraft must be available to any buyer at minimal cost. Further, U.S. spacecraft must be licensed by the Secretary of Commerce; a copy of all data must be sent to the Depart-

ment of Commerce's archives, from where it may be distributed to anyone; Commerce Department approval is to be obtained before any foreign customer is approached; and the Commerce Department reserves the right to inspect all satellites and all ground-based hardware and software, including that located in client countries.

These are extremely onerous provisions if they are closely adhered to in practice, and ones which may discourage any commercial company from offering remote sensing services in competition with Landsat. In this case, the legislation may well adversely affect U.S. relations with other industrial nations, who could see it as an effort to unfairly restrict international trade. This could have a boomerang effect in ongoing discussions with these nations regarding cooperative projects with the United States.

On the other hand, in a classic example of just how complex these issues can be, the continuing provision of remote sensing data at an affordable price will be well regarded by the majority of third world nations that have come to depend on it for information about their own country. In this case again, the government is caught in a dilemma between its foreign policy needs and the needs of its commercial sector.

Undoubtedly, the decision to continue subsidizing Landsat data has an impact on the commercialization prospects for remote sensing. This can already be seen in the decision by Sparx Corporation not to continue with its planned flight on the Shuttle of a special remote sensing camera mounted on the German SPAS free-flying satellite. Sparx opted to use the European Ariane launch vehicle instead, thus avoiding the provisions of the Congressional legislation that apply only to U.S. vehicles and satellites.²³ In this case, the effect of the legislation, which was aimed at protecting a national system from competition, was to provide a new customer for foreign competitors.

²¹*Satellite Week*, Vol. 6, No. 31, July 30, 1984, pp. 2-3

²²U.S. Senate, *Land Remote-Sensing Commercialization Act*, 98th Congress, Report 98-458, May 14, 1984.

²³*Aviation Week & Space Technology*, June 25, 1984, pp. 147-49.

Space Commercialization: National Issues

Public Perceptions: The Need for Information

Some other nations (e.g., Soviet Union, Japan and the European nations represented in the European Space Agency) are indicating that they believe space to be the arena in which the next industrial revolution will occur, and are preparing themselves accordingly. To remain competitive, the United States will need to do more in space than at present. This will require a greater public understanding of what is at stake than now exists.

It is for this reason that the Reagan Administration has made public education an important part of its space policy initiatives. At present, the media, outside of the technical press, appear to be still unsure whether space should be covered as a "gee-whiz" event, or as a serious area of vital economic concern to the future well-being of the nation. There is very little understanding of the possibilities of commercial development in space. The media and the public, if they think of it at all, appear to understand only that the space communications industry is doing so well that they don't have to be concerned about it.

Public information is, then, a basic issue. Without an informed public, it will be difficult for even the most supportive administration and Congress to place greater emphasis on space development without running the risk of creating the kind of backlash that brought about the early demise of the Apollo program.

Corporations should take an active part in public education. Corporate information efforts should present the opportunities, problems, plans and accomplishments of space commercialization.

Political Activities: Lack of a Constituency for Space

The space program cannot operate in a political vacuum nor will commercialization occur on its own: government support is required and a strong space constituency will have to make itself heard in order to influence the type and extent of that support.

To date, the lack of a defined space constituency has slowed progress toward the resolution of space-related issues. An important role for aerospace industries to play would be to ensure that Congress and the public is made more fully aware of the need for enabling legislation to help private industry enter space. Industry support may also be required to enhance the effectiveness of the Reagan Administration's policy on space commercialization. (The document outlining the policy was released July 20, 1984, a copy may be found in Appendix C; its contents are examined in the later section on Financial Issues).

An industry advisory panel had been assembled by the administration to suggest specific items for inclusion in the policy initiative and the result plainly shows its input. Public reaction to the policy will provide an indication of the nation's willingness to accept a strong private sector in space, as well as industry's readiness to pursue one. To ensure that the practice will be equal to the words, industry may need to cooperate actively to push for implementation of the policy initiatives. Another opportunity to influence regulatory policy was afforded industry in late September 1984 when Transportation Secretary Elizabeth Dole appointed 23 members, mainly industry executives, to a DOT advisory committee to promote the commercial space industry. A third opportunity will come with the establishment of the National Commission on Space. There is no reason that, given the opportunity, the private sector cannot develop space just as successfully as it has developed other areas of the terrestrial economy.

Establishing Markets

The real driver for space commercialization will be the identification of the economic value of space products and services, i.e., the identification of markets. As noted early in this report, an existing market for broadcast communications led to the relatively rapid success of satellite communications—satellites being a more effi-

cient means of long-distance communications. Venture capital will undoubtedly be available for space ventures (a later section in this chapter examines this issue), but a prerequisite for investment is the real possibility of return. Market risk, not technical risk, is the venture capitalists' major concern when it comes to space projects, one investment manager has explained.¹ And more investment possibilities need to be identified. Aerospace analyst Wolfgang Demisch believes the private sector needs to come up with new products and projects in order to get Wall Street's attention.² Just as important is the necessity of identifying the full range of potential benefits of projects already underway.

Despite the difficulties, numerous commercial enterprises have been pursuing space business opportunities in the areas of transportation, communications, remote sensing, manufacturing and services. *Aerospace*

America recently placed the number at 350 firms.³ It is generally thought, however, that few firms will survive the early period of commercialization because of insufficient business volume. In the ultimately promising materials processing area, for example, experts point out that only very high-value products can be immediate candidates for space production: drugs and semiconductors are examples.⁴ Advances in space manufacturing have the added disadvantages of having to compete against constant advances—and improved economics—in materials production on Earth. A stimulus for space investment, however, could be process innovation: the opportunity to better understand and improve upon Earth-based manufacturing techniques.

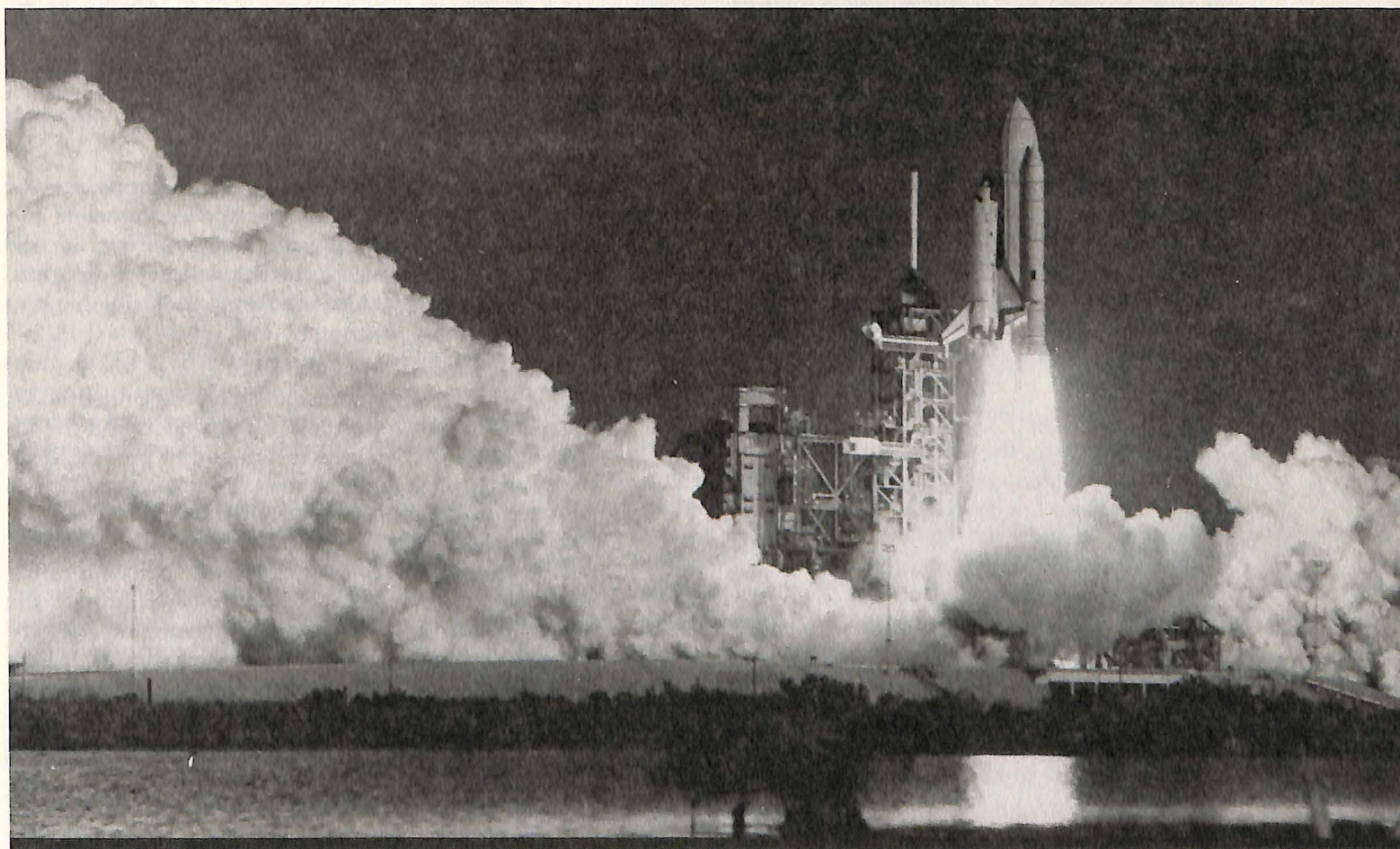
The existence of the space station should bring costs of production in space down, but until that time,

¹"Financiers Interested, But Not Yet Sold, On Space Business," *Space Business News*, April 9, 1984, p. 5.

²*Ibid.*

³Jerry Grey, "Investing in Space: Now, Soon, or Later?" *Aerospace America*, April 1984, pp. 91.

⁴John Hillkirk, "Outer Space: Factories of the Future," *USA Today*, December 7, 1982.



the market for space products is seen as being very limited in many areas. A great deal of research and experimentation will have to precede the offering of new products and services with real economic potential, and this will require considerable, high-risk investment. If the private sector is to make a substantial investment in the all-important foundation of space research, a stable business environment will be essential. How the government might address itself to this problem is discussed in the following sections on bringing research to market and the formation of capital for investment.

The aerospace industry has traditionally been more concerned with providing the infrastructure for potential space commerce than with potential products and services. Aerospace can, however, explore space venture possibilities in concert with other industries. Joint R&D ventures provide one means through which aerospace can help identify the real economic potential of space.

Although the aerospace industry's support will be essential to the successful commercialization of space, the industry's cooperation with space entrepreneurs and other space commercialization supporters may require adaptation of its risk/reward perspective. Good management requires a skillfully balanced assessment of risk and reward, but the potential rewards of space enterprises may require a greater degree of risk than the industry would normally consider judicious. As other countries become more and more competitive in space—with government support in many instances—the question is whether the U.S. aerospace industry can afford not to assist in establishing a solid foundation for commercial space ventures. Without the industry's support, the commercialization program will certainly remain smaller than it could be with the industry behind it but, in the end, a lack of support for space enterprise could cost the industry substantially.

For some time, the bulk of in-house R&D funds in the aerospace industry have gone to aeronautical programs, and there has been little motivation to spend on research in another, still higher-risk area with a great many unknowns. Yet, clearly, the industry's own lack of commitment will not encourage venture capitalists and other funding agencies outside the space field to place new investment capital at risk either.

Successful commercial development of space will, most likely, necessitate a change toward more of a risk-taking stance on the part of industry, and the development of enlarged in-house research and development activities oriented toward potential commercial ventures in space.

The aerospace industry needs to carefully examine and take advantage of potential opportunities presented by NASA's new Commercial Space Policy, announced in October 1984. NASA has proposed stimulation of private sector research with agency seed funding. However, a guiding principle will be that the Government should not expend tax dollars for endeavors the private sector is willing to underwrite. Should the seed money NASA envisions become available, the private sector will still have to have significant capital at risk. It will also have to show solid expectations for very significant national benefits.

NASA also hopes to encourage space R&D through:

- New NASA research designed to enhance and encourage commercial space endeavors;
- NASA purchase of selected space venture products and services;
- Quicker decisions on joint endeavor agreements;
- Planning to encourage private development of new support hardware and space-related services not essential to maintaining NASA developments, as well as investment in facilities necessary for commercial use of space; and
- Support of industry/university/government advanced research institutes to highlight research transferable to commercial product development.

Aerospace can be active in pursuing opportunities made possible by this government policy statement and in pressing for policy implementation. (See later section on The Role of NASA for further details on the Commercial Space Policy. Also see Appendix D.)

Bringing Research to the Market Place

One of the major issues affecting the United States competitively is the flagging of innovation and the increasing time that elapses in bringing a product from the research stage to the market. In recent years, it has not been uncommon to see another country market a product based on U.S. research, before any U.S. corporation can do so. This may be largely the result of the very high cost of carrying basic research through the demonstration and development phases, and the consequent decisions of business not to accept such high levels of risk. In other nations, much of the cost of research and development activities is often borne by government while in the United States, industry is usually expected to bear a larger share of the costs.

This barrier has particular impact on the commercial development of space, because of the extremely

high costs and long lead times associated with space ventures. Today, only the very largest companies can afford the costs associated with bringing new space technologies to market. This is unfortunate since much innovation in this country takes place in small concerns.

In recent years, Congress has attempted to address this slow-down in innovation in the United States. Several variations of development banks have been suggested in order to help smaller concerns find capital at a rate that they can afford; none of these ideas have attracted sufficient support to be passed into law. The Stevenson-Wydler Act, which became law October 21, 1980, approached the problem of innovation in a different way.⁵ The Act's originators and supporters believed that the most effective way for the nation to meet the problem was through the establishment in different parts of the country of a number of Industrial Technology Centers, and through fostering an exchange of scientific and technical personnel among academia, industry, and Federal laboratories and research institutions. Despite the authorization of funds by the Congress, this innovative approach to the issue of bringing research to market is being only partly implemented by the present administration (none of the Industrial Technology Centers are being established).⁶

The slowdown in U.S. innovation is a major problem for the country and remains a significant barrier to the rapid development of space.

Financial Issues

Financial issues in the area of space commercialization fall into three categories: those the result of or responsive to government regulations or incentives; those the result of or responsive to private sector activity; those the result of or responsive to the space environment itself. The latter includes such issues as the high cost of going to and of operating in space; and the need for insurance and other additional costs and requirements brought about by the special environment of space.

Private sector issues include such questions as the internal financing capabilities of aerospace corporations, possible problems in raising sufficient venture capital, available alternatives, and implications of requesting special treatment for space enterprise from the federal government.

The role of government comes into play in such issues as the impact, positive and negative, of the Investment Tax Credit, the Accelerated Cost Recovery System, R&D Limited Partnerships, and others. These federal incentives for investment have been of considerable concern because many of them were formulated prior to the advent of space development, consequently, with certain exceptions, they do not apply to space ventures. This has a negative impact on the possibility of finding sufficient capital in the regular financial market structure to develop this sector within a reasonable time-frame. A number of similar existing rules and regulations are also seen as possible barriers to this process if they are to remain unchanged. Fortunately, the National Policy on the Commercial Use of Space, announced by President Reagan in July, 1984, deals with many of these issues and, provided the policy is carried out, will do much to erase the uncertainties over space investment.

The economic incentives announced in the President's policy statement include the following:

- Replace the current "carry-on test" for the 25 percent research tax credit with provisions allowing corporations engaged in a trade or business to form joint ventures and be eligible to use any R&D tax credits resulting from the venture.
- Modify the tax code to assure that space capital projects owned principally by United States interests and operated for domestic purposes are eligible for the 10 percent Investment Tax Credit and the accelerated cost recovery system.
- Facilitate long-term contracts with new space ventures if the government has a need for the product and if the purchase would be cost-efficient.
- Direct the Treasury to develop a proposal designed to identify those prototypes eligible for the R&D credit even though they will eventually be used in commercial service, so that the current uneconomic incentives will be reduced.
- Clarify the appropriate tariff regulations to ensure that space-made products are not considered imports when returned to the United States.*⁷

⁵U.S. Congress, Public Law 96-480, Oct. 21, 1970, 96th. Congress, 94 Stat. 2311.

⁶Secretary of Commerce, Report to the President and the Congress, *The Stevenson-Wydler Technology Innovation Act of 1980*, Department of Commerce, February, 1984, 59 p.

*The Trade and Tariff Act of 1984 contains a provision permitting products manufactured in space by U.S. companies to enter the U.S. without import duties.

⁷White House, *National Policy on the Commercial Use of Space*, Fact Sheet, Washington D.C., July 20, 1984. 4 p.

To ensure implementation of these initiatives and to "establish a high-level national focus for commercial space issues," a Working Group on the Commercial Use of Space is being created within the Cabinet Council on Commerce and Trade (CCCT). The Working Group is to be chaired by a representative of the Commerce Department, with a representative of NASA as vice chairman. It is to be hoped that the group (working in concert with whatever policy-making organization results from the recommendations of the Senior Inter-agency Group - Space) will help establish long and short-term budget levels for the space program. For the past ten years, the Office of Management and Budget (OMB) has acted as an unofficial policy-setting body through the establishment of annual budget levels that NASA was not to exceed. This, coupled with the annual budget review process, places a heavy restraint on the successful development of high-technology ventures by any U.S. government agency.

One qualification expressed in the administration's space policy pronouncement is that changes will be made "in accordance with decisions on fundamental tax reform later this year." The public debate over taxation could strongly impact any progress on economic incentives for space business. Nonetheless, a fundamental point has been made: until now, space has been treated differently from other economic sectors and this needed to be changed.

The administration's policy initiatives are essential to the incorporation of space commercialization into the ongoing economic fabric of the nation. Without the suggested changes, space commercialization will continue to be regarded as a special case with all the negative ramifications that entails, particularly when attempting to raise funds for commercial ventures. The venture capital community is unlikely to place funds into high-risk areas that are outside existing regulations, or have special problems of their own, unless they also have special features to attract investment. This raises the issue whether space ventures should not receive special treatment from government through specific tax breaks and other means.

The oil and gas industry, for example, has a special tax provision allowing exploration companies to write off "dry holes." A case could be made for a similar provision to apply to failed space launches. But on balance, special treatment may be less of an advantage than it at first appears. Special cases can often have a boomerang effect, causing other groups to plead their own case. The final result can be an excessively fragmented approach to investment, and more regulation.

If space commercialization is to be facilitated without special investment and regulatory treatment, how-

ever, it will be necessary for the space community to ensure that the economic initiatives proposed by the Reagan Administration are put into effect. Equally important, financial and organizational problems associated with the development of important generic technology and with moving new processes from the basic research phase through their demonstration phase, will need to be identified and corrected. These issues may well have greater impact upon space commercialization than all others.

There are two areas of concern regarding the Reagan Administration's policy initiative that will require specific attention from the space community: one is the 25 percent research tax credit that will end for everyone at the close of 1985 unless there is legislation to the contrary. The Senate proposed such legislation in the 98th Congress, but it was lost in conference with the House of Representatives. Legislation should be introduced and passed early in the 99th Congress or the lack of a research tax credit will become a major barrier to obtaining venture capital funds.

The other area of concern is that the administration's policy initiative did not deal with the issue of the tax value of benefits received under a JEA with NASA. This is an important issue because if JEAs are treated as income for tax purposes it would obviously benefit signees if they are taxed at less than their full value. According to reports, the question whether launches obtained under a JEA are taxed at less than the full amount NASA would charge if there were no JEA is already so contentious within the Treasury that it has been withdrawn for the time being.⁸ This is another indication of the difficulty to be expected if the space commerce community requests or expects special treatment.

Although most terrestrial commercial ventures face problems in obtaining financing, in meeting competition from similar or alternative products, in maintaining profitability, paying back investors, and so forth, these difficulties are greatly magnified for space entrepreneurs who also face additional problems not encountered by their terrestrial counterparts. These include: the long lead time and high costs associated with space ventures due to the need for new technology, and the difficulty or impossibility of testing processes without going into space; the very high transportation costs, coupled with long lead times; the need to process only light weight (mass) very high value materials; the additional uncertainty of competition, not only from other space entrepreneurs but from newly-developed or re-

⁸Space Enterprise Today, August 1984, Vol. 1, No. 4, pp. 1-3.

TABLE 1
Venture Capital Pool 1977, 1982, 1983
(\$ Millions)

	1977	% of total	1982	% of total	1983	% of total
Individuals & Venture Capital Partnerships	\$ 887	35%	\$4,400	58%	\$ 7,600	66%
Small Business Investment Corps.	612	24%	1,300	17%	1,500	13%
Corporate Funds (other than SBIC's)	1,022	41%	1,900	25%	2,400	21%
Totals	\$2,521	100%	\$7,600	100%	\$11,500	100%

SOURCES: 1977, 1982 — Office of Technology Assessment, *Commercial Biotechnology*, p. 278;
1983— *Venture Capital Journal*. Telephone conversation, June 1984.

fined, ground-based alternatives or processes; and finally, the difficulty of having to create a market for what in most cases will be a new product.

All these factors taken together make space a very high-risk investment. In the communications sector, the risk was mediated to some extent because of a known, growing market demand, coupled with an existing infrastructure. Neither a clear demand, nor an infrastructure exists in the other sectors, making the risks even higher in these areas.

There is considerable disagreement among financial experts regarding the availability of venture capital for commercial development of space. James E. Connor, of the First Boston Corporation, noting that the large investment pools in this country are in trust for pension funds and depositors, points out: "That money is not risk money. When people say there are large pools to be tapped for risky ventures, they are kidding themselves." Others agree, noting the tens of millions of dollars required for most space ventures, versus the average five million dollars for new terrestrial projects. As a result, many start-up ventures include a large corporate partner supplying much of the initial capital funding.

At a conference on space business opportunities in May, 1984, David Thompson, president of Orbital Sciences Corporation, outlined four sources of private investment:

Equity Financing
in which stock in the new company is exchanged for capital investment

Debt Capitalization
in which term-loans are made available by lenders, usually against collateral

Internal Funds
in which funds generated within an existing business are reinvested in new projects

Innovative Financing
in which R&D Limited Partnerships and/or long-term convertible debt instruments are used to generate funds⁹

Thompson noted that current growth rates in space commercial investments, if extrapolated, would reach approximately one billion dollars per year by 1987. He estimated that some \$265 million had been invested in this field in the four years from 1980 to 1983. The division of these funds, however, tends to reinforce the

⁹David W. Thompson, *Space Enterprise and Capital Formation*, Financing Business in Space Conference, Arlington, Va., March 26-27, 1984, pp. 4-5.

position of those who feel that most capital for space ventures will come from internally generated financing, coupled with outside borrowing. Thus, of the \$265 million, \$180 million was internally generated; \$12 million came from outside borrowing; \$21.5 million from equity financing, and approximately \$51 million through R&D Limited Partnerships, or debt/equity instruments.¹⁰

Given that space ventures are accorded equal treatment with Earth-bound enterprises, it appears that the most potent source of venture capital for new space organizations may come through R&D Limited Partnerships. Such partnerships have attractive features for both parties concerned. The general partner (i.e., the company seeking funds) assumes all liability; the limited partner (often an individual investor) is liable only for the loss of his investment. For a company, the most attractive feature of this arrangement is that the funds are paid in up front with no loss of equity, and they appear on the balance sheet as revenue rather than debt, enhancing the chances of the corporation obtaining additional funds. For the limited partner, the most attractive feature is that profits and losses passing through the partnership can be taken each year and combined with other income and expenses. In addition, limited partners can immediately deduct 85-95 percent of their initial investment; this decreases their after-tax cost and risk while more than doubling their potential rate of return.¹¹

The attractiveness of these features to investors can be seen in the rapidly increasing amount of venture capital funds available from individuals, as reflected in the table on page 25.

Insurance Issues

Space insurance became a topic of public discussion after the loss of two communication satellites on STS-11, but it had already been a subject of concern for some time for those who were a part of the industry. Figure 1 to the right shows why:

It can clearly be seen that space insurance has never been overly profitable and, in fact, that the market has been in some trouble since 1977. Brian Hughes, Senior Vice President of U.S. Aviation Underwriters Inc., explains that space insurance in the seventies and early eighties suffered from an overly competitive situation. This was due to a move into this new area by a number of marine insurance underwriters, who were

facing a slack market, consequently space insurance rates fell sharply.¹²

Mr. Hughes has outlined some of the risks involved in space insurance:

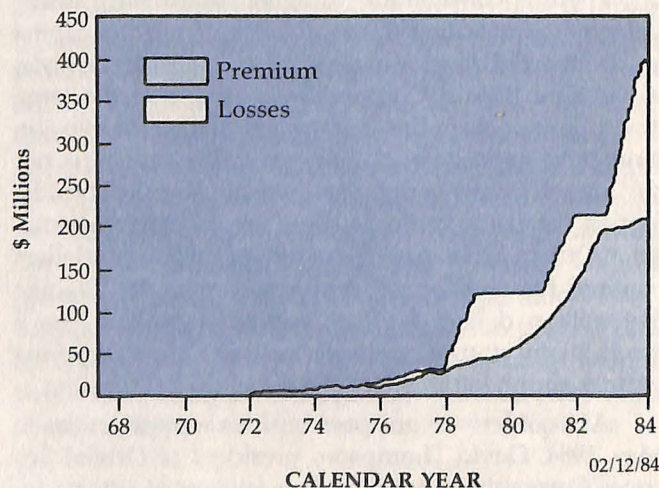
"(In the space insurance business) the probability of loss is relatively high, somewhere between 8 to 15 percent of launches will fail. Which launches will fail is unpredictable. The values at risk range from \$65 million to \$125 million per spacecraft. Multiple satellite launches on the Shuttle and Ariane can increase the exposure to \$250 million or more."¹³

Inevitably, results were as predicted, and as the figures show, every year for six years the business took some heavy losses, culminating in the \$190 million loss of the two communication satellites on STS-11 in February 1984 when rocket misfires failed to propel them into the proper orbit. During the previous two years there had already been a reduction in the worldwide space insurance available, as more and more companies, stung by losses in previous years, left the market. The loss of the Westar and Palapa satellites in February 1984 was expected to create an even tighter market for insurance, posing a possibly severe barrier to the fledgling

¹²Personal interview, February, 1984.

¹³Brian G. Hughes, *Insurance and Regulation of Commercial Space Activities*, Financing Business in Space Conference, Arlington, Va., March 26-27, 1984, p. 9.

FIGURE 1
Cumulative Net Premiums & Losses



¹⁰Ibid., pp.5-6.

¹¹For a discussion of R&D Limited Partnerships, see U.S. Congress, Office of Technology Assessment, *Commercial Biotechnology: An International Analysis*, Washington D.C., 1984, pp. 278-279.

space commerce sector. Despite retrieval of the satellites during the November 1984 flight of the Shuttle Discovery, space insurance rates are expected to increase substantially.¹⁴

No one knows just how severe the shortage of insurance money is going to be. In March, 1984, Brian Hughes estimated that there was already a shortfall approaching 50 percent to cover the launches projected for 1984. That was two months before the failure of the two satellites on STS-11 to reach the correct orbit. With a considerable increase in launches projected for the next three years, a potentially serious situation is in the making. Potentially serious because there will probably be a sharp increase in the price of insurance in order that supply will increase to meet demand. Some observers are unsure, however, that a doubling or even tripling of the price will bring enough insurance back into the space market to provide coverage for all those seeking it.

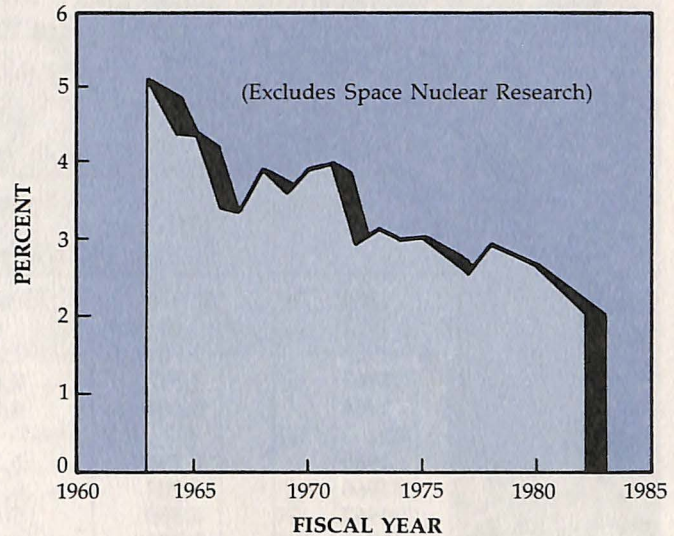
It is difficult to be precise on just how much higher the price of insurance is likely to be. During the period 1979-83 the net loss ratio for space insurance was 208 percent, i.e., more than twice as much was paid out by insurance companies in losses, as was taken in in premiums. To break even would require a doubling of the gross rate. As this represented approximately 8 percent of the value of a satellite during the period under review, an increase to at least 18 percent of the gross cost would not be unexpected. With the average cost of a satellite and its launch being close to seventy million dollars today, this would mean a gross premium of some \$12.6 million.

One may agree in principle with the view that if a doubling or even tripling of space insurance launch rates is enough to make a deal unprofitable it had no business being financed in the first place. On the other hand, launch costs are already uncomfortably high, and the increasing costs of insurance can only slow down the rate of space development. But, if there is insufficient insurance available at any cost, then some other way will have to be found to guarantee sufficient coverage if the commercialization of space is to continue at all. Jerome Simonoff, vice-president of Citicorp Industrial Credit Inc., suggested that NASA could become the insurer of last resort similar to the role of the Federal Reserve System. This idea did not receive very widespread acceptance on first hearing, most of those in the insurance business believing that the free working of

¹⁴For a discussion of this issue, see also *Aviation Week & Space Technology*, June 25, 1984, pp. 85-88, and November 19, 1984, p. 18.

FIGURE 2

Space R&T as Percent of NASA's R&D Budget



SOURCE: NASA/OAST

the market place would result in sufficient insurance being available.¹⁵

The Role of NASA

In the sixties, the National Aeronautics and Space Administration (NASA) was the world's preeminent research organization in space technology. In 1983, however, the agency spent less than one-half the amount (in real terms) on research and development that it spent through the latter half of the sixties (Table 2). Not only has NASA's R&D budget seriously declined but space R&T, as a percent of NASA's R&D budget, moved generally downward through the last decade (Figure 2).

By the eighties, the largest amount allocated to NASA research and development was being spent on Space Shuttle operations. Beginning in 1984, NASA restructured its budget to introduce the new category of space flight, control and data communications, as distinct from research and development (Table 2); these programs were formerly included in the research and development budget category total. Table 3 shows that

¹⁵Jerome Simonoff, *Government Industry Cooperation in Financing Industrialization of Space*, Financing Business in Space Conference, Arlington, Va., March 26-27, 1984, p. 4.

TABLE 2
National Aeronautics and
Space Administration
Outlays in Constant Dollars
 Fiscal Years 1960-1985
 (Millions of Constant Dollars, 1972 = 100^a)

Year	TOTAL	Research and Development	Construction of Facilities	Research & Program Management	
1960	\$ 576	\$ 368	\$ 78	\$131	
1961	1,057	692	139	226	
1962	1,761	1,311	160	290	
1963	3,517	2,635	310	573	
1964	5,664	4,504	595	565	
1965	6,792	5,313	708	771	
1966	7,707	6,159	744	804	
1967	6,830	5,648	364	818	
1968	5,739	4,794	153	792	
1969	4,933	4,097	75	761	
1970	4,122	3,286	59	776	
1971	3,537	2,750	46	740	
1972	3,422	2,623	50	749	
1973	3,174	2,433	43	698	
1974	2,906	2,160	67	678	
1975	2,649	1,963	69	617	
1976	2,782	2,084	92	606	
Tr. Qtr.	702	539	19	144	
1977	2,802	2,117	75	611	
1978	2,650	1,988	82	579	
1979	2,567	1,920	81	566	
1980	2,732	2,084	79	569	
1981	2,783	2,168	75	538	
1982	2,890	2,297	52	541	
1983	3,061	2,442	50	570	
Year	TOTAL	Research and Development	Space Flight Control and Data Communications	Construction of Facilities	Research and Program Management
1984 ^F	\$3,116	\$1,148	\$1,354	\$61	\$554
1985 ^E	3,099	999	1,472	69	560

SOURCE: AIA, derived from "The Budget of the United States" (Annually).

NOTE: Detail may not add to totals because of rounding.

^a Based on fiscal year GNP implicit price deflator.

^E Estimate.

TABLE 3
National Aeronautics and Space Administration
Budget Authority for
Research and Development and
Space Flight, Control & Data Communications

Fiscal Years 1983-1985
(Millions of Dollars)

	1983 ^a	1984 ^E	1985 ^E
RESEARCH AND DEVELOPMENT—TOTAL	\$1,903	\$2,028	\$2,400
Space Station—Total	—	—	150
Space Transportation Capability Development—Total ..	416	432	361
Space Science & Applications—Total	1,060	1,134	1,372
Physics and Astronomy	470	568	677
Planetary Exploration	186	217	287
Life Sciences	56	58	63
Space Applications	348	291	344
Technology Utilization—Total	9	9	10
Aeronautics & Space Technology—Total	405	439	492
Aeronautical Research & Technology	280	302	342
Space Research & Technology	125	137	150
Tracking and Data Acquisition—Total	13	14	15
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS—TOTAL	\$3,633	\$3,775	\$3,600
Space Shuttle Production & Operational Capability—Total	1,726	1,649	1,466
Orbiter	904	716	607
Launch & Mission Support	246	278	235
Propulsion Systems	576	618	599
Changes & System Upgrading	—	37	25
Space Transportation Operations—Total	1,422	1,452	1,339
Shuttle Operations	1,339	1,402	1,339
Expendable Launch Vehicles	83	50	—
Space Tracking & Data Acquisition—Total	486	674	796

SOURCE: "NASA Budget Briefing Background Material" (Annually).

NOTE: Detail may not add to totals because of rounding.

^a Shown on a comparative basis with the FY1984-85 budget structure, which introduces the new category of "Space Flight, Control and Data Communications Programs."

NASA's R&D budget authority for 1984 was only slightly more than half that allotted for space flight, control and data communications. Unquestionably, NASA's budget and resources have been significantly impacted by the Shuttle and, more recently, by Space Station activities. The agency expects to continue to operate the Shuttle and has announced worldwide launch market goals for the next few years; NASA plans to hire a private company to market the Shuttle for it.¹⁶ The private sector has expressed interest in operating the Shuttle for NASA but, to date, private companies have been unable to reach an agreement with the agency to do so.¹⁷

A number of Congressional leaders with an interest in the space program and representatives of the private business community feel that NASA's continuing concern with the operation of the Shuttle places the agency (and hence, the government) in competition with the private sector. Debate flourishes over the impact of the present federal support of the Shuttle program, which some feel makes it difficult for private operators to compete. Others point out that private and government-subsidized operations have existed side-by-side successfully in numerous instances—private and government satellite communications systems being one example.¹⁸ The issue of "full recovery pricing" is complicated, as discussed in the previous chapter with reference to expendable launch vehicles, by the need for the Shuttle to remain competitive with Europe's Ariane and to encourage R&D investment in innovative technologies. The apparent solution to these requirements—less than full recovery pricing of the Shuttle—seemingly conflicts with the Reagan Administration's policy of encouraging a private launch service industry.

The issue of Shuttle pricing is currently under review by the Reagan Administration; policy may well have been announced by the time of publication of this study. Maintaining the proper balance between operational and research activities within NASA is still an

other focus of debate within the administration regarding long-range space policy.

While the Shuttle program has heavily impacted the NASA budget, Shuttle "operations" contain significant elements of transportation "demonstration," including improvements important to continued development of a space transportation system. NASA Shuttle activities provide an assured, stable and improving transportation and space operations system with stable pricing, which is beneficial to the advancement of commercial ventures in space. However, some express concern that NASA's operation of the Shuttle represents an orientation of the agency away from its research functions, and endangers its status as a top technological research organization. This was the thrust of a letter from Congressman Zschau and five fellow Republican Congressmen who wrote President Reagan on July 18, 1984, drawing his attention to the problem.¹⁹

A Congressional Office of Technology Assessment (OTA) study, *Civilian Space Stations and the U.S. Future in Space*, addresses the issue of NASA's role in terms of the agency's commitment to the Space Station project. OTA notes that NASA's decision not to use existing hardware, but to embark on a large-scale, high-technology civilian Space Station, will foreclose for perhaps five to ten years the possibility of NASA's effecting any fundamental changes in its major program mix or in the way it acquires space technology. Such changes are seen by OTA as essential in order for the United States to respond to the beginnings of fundamental shifts in national and international circumstances: the development of competitive programs in Europe and Canada, and the emergence of private sector space capabilities. OTA stressed the importance of planning for international cooperation, which affords the option of reducing the cost of the space station to the American taxpayer by incorporating other countries into the overall planning, funding and building of the station.²⁰

In November 1984, NASA issued a Commercial Space Policy (Appendix D) which addresses some of the points which have been raised concerning its role. In addition to its plans to stimulate space R&D, an agency review of space facility plans is underway that could involve basic changes in acquisition procedures and lead to new commercial services, including commercial operation of the Space Shuttle.

¹⁶NASA, Office of Space Flight, *STS Marketing: Industry Briefing*, May 1, 1984, 11 p. The announcement that NASA hopes for 75 percent of the world launch market caused discussion concerning a public agency competing with the private sector. See *Space Business News*, July 30, 1984, p. 6.

¹⁷In 1981, SpaceTran of Princeton, N.J., attempted to purchase a shuttle but was unable to reach agreement with NASA, reportedly because the DOD was against the plan. In 1984, Astrotech International and its subsidiary Space Shuttle of America Corp., began negotiations for the purchase of two shuttles for \$1 billion each. See *Aviation Week & Space Technology*, June 25, 1984, pp. 116-119.

¹⁸Grey, *Aerospace America*, op. cit. pp. 92-93.

¹⁹Congressman Zschau's office, *Press Release*, July 18, 1984.

²⁰Congress of the United States, Office of Technology Assessment, *Civilian Space Stations and the U.S. Future in Space*, OTA-STI-241, Washington, D. C., November 1984.

Commercial use of the Shuttle is to be enhanced through:

- Reduced Shuttle flight charges to commercial ventures during the R&D phase;
- Speedup of integration of commercial space payloads with the Shuttle;
- Making ground test facilities and equipment available to the private sector at reduced prices;
- Reservation of specific orbiter capabilities for commercial operations.

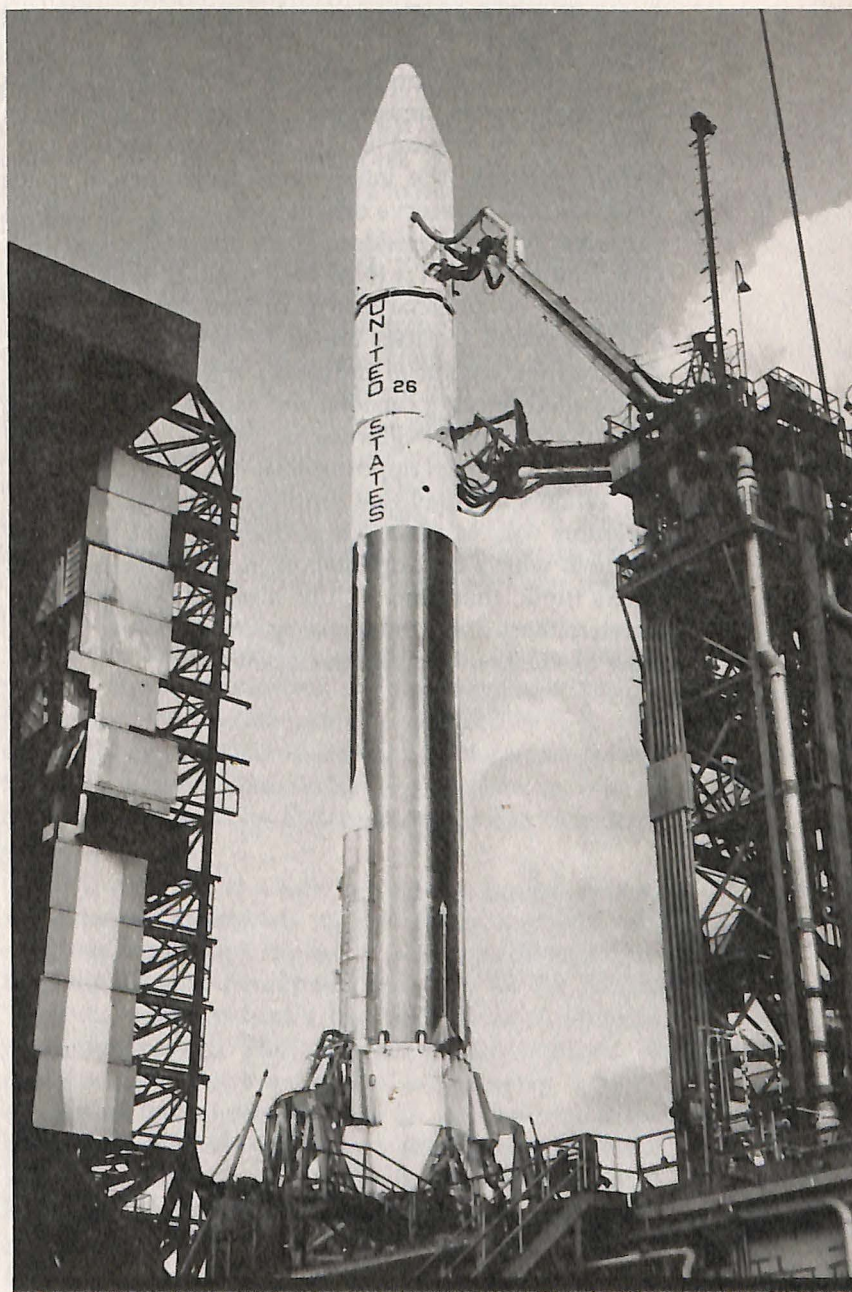
NASA, building on this policy, is attempting to answer concerns regarding conflict between its operational and research roles. It will be some time before it is clear to what extent NASA's initiatives are being implemented and what impact they might have, particularly in view of the many pressures—from budgetary to political—that will help define NASA's role in the next few years.

National Security Issues

Issues surrounding the impact of national security on the process of space commercialization are extremely complex. An immediate example relates to the space transportation system itself. While there has been private sector interest in operation of the shuttle, no agreement has been made by NASA with a private firm, and some believe that concerns of the Department of Defense have stood in the way of private operation of the Shuttle. DOD's primary interests, of course, are that there be no question regarding the Shuttle's availability in a national emergency, and the security and secrecy of military payloads.

The issue of private sector versus national security interests is endemic in a free society, when both military and civilian sectors share the use of facilities, or systems. In the present case, it is complicated by a number of factors. One is the economic necessity of using one transportation system for multiple purposes in an area as difficult and expensive to reach as space. Another is the fact that the Shuttle system may not have existed if not for the support of the military when, early in the Carter Administration, there was reportedly considerable discussion about cancelling the program. It has been suggested that an alternative to security, scheduling and other potential problems arising from joint civilian and military use of the Shuttle would be for the military to have its own space transportation system—perhaps its own fleet of Shuttles. However, it is also true that if the military services do not use the Shuttle at all, the costs that they have been absorbing will have to be borne by commercial or other users.

In early March 1985, the issue of a separate military space transportation system was rendered moot by the White House when it directed the Air Force and NASA to begin studying joint development of a bigger and more powerful Space Shuttle for the 21st century. The Reagan Administration feels the Air Force should share the cost of a "second generation" Shuttle with NASA, although the Air Force will use the vehicle only one-third of the time. The new "National Security Launch



Strategy" also covers an agreement by the Air Force to use the present Shuttle at least eight times a year for 10 years starting in 1988. A totally separate military space transportation system is clearly not envisaged.

The Air Force has been concerned, however, over availability of the current Shuttle and had announced intentions to continue use of expendable launch vehicles into the early 1990's, rather than phasing them out as previously planned. It explored development of both new and upgraded ELV's and also considered a NASA Shuttle-derived vehicle. The new White House directive announced the Air Force's intention to buy an improved version of the Titan rocket to supplement the Space Shuttle for military launches starting in 1988 and ending in 1993.

The NASA Commercial Space Policy does address in a general sense the issue of commercial needs versus military needs by establishing, as a major initiative, efforts to facilitate the integration of commercial space payloads and to reserve orbiter facilities for commercial ventures. A part of middeck space and utilities on each civil Shuttle mission is to be held until 20 weeks before launch for commercial needs; orbiter cargo bay space and associated facilities are to be reserved every six months for commercial endeavors which are integrated with pallets or other carriers; and access to all or part of a flight each year, beginning in 1986-87, will be dedicated to commercial opportunities.

While some feel that emphasis on military space programs will, in effect, short-change development of ventures with a civil orientation, it is also possible, as others think, that there will be a useful synergism between military and commercial space technology, just as there has been in aircraft development.

In the view of some, the military use of space, and the possibility of a new arms race in that milieu, injects another uncertainty factor into the mix that has to be weighed by private venture capitalists thinking of placing funds into the commercial development of space. Although the military presence in space may be regarded by some as a normal business risk, to others it may represent a large additional risk factor to the viability of space-based ventures. The presence of weapons in space may increase the chance of accidental damage to expensive facilities. Further, political sensitivity regarding sovereign actions in space may preclude U.S. intervention if commercial facilities are damaged by actions of other countries. On the other hand, a military space presence could represent a measure of additional security for private facilities.

It is early and yet unclear how investors will gauge the military presence in space, particularly if it includes the introduction of weapons into that arena. The question is: will the military presence in space lead investors to perceive the new frontier of space as any more risky than others that businessmen have faced over the centuries?

Another concern is the long-range impact of the growing military effort to control the flow of scientific and technical information between the United States and its allies. This has caused considerable dispute in scientific circles in this country and has angered some friendly nations, who view it as a threat to their sovereignty, and an attempt by the United States to control the flow of information and technology for its own economic advantage. The issue has the potential to create difficulties where international cooperative space ventures are concerned.

Space Commercialization: International Issues

International Competition

A critical issue in the space field is how the United States is to maintain its position in this arena, now that other nations have targeted it as the one in which the next industrial revolution will occur. Only ten years ago, the United States stood supreme in the world in space development: many thought that the U.S. lead was so great that it could never be surpassed, certainly not in less than twenty years, and then only if the nation did nothing to maintain its technological competitiveness.

Today, in a demonstration of how rapidly technology is moving, that lead has been eroded in many sectors of space. The Soviet Union has had a manned station in space for most of the past ten years. The USSR has shown a considerable capacity in maintaining such a structure, as noted recently in a report on the Soviet space program issued by the Congressional Office of Technology Assessment (OTA).¹ The Soviet's in-space experience far surpasses what the United States gained with Skylab. Lack of adequate planning and funds to support Skylab led to the decision to allow it to reenter the atmosphere and be destroyed. Meanwhile, the Soviets, according to one researcher quoted by OTA, spent approximately \$40 billion on their space station program in the decade of the seventies, as much as the United States spent on the entire Apollo program. OTA believes that the Soviet's announced next step of creating large, permanently manned, multi-team "orbital collectives" in space, is well within their capabilities and should be taken very seriously.²

Competition in the space arena does not come only from the Soviet Union. The eleven-nation European

Space Agency has shown the world that international, intra-country cooperation is not only possible, but can produce results. The Ariane launch vehicle and the Spacelab are both excellent examples of high technology, and Europe has earned the right to be taken seriously in the area of space technology.

In the remote sensing area, the United States has lost ground both to the Europeans in sensor technology, and to the Europeans and Canadians in the provision of ground stations. Canada is supplying Brazil with a data treatment facility which will be one of the world's most modern. It is also supplying the know-how to the Brazilians to design and build their own remote sensing and communication satellites. The French have built and will soon be operating the SPOT IMAGE remote sensing satellite that has 10-meter resolution in seven channels, versus the 30 meter, 5-channel color resolution of Landsat 5.

In the communication satellite field, long the domain of U.S. preeminence, the Japanese now supply two ground stations for each one supplied by U.S. concerns. The Japanese have also launched and are testing the world's first civilian 30/20 Ghz. satellite, as well as operating the world's first dedicated direct broadcast satellite.

It is unlikely in a time of massive budget deficits and increasing demands on the federal budget by all sectors of society that the government would be able to fund the heavy expenditures necessary for the United States to regain its leadership position in all areas of space technology. The commercial development of space would, however, make unnecessary a large amount of that expenditure. If the government helps the process of commercialization develop rapidly, in the long run it will cost much less to maintain a strong lead in space. This has been the historical manner in which government and industry have opened previous frontiers to the benefit of the nation's economy.

¹Congress of the United States, Office of Technology Assessment, *Salyut: Soviet Steps Toward Permanent Human Presence in Space*, A Technical Memorandum, Washington, D.C., Dec. 1983, 70 p.

²Ibid, p. 43.

International Political and Legal Issues

Due to its global applicability, space development was from the outset subject to worldwide interest and concern. This was expressed within the United Nations by the early formation of the Committee on the Peaceful Uses of Outer Space, a committee responsible, since 1962, for all matters pertaining to space. From the beginning, considerable emphasis was placed in the Committee on trying to formulate and establish a branch of international space law. This has been effective only to a certain extent.

The Committee works under the unanimity rule (one of the few in the U.N. that does). When the membership was small (originally there were 11 members, now there are 54) it was relatively easy to reach agreement, particularly if the representatives of the two superpowers agreed. Today, however, there are a number of items of disagreement, reflecting the more important role space is playing in world politics. Issues include control over orbital slots in the geosynchronous orbit; control over information that may be extracted (sensed) in one nation and used by another for its own purposes; possible control over resources extracted from other bodies in the solar system; and the introduction of weapons into space. Space law as part of international law is, itself, an evolving process subject to the changes and pressures engendered by international politics. This adds to the uncertainty surrounding the development of space and can make some potential investors very nervous.

The major piece of international legislation governing space is the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies. Generally known as the Outer Space Treaty and written before anyone was aware of what would happen in the area of space exploration and development, it leaves open nearly as many questions as it settles.

Article 1 of the Treaty states that space is to be the province of all mankind, and that its exploration and development is to be carried out for the benefit of all mankind. The precise legal meaning of these expressions is unclear. Some observers and international lawyers originally interpreted the latter clause to mean that space could only be entered and developed by nation states. Fortunately, another clause in article VI specifically states that the activities of non-governmental entities in outer space were to be subject to the authorization and supervision of the appropriate national agency. This reference was considered strong enough to ensure the entry into space of commercial interests as well as other non-governmental entities.

The latter provision itself raises some interesting issues in international law. If national governments are to be responsible for the actions of non-governmental agencies, what happens, for example, if nationals from a number of countries jointly launch from the territory of a third country a vehicle designed and manufactured in a number of other countries (Europe's Ariane, for example), which then falls into the territory of yet a fourth country causing considerable damage? This is the kind of event which could happen, yet no one knows which nation would or could be held responsible. Such uncertainty still clouds many issues in space law, and represents potential if not actual barriers to commercial development of space.

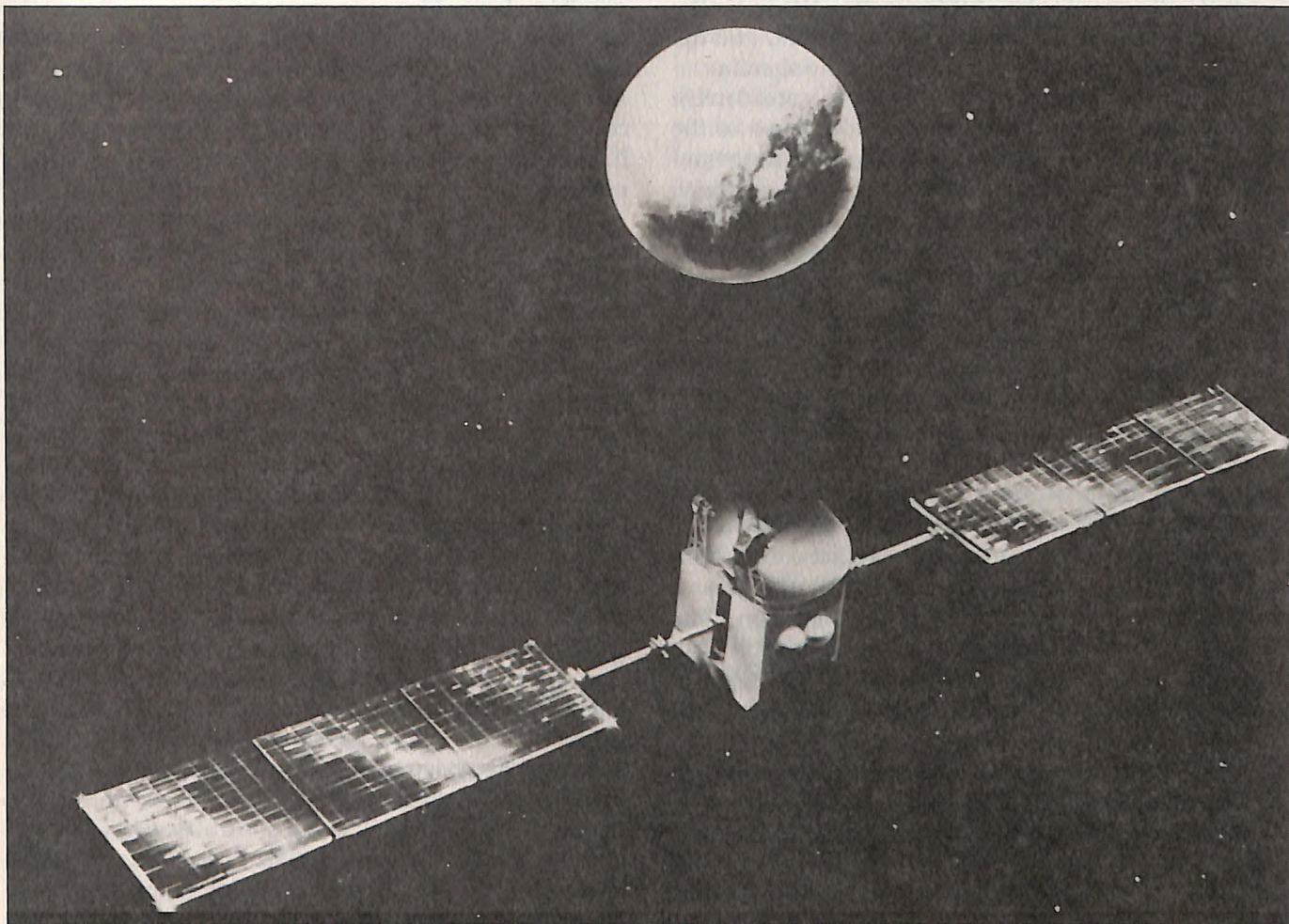
Professor Stephen Gorove, an internationally respected authority on space law from the University of Mississippi, lists five areas of concern which have, or can have an impact on the process of space commercialization. They are:

1. The utilization of the geostationary orbit;
2. The exploitation of the natural resources of the moon and other celestial bodies;
3. The international implications of direct television broadcasting by satellites;
4. Harm, damage or interference encountered in connection with space activities; and
5. The state of governmental supervisory procedures.³

Questions regarding use of the geosynchronous orbit, particularly by direct broadcast satellites, are the most immediately pertinent to space commercialization. These issues have been touched upon previously in this study, but they warrant more specific treatment here: international communications are subject to the authority and control of the International Telecommunications Union (ITU), now a specialized agency of the United Nations, which it predates by many years. The ITU authorizes the allotment of wavebands that may be used by governments and nationals of a particular country, and those open for international use for specific purposes, e.g., marine, aircraft, amateur, and so forth. Although neither the United States, nor the ITU, has any method of enforcing these rules, most nations abide by them rigorously in the interests of having interference-free communications.

Communication satellites quite evidently fall under the authority of the ITU, and have been the subject of

³Stephen Gorove, "Major Concerns of Private Enterprise Regarding Recent Developments in Space Law," paper given to the Sixth Princeton Conference on Space Manufacturing, May 9-12, 1983, in James Burke and April S. Whitt, eds., *Space Manufacturing 1983*, American Astronautical Sciences, San Diego, Univelt Inc., 1983, p. 200.



international agreements since they were first placed in orbit. As the geostationary arc is located over the equator at an altitude of 22,300 miles, it is a limited resource. Only a finite number of satellites can be placed on the arc at any one time, their spacing being subject not only to the interference level of their signals, but also to the part of the Earth's surface to which their signals are aimed. In other words, due to the curvature of the Earth, in order to "see" one specific region it is necessary that the satellite be located in a precise point on the geosynchronous arc.

It is the stance of the United States that the arc is available to all on a first-come first-served basis. This was acceptable in the early days of communication satellites, because most people did not predict the speed with which their use would grow. As this became more evident, those nations without either the immediate need for their own satellite, or without the capability of launching one, became concerned that when and if

they did want to place a satellite in a position to "see" their country, there might be no room left on that particular portion of the arc. They, therefore, urged a system of a priori planning, under which specific orbital locations would be allotted to each country under an internationally negotiated treaty.

This subject has been under continuous consideration and negotiation for ten years in the U.N. Committee on the Peaceful Uses of Outer Space. Although there has been no general resolution as yet, many nations have accepted the allocation system. For administrative purposes the world is divided into three regions by the ITU (basically, region 1 comprises Europe and Africa; region 2, the Americas; region 3, Asia). Both regions 1 and 3, have accepted the allotment system. Only the Americas have not.

In 1985, this issue will be finally settled when the World Administrative Radio Conference (WARC) will meet to decide the shape of the world communications

system for the remainder of this century. WARC is the overall international planning body for the ITU and the issue of orbital slot allotment is high on the agenda.

Orbital slot allotment has received considerable added attention in the past two years because of the imminent arrival of satellite direct broadcasting systems. Many nations are fearful that under an open skies, or first-come basis, these satellites may be used by one nation to broadcast television signals directly into the territory of another. The developing nations, in particular, regard this possibility as a form of cultural imperialism, and in company with the Communist bloc, will fight the concept.

It is uncertain that the U.S. position will prevail at WARC '85 and, if it does not, what this will mean in terms of slot allocations and other restrictions. In the latter part of July 1984, the ITU held a preparatory conference for WARC '85 at which India put forward a proposal that the previous basis of first-come, first-served should not even be discussed at WARC '85 as a possible alternative plan to a priori allocation. The United States and most other industrial nations objected that a preparatory conference had no right to dictate in advance one of the results that WARC was being called to discuss.

Had the Indian motion been accepted, there was no hope that there could be any other conclusion to WARC '85 than the a priori slot allocation system. Surprisingly, the developing nations did not all vote together and the conference was deadlocked. Finally the Algerians put forward a compromise resolution keeping the door open for discussion of a U.S.-proposed plan for "identification, harmonization and implementation" between existing methods and overall slot allocation. The State Department believes this to be a major victory for the U.S. position, and one that augurs well for the Conference in 1985. Some industry members of the U.S. delegation, however, are much less sanguine. They feel that the United States is still unprepared for serious discussion of the real issues and the State Department appears interested only in "damage control" at this time.⁴

Should the final disposition at WARC '85 go against the United States, it may not be in the interests of this country for it to attempt to unilaterally maintain the status quo. Despite there being no international agency to enforce any of the resolutions that may result at WARC, the United States, as the largest user by far of the international communication system, cannot take unilateral action in this area without exposing itself to

possible damaging economic retribution. From the viewpoint of future commercial activities in the satellite communications area, U.S. corporations may have to adjust to negotiating any use of slots with the nations concerned. British and French companies have already been actively conducting such negotiations with African nations.

Another area of concern in the satellite communications field with both national and international ramifications is the attempt by a number of U.S. corporations to establish an international communications network that would compete with the present monopoly of Intelsat. This has raised considerable controversy in this country and abroad. The creation of Intelsat is considered by many as one of the great achievements of U.S. diplomacy in the post-World War II era. Although that should not mean that its monopoly position should last forever, anything that may threaten the viability of the Intelsat system requires careful review because of the potentially serious impact upon not only the space commercialization process, but possibly upon the entire spectrum of U.S. international policy and interests.

Two recent studies of the issue by U.S. experts in international telecommunications (both have served the government in senior positions) reach the conclusion that a private system competitive with Intelsat is an area fraught with pitfalls for the United States unless it is exceptionally diplomatic and careful about how any future competitive private system is introduced. Philip Trezise, now a senior fellow at Brookings Institution and formerly assistant secretary of state for economic affairs and U.S. ambassador to the Organization of Economic Cooperation and Development, reportedly concludes that the result of evaluating all factors in the debate "will be the recognition of the critical value to the United States of a strong Intelsat, that unrestrained private sector competition cannot be squared with the international cooperative concepts underlying the Intelsat arrangements, and that, in any event, an effort by the U.S. government to impose its philosophies on the rest of the world will produce controversy and deadlock without any commensurate benefits."⁵

In November 1984, President Reagan approved a policy allowing private companies to build international satellite communications systems to compete for a limited portion of the Intelsat international communications business. However, private competition with Intelsat is to be restricted to intracompany, video, data and voice transmissions. Estimates were that the Presi-

⁴*Satellite Week*, Vol. 6, No. 32, Aug. 6th, 1984, pp. 3-4.

⁵Philip Trezise, "Unilateralism in International Trade: Will We Ever Learn," reported in *Satellite Week*, Vol. 6, No. 30, July 23, 1984, pp. 6-7.

dent's policy would protect about 85 percent of Intelsat's revenues from competition. Assistant Secretary of Commerce David J. Markey, reportedly said of the policy decision that it "is not a decision to destroy the Intelsat concept."⁶

One other area, mentioned by Gorove, that will have long-term implications for the commercialization of space is the question of the exploitation of natural resources on the moon and other celestial bodies. After nearly eight years of negotiation in the Committee on the Peaceful Uses of Outer Space, an Agreement Governing Activities of States on the Moon and Other Celestial Bodies, more popularly known as the Moon Treaty, was drawn up. Article 9, the key clause in the treaty, described the resources of the universe as the "common heritage of mankind." (This statement was originally suggested by the United States, and finally included after seven years when the Soviet Union reluctantly withdrew its original objection). Paragraph 5, of Article 9, established an International Regime (similar to that set up under the Law of the Sea Treaty) which would control the development of resources by and on behalf of member states.⁷

These two clauses, which the United States fought so long and hard to include, caused a furor when the Agreement came before the U.S. Senate for ratification. The Treaty was not signed by the United States on the grounds that an International Regime would prevent the commercial exploitation of space resources and hence was antipathetic to the U.S. capitalist system. (On similar grounds, the United States is the only nation to have voted against the Law of the Sea Treaty.) The matter rests there for the time being, but long and hard negotiations on this question remain. In one respect, the U.S. position on space differs from its position on the Law of the Sea Treaty: the United States is already signatory to the 1967 Outer Space Treaty which forbids the claiming or exploitation of space resources for its own use by any nation, non-governmental organization, or other group.

The future impact of these issues cannot be foreseen at this time. It is likely, however, as the possibility of lunar and asteroidal mining grows closer, that they will act as a significant restraint, much as the long drawn out negotiations on the Law of the Sea over the

past ten years effectively restrained commercial development of the seabed. The possibility of asteroidal and lunar mining is much closer than most people appear to believe. The California Space Institute has already completed one study of the issue and is now involved in a larger follow-up study with particular emphasis on the asteroids.⁸ Industry could help itself and the United States if it joined with the government in convening an international conference (if necessary through the United Nations) to discuss how the development of space resources is going to be handled before the issue becomes critical.

The United States might want to consider a number of other ways of addressing the rights of private firms in the commercial development of space including bilateral negotiations for freedom of action for private companies in space, and negotiation of international agreements on fair and free trade in space products and services.

U.S. Preparation for International Conferences

The previous section raises an issue that has not been widely considered a problem within this country, but is becoming much more of a concern today, that is: the level of preparation of U.S. delegates to international conferences. Although such conferences usually can pass no binding resolutions, they are important arenas for announcing carefully thought through policies, discovering other nations' positions and attempting to win them over to one's viewpoint.

U.S. experience with regard to the negotiation of the Moon Treaty is one instance of a visible failure to coordinate our policy position. Two United Nations global conferences on space issues are other examples. The Congressional Office of Technology Assessment's reports on these conferences indicate the lack of preparation by the United States. The first conference was the 1979 World Administrative Radio Conference (WARC) on radio frequency use and management. OTA's report states:

"Consistent with the findings of past study commissions and task forces going back to 1950, this study finds that the present U.S. Government structure for spectrum management and participation in international telecommunication conferences is inadequate. Primarily, the problems stem from the absence of high-level government attention to effective policy development and coordina-

⁶*Defense Daily*, November 30, 1984, p. 146.

⁷For detailed account of negotiations and U.S. position on the Moon Treaty, including all relevant documents, see U.S. Senate, Committee on Commerce, Science, and Transportation, *Agreement Governing Activities of States on the Moon and Other Celestial Bodies*, 96th Congress, 2nd Session, May 1980, Committee Print, Washington D.C., U.S. Government Printing Office, 1980, 264 p.

⁸*Space Business News*, July 30, 1984, pp. 4-5.

tion on a consistent and continuing basis with centralized accountability."⁹

The second example is U.S. preparation for Unispace '82, the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space. Unispace was an opportunity for the United States to capitalize on the international goodwill its space program had brought to politics from the very beginning. The United States and the Soviet Union disagreed on the appointment of a new administrator to the outer space secretariat of the United Nations, and as a result, the United States withdrew from the Conference. The matter was only settled some eight months before the Conference was due to begin. However, the U.S. delegates were appointed only two weeks prior to the conference, too short a time for proper preparation for the complex issues on the agenda. The OTA report sums up:

"Unfortunately, the absence of long-term domestic policy goals for space, the difficulties of coordinating strategies among U.S. agencies, and in the specific case of Unispace '82, the abbreviated preparation time, have prevented the United States from taking the maximum advantage of its space program and using space technology as a tool of foreign policy. Moreover, the United States has allowed itself to become isolated on the military and DBS issues, and its tactics regarding the militarization issue at Unispace '82 may well have been overly strident. This is particularly distressing because space technology is one area in which the United States has an exemplary record in "north-south" relations."¹⁰

It was noted in the previous section that it appears as if the United States is no better prepared for WARC '85. This could be much more damaging to U.S. interests than other conferences as the International Telecommunications Union has real power. WARC could be a watershed in awakening the nation to the responsibilities that have become part of living in an increasingly interdependent world.

The impact on the commercialization of space of the lack of overall space policy, coupled with the lack of preparation for international conferences, will increase considerably as space development proceeds. So far, they have been more of a restraint than a fully formed

barrier. Later, however, such weaknesses in policy development and coordination could pose formidable obstacles to the initiation by the private sector of large scale space development projects.

The entire question of U.S. attendance at international forums and conferences, along with the formulation of overall goals for the nation in space, could be a fruitful field of inquiry and action for the administration and Congress.

International Cooperation in Space

Despite NASA's solid accomplishments in international cooperation (more than 2,200 separate agreements since the agency was formed) many foreigners consider that the United States displays a considerable degree of ambivalence about international cooperation in technological ventures. Much of this is due to the concern of the military regarding the drain of U.S. technology secrets to the Soviet Union. Nonetheless, many observers from friendly foreign nations appear to have an uncomfortable feeling that this concern is and has been used as a means of maintaining U.S. technical leadership by controlling the export of advanced technologies to other nations.

Whatever the reality of the situation, this perception is already affecting the discussions between NASA and other countries about cooperation on the Space Station. The Europeans, unhappy with their experience with Spacelab, are especially wary of U.S. intentions. Despite their own advances in space technology, they do not believe that they will be treated as equal partners by the United States, yet their own pride will demand nothing else.

Traditional cooperation is a key issue in commercialization of space. One reason is that space development is extremely expensive. It is difficult for one country to go it alone in this area, especially in a time of massive budget deficits and a troubled world economy.

The issue, then, is long term, and it impacts the question of space commercialization because of the natural caution that corporations in every country show in deference to the political attitudes expressed by their own governments and their own experiences. In many cases, it appears that corporations and governments in other nations are fearful of developing close relations with the United States at any level, because of issues such as annual congressional budget review of each and every program, and the lack of even a reasonable degree of assurance regarding what may be considered permissible tomorrow in the way of technological cooperation started today.

⁹Congress of the United States, Office of Technology Assessment, *Radio Frequency Use and Management: Impacts from the World Administrative Radio Conference of 1979*, Washington D.C. 1981, pp. 12-13.

¹⁰Congress of the United States, Office of Technology Assessment, *UNISPACE '82: A Context for International Cooperation and Competition*, Washington D.C., 1983, p. 8.

Although the question of international cooperation may not appear to be much of a barrier to the commercial development of space at the present time, the long term prognosis is more serious. As has been discussed previously in this paper, the U.S. lead in space technology has been seriously eroded in just a few years, technology transfer is no longer a one-way street and advances in space technology are now being made by other nations. As the world moves more and more toward global interdependence it would appear to be in the interests of the United States to ensure as wide a sharing of technology as is permissible within the bounds of national security and market competitiveness.

IN CONCLUSION

While all of the issues and concerns discussed in this report are complex and are not easily resolved, there is a tremendous impetus to do so. The immense potential of space impels us as an adventurous, creative people to search for new space-related products, services and processes to enhance life on earth. The United States is a free market economy and the wisdom of relying on the private sector for its technological, managerial and financial expertise has been proven time and again. If we seriously address the possible roadblocks to space enterprise, it will be demonstrated—magnificently—one more time.

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Note: The following titles were selected from a wide range of materials dealing with space generally and various aspects of space commercialization in particular. For more specific technical material the reader is referred to the library facilities in the NASA Centers and at headquarters. NASA maintains computerized bibliographic files on all aspects of space development.

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Appendix A—White House Policy— Expendable Launch Vehicles

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release

May 16, 1983

The President today announced that the U.S. Government fully endorses and will facilitate commercial operations of Expendable Launch Vehicles (ELVs) by the U.S. private sector. This policy applies to both those ELVs previously developed for U.S. Government use, as well as new space launch systems developed specifically for commercial applications. This policy is consistent with the President's National Space Policy and represents a positive step toward encouraging U.S. private sector investment and involvement in civil space activities.

The basic goals of U.S. space launch policy as stated in the President's Directive on Commercialization of Expendable Launch Vehicles are to: (a) ensure a flexible and robust U.S. launch posture to maintain space transportation leadership; (b) optimize the management and operation of the Space Transportation System (STS) program to achieve routine, cost-effective access to space; (c) exploit the unique attributes of the STS to enhance the capabilities of the U.S. space program; and (d) encourage the U.S. private sector development of commercial launch operations. The policy specifies that:

- The U.S. Government fully endorses and will facilitate the commercialization of U.S. Expendable Launch Vehicles (ELVs).
- The U.S. Government will license, supervise, and/or regulate U.S. commercial ELV operations only to the extent required to meet its national and international obligations and to ensure public safety. Commercial ELV operators must comply with applicable international, national and local laws and regulations including security, safety, and environmental requirements.

- The U.S. Government encourages the use of its national ranges for U.S. commercial ELV operations. Commercial launch operations conducted from a U.S. Government national range will, at a minimum, be subject to existing U.S. Government range regulations and requirements. Consistent with its needs and requirements, the U.S. Government will identify and make available, on a reimbursable basis, facilities, equipment, tooling and services that are required to support the production and operation of U.S. commercial ELVs.
- The U.S. Government will have priority use of U.S. Government facilities and support services to meet national security and critical mission requirements. The U.S. Government will make all reasonable efforts to minimize impacts on commercial operations.
- The U.S. Government will not subsidize the commercialization of ELVs but will price the use of its facilities, equipment, and services consistent with the goal of encouraging viable commercial ELV launch activities.
- The U.S. Government will encourage free market competition among the various systems and concepts within the U.S. private sector. The U.S. Government will provide equitable treatment for all commercial launch operators for the sale or lease of government equipment and facilities consistent with its economic, foreign policy, and national security interests.
- The U.S. Government will review and approve any proposed commercial launch facility and range as well as subsequent operations conducted therefrom. Near-term demonstration or test flights of commercial launch vehicles conducted from other than a U.S. Government national range will be reviewed and approved on a case-by-case basis using existing licensing authority and procedures.

Notwithstanding the U.S. Government policy to encourage and facilitate private sector ELV entry into the space launch market, the U.S. Government will continue to make the Space Shuttle available for all autho-

rized users—domestic and foreign, commercial and governmental—subject to U.S. Government needs and priorities. Through FY 1988, the price for STS flights will be maintained in accordance with the currently established NASA pricing policies in order to provide market stability and assure fair competition. Beyond this period, it is the U.S. Government's intent to establish a full cost recovery policy for commercial and foreign STS flight operations.

Implementation

An interim working group under the Senior Inter-agency Group (SIG) for Space on Commercial Launch Operations will be formed and co-chaired by the Department of State and NASA. The Working Group will be composed of members representing the SIG (Space) agencies and observers as well as other affected agencies. Additional membership, at a minimum, will include the Federal Aviation Administration and the Federal Communications Commission. This group will be used to (a) streamline the procedures used in the interim to implement existing licensing authority, (b) develop and coordinate the requirements and process for the licensing, supervision, and/or regulations applicable to routine commercial launch operations from commercial ranges, and (c) recommend the appropriate lead agency within the U.S. Government to be responsible for commercial launch activities. Until a final selection of a lead agency is made, the Department of State will serve as the U.S. Government focal point for all inquiries and requests relative to seeking U.S. Government approval for commercial ELV activities.

Background

The National Space Policy identified the STS as the primary launch system for the U.S. Government. The U.S. Government is in the process of phasing out its current ELV operations (i.e., Delta, Atlas, and Titan launch systems) as the capabilities of the STS become sufficient to meet its needs and obligations. Increasing private sector interest in continuing these ELV systems has resulted in requests for a U.S. Government policy on such activities. In addition, an increasing number of new enterprises have been established with the express

purpose of developing commercial space launch capability.

The SIG (Space) was asked to review these issues and make recommendations to the President. This four-month interagency study concluded that a U.S. commercial ELV capability would offer substantial benefits to the Nation and would be consistent with the goals and objectives of the President's Space Policy.

The existence of a viable commercial ELV industry would add to the general economic vitality of the United States and provide the United States with a more robust space launch capability.

The creation of a domestic ELV industry would also maintain a high technology industrial base unequalled in the free world and provide jobs for thousands of workers while adding to the federal tax base of the U.S. and a number of states. Each commercial launch conducted in the U.S., rather than by foreign competitors, would strengthen our economy and improve our international balance of payments. Further, continuing commercial ELV operations are expected to spawn numerous spinoffs and supporting activities and strengthen the U.S. position in what is projected to be a growing commercial market, thereby providing substantial long-term economic benefits to the United States.

In addition to the general economic benefits, both NASA and the Department of Defense would benefit from continuing commercial ELV production and launch. It would provide a more robust U.S. launch capability and offer a domestic backup for the Shuttle at essentially no cost to the U.S. Government. The private sector would assume all costs of ELV production now borne by the U.S. Government. There would also be a market for U.S. Government facilities and equipment that would otherwise be underutilized or no longer required. This would also reduce or eliminate U.S. Government close-out costs for discontinuing its ELV operations. It would provide a potential market for excess flight hardware, special purpose tooling and test equipment, as well as propellants which will become excess as the Air Force deactivates the Titan II ICBMs.

In summary, partnership between the U.S. private sector and the U.S. Government will strengthen the U.S. space launch capability, develop a major new industry, contribute favorably to the U.S. economy, and maintain U.S. leadership in space transportation.

Appendix B—National Space Policy

EMBARGOED FOR RELEASE AT 10:00 A.M.,
PACIFIC TIME, JULY 4, 1982
Office of the White House Press Secretary

THE WHITE HOUSE FACT SHEET National Space Policy

The President announced today a national space policy that will set the direction of U.S. efforts in space for the next decade. The policy is the result of an inter-agency review requested by the President in August 1981. The ten-month review included a comprehensive analysis of all segments of the national space program. The primary objective of the review was to provide a workable policy framework for an aggressive, far-sighted space program that is consistent with the Administration's national goals.

As a result, the President's Directive reaffirms the national commitment to the exploration and use of space in support of our national well-being, and establishes the basic goals of United States space policy which are to:

- strengthen the security of the United States;
- maintain United States space leadership;
- obtain economic and scientific benefits through the exploitation of space;
- expand United States private sector investment and involvement in civil space and space related activities;
- promote international cooperative activities in the national interest; and
- cooperate with other nations in maintaining the freedom of space for activities which enhance the security and welfare of mankind.

The principles underlying the conduct of the United States space program, as outlined in the Directive are:

— The United States is committed to the exploration and use of space by all nations for peaceful pur-

poses and for the benefit of mankind. "Peaceful purposes" allow activities in pursuit of national security goals.

— The United States rejects any claims to sovereignty by any nation over space or over celestial bodies, or any portion thereof, and rejects any limitations on the fundamental right to acquire data from space.

— The United States considers the space systems of any nation to be national property with the right of passage through and operation in space without interference. Purposeful interference with space systems shall be viewed as an infringement upon sovereign rights.

— The United States encourages domestic commercial exploitation of space capabilities, technology, and systems for national economic benefit. These activities must be consistent with national security concerns, treaties and international agreements.

— The United States will conduct international cooperative space-related activities that achieve scientific, political, economic, or national security benefits for the nation.

— The United States space program will be comprised of two separate, distinct and strongly interacting programs—national security and civil. Close coordination, cooperation and information exchange will be maintained among these programs to avoid unnecessary duplication.

— The United States Space Transportation System (STS) is the primary space launch system for both national security and civil government missions. STS capabilities and capacities shall be developed to meet appropriate national needs and shall be available to authorized users—domestic and foreign, commercial and governmental.

— The United States will pursue activities in space in support of its right of self-defense.

— The United States will continue to study space arms control options. The United States will consider verifiable and equitable arms control measures that would ban or otherwise limit testing and deployment of specific weapons systems, should those measures be compatible with United States national security.

SPACE TRANSPORTATION SYSTEM

The Directive states that the Space Shuttle is to be a major factor in the future evolution of United States space programs, and that it will foster further cooperative roles between the national security and civil programs to insure efficient and effective use of national resources. The Space Transportation System (STS) is composed of the Space Shuttle, associated upper stages, and related facilities. The Directive establishes the following policies governing the development and operation of the Space Transportation System:

- The STS is a vital element of the United States space program, and is the primary space launch system for both United States national security and civil government missions. The STS will be afforded the degree of survivability and security protection required for a critical national space resource. The first priority of the STS program is to make the system fully operational and cost-effective in providing routine access to space.

- The United States is fully committed to maintaining world leadership in space transportation with a STS capacity sufficient to meet appropriate national needs. The STS program requires sustained commitments by each affected department or agency. The United States will continue to develop the STS through the National Aeronautics and Space Administration (NASA) in cooperation with the Department of Defense (DoD). Enhancement of STS operational capability, upper stages and methods of deploying and retrieving payloads should be pursued, as national requirements are defined.

- United States Government spacecraft should be designed to take advantage of the unique capabilities of the STS. The completion of transition to the Shuttle should occur as expeditiously as practical.

- NASA will assure the Shuttle's utility to the civil users. In coordination with NASA, the DoD will assure the Shuttle's utility to national defense and integrate national security missions into the Shuttle system. Launch priority will be provided for national security missions.

- Expendable launch vehicle operations shall be continued by the United States Government until the capabilities of the STS are sufficient to meet its needs and obligations. Unique national security considerations may dictate developing special purpose launch capabilities.

- For the near term, the STS will continue to be managed and operated in an institutional arrangement consistent with the current NASA/DoD Memoranda of Understanding. Responsibility will remain in NASA for operational control of the STS for civil missions and in the DoD for operational control of the STS for national security missions. Mission management is the responsibility of the mission agency. As the STS operations ma-

ture, the flexibility to transition to a different institutional structure will be maintained.

- Major changes to STS program capabilities will require Presidential approval.

THE CIVIL SPACE PROGRAM

In accordance with the provisions of the National Aeronautics and Space Act, the Directive states that the civil space program shall be conducted:

- to expand the knowledge of the Earth, its environment, the solar system and the universe;
- to develop and promote selected civil applications of space technology;
- to preserve the United States leadership in critical aspects of space science, applications and technology; and
- to further United States domestic and foreign policy objectives.

The Directive states the following policies which shall govern the conduct of the civil space program:

- United States Government programs shall continue a balanced strategy of research, development, operations, and exploration for science, applications and technology. The key objectives of these programs are to: (1) preserve the United States preeminence in critical space activities to enable continued exploitation and exploration of space; (2) conduct research and experimentation to expand understanding of: (a) astrophysical phenomena and the origin and evolution of the universe through long-lived astrophysical observation; (b) the Earth, its environment, its dynamic relation with the Sun; (c) the origin and evolution of the solar system through solar, planetary, and lunar sciences and exploration; and (d) the space environment and technology to advance knowledge in the biological sciences; (3) continue to explore the requirements, operational concepts, and technology associated with permanent space facilities; (4) conduct appropriate research and experimentation in advanced technology and systems to provide a basis for future civil applications.

- The United States Government will provide a climate conducive to expanded private sector investment and involvement in space activities, with due regard to public safety and national security. These space activities will be authorized and supervised or regulated by the government to the extent required by treaty and national security.

- The United States will continue cooperation with other nations in international space activities by conducting joint scientific and research programs, consistent with technology transfer policy, that yield sufficient benefits to the United States, and will support the public, nondiscriminatory direct readout of data from Federal civil systems to foreign ground stations and the provision of data to foreign users under specified conditions.

— The Department of Commerce, as manager of Federal operational space remote sensing systems, will: (1) aggregate Federal needs for these systems to be met by either the private sector or the Federal government; (2) identify needed research and development objectives for these systems; and (3) in coordination with other departments or agencies, provide regulation of private sector operation of these systems.

THE NATIONAL SECURITY SPACE PROGRAM

The Directive states that the United States will conduct those activities in space that it deems necessary to its national security. National security space programs shall support such functions as command and control, communications, navigation, environmental monitoring, warning, surveillance and space defense. The Directive states the following policies which shall govern the conduct of the national security program:

— Survivability and endurance of space systems, including all system elements, will be pursued commensurate with the planned use in crisis and conflict, with the threat, and with the availability of other assets to perform the mission. Deficiencies will be identified and eliminated, and an aggressive, long-term program will be undertaken to provide more-assured survivability and endurance.

— The United States will proceed with development of an anti-satellite (ASAT) capability, with operational deployment as a goal. The primary purposes of a United States ASAT capability are to deter threats to space systems of the United States and its Allies and, within such limits imposed by international law, to deny any adversary the use of space-based systems that provide support to hostile military forces.

— The United States will develop and maintain an integrated attack warning, notification, verification, and contingency reaction capability which can effectively detect and react to threats to United States space systems.

— Security, including dissemination of data, shall be conducted in accordance with Executive Orders and applicable directives for protection of national security information and commensurate with both the missions performed and the security measures necessary to protect related space activities.

INTER-PROGRAM RESPONSIBILITIES

The Directive contains the following guidance applicable to and binding upon the United States national security and civil space programs:

— The national security and civil space programs will be closely coordinated and will emphasize technology sharing within necessary security constraints. Technology transfer issues will be resolved within the framework of directives, executive orders, and laws.

— Civil Earth-imaging from space will be permitted

under controls when the requirements are justified and assessed in relation to civil benefits, national security, and foreign policy. These controls will be periodically reviewed to determine if the constraints should be revised.

— The United States Government will maintain and coordinate separate national security and civil operational space systems when differing needs of the programs dictate.

POLICY IMPLEMENTATION

The Directive states that normal interagency coordinating mechanisms will be employed to the maximum extent possible to implement the policies enunciated. A *Senior Interagency Group (SIG) on Space* is established by the Directive to provide a forum to all Federal agencies for their policy views, to review and advise on proposed changes to national space policy, and to provide for orderly and rapid referral of space policy issues to the President for decisions as necessary. *The SIG (Space)* will be chaired by the Assistant to the President for National Security Affairs and will include the *Deputy Secretary of Defense, Deputy Secretary of State, Deputy Secretary of Commerce, Director of Central Intelligence, Chairman of the Joint Chiefs of Staff, Director of the Arms Control and Disarmament Agency, and the Administrator of the National Aeronautics and Space Administration*. Representatives of the Office of Management and Budget and the Office of Science and Technology Policy will be included as observers. Other agencies or departments will participate based on the subjects to be addressed.

BACKGROUND

In August 1981, the President directed a National Security Council review of space policy. The direction indicated that the President's Science Advisor, Dr. George Keyworth, in coordination with other affected agencies, should examine whether new directions in national space policy were warranted. An interagency working group was formed to conduct the study effort and Dr. Victor H. Reis, an Assistant Director of the Office of Science and Technology Policy was designated as Chairman. The group addressed the following fundamental issues: (1) launch vehicle needs; (2) adequacy of existing space policy to ensure continued satisfaction of United States civil and national security program needs; (3) Shuttle organizational responsibilities and capabilities; and, (4) potential legislation for space policy. The reports on the various issues formed the basis of the policy decisions outlined here. The following agencies and departments participated: State, Defense, Commerce, Director of Central Intelligence, Joint Chiefs of Staff, Arms Control and Disarmament Agency and the National Aeronautics and Space Administration, as well as, the National Security Council Staff and the Office of Management and Budget.

Appendix C—National Policy on the Commercial Use of Space

THE WHITE HOUSE Office of the Press Secretary

FOR RELEASE AT 2:00 P.M. EDT
FRIDAY, JULY 20, 1984

NATIONAL POLICY ON THE COMMERCIAL USE OF SPACE

FACT SHEET

Private sector investment and involvement is essential if the enormous commercial potential of space is to be developed. The key to the success of industrial research and manufacturing in space and the development of space-based services is a clear policy defining government's role in encouraging private sector space-based activities that will benefit life on earth.

The President today issued his National Policy on the Commercial Use of Space. The policy extends to four general categories:

I. Economic Initiatives:

Tax laws and regulations which discriminate against commercial space ventures will be changed or eliminated. Such changes will be subject to revision in accordance with decisions made on fundamental tax reform later this year.

II. Legal and Regulatory Initiatives:

Laws and regulations predating space operations will be updated to accommodate the commercial use of space.

III. Research and Development Initiatives:

In partnership with industry and academia, government will expand basic research and development which may have implications for investors aiming to develop commercial space products and services.

IV. Initiatives to Implement the National Policy on the Commercial Use of Space:

Since commercial developments in space often require many years to reach the production phase, entrepreneurs will receive assurances of consistent government actions and policies over long periods.

Following are details of these initiatives.

The Administration will take the following initiatives to facilitate the commercial use of space:

Economic Initiatives:

- Replace the current "carry-on test" for the 25% research tax credit with provisions allowing corporations engaged in a trade or business to form joint ventures and be eligible to use any R&D tax credits resulting from the venture.

- Modify the tax code to assure that space capital projects owned principally by United States interests and operated for domestic purposes are eligible for the 10% Investment Tax Credit and the accelerated cost recovery system.

- Facilitate long-term contracts with new space ventures if the Government has a need for the product and if the purchase would be cost-efficient.

- Direct the Treasury to develop a proposal designed to identify those prototypes eligible for the R&D credit even though they eventually will be used in commercial service, so that current uneconomic incentives will be reduced.

- Clarify the appropriate tariff regulations to ensure that space-made projects are not considered imports when returned to the United States.

These proposed changes are in reference to the current tax law. They would, of course, be revised in accordance with decisions made on fundamental tax reform later this year.

Legal and Regulatory Initiatives:

- Assure that radio frequency assignment for private sector use is timely.
- Provide additional protection of proprietary information through the Space Act.
- Assure fair international competition.

Research and Development Initiatives:

- Expand current practices to increase private sector awareness of space opportunities and to encourage increased industry investment in high-tech, space-based research and development.

Initiatives to Implement the National Policy on the Commercial Use of Space:

- Increase public awareness about the commercial opportunities in space.
- Develop a plan for privatization of specific government space activities.
- Establish a high-level national focus for commercial space issues by creating a Cabinet Council on Commerce and Trade (CCCT) Working Group on the Commercial Use of Space. The Working Group will be chaired by a representative of the Commerce Department with a representative of NASA serving as vice chairman. Membership will consist of all interested departments and agencies. The SIG-Space Interagency Group will continue in its current policy role.

Appendix D—NASA Commercial Space Policy

EXECUTIVE SUMMARY

Introduction

President Reagan, in his National Space Policy of July 4, 1982, made the expansion of private investment and involvement in space a major objective of the United States Government. Committee reports from both Houses of Congress strongly endorsed this thrust in 1983. Supporting statements also have come from studies by non-government groups.

Opportunities for benefiting the nation are significant. Commercial space endeavors offer the potential for new industries, new jobs, lower product costs and an improved balance of trade. Technological advances from commercial use of space could help conquer diseases, produce computers faster and smarter than presently exist, develop metals lighter and stronger than any presently known, increase communications and information availability around the world and enhance our understanding of our environment and its resources.

NASA's Commercial Space Policy is designed to encourage private involvement in commercial endeavors in space to help take advantage of these opportunities. The Policy introduces approaches and incentives to reduce the risks inherent in commercial space ventures to levels competitive with conventional investments.

This "Executive Summary" presents an overview of the goals and principles of the NASA Commercial Space Policy, as well as a summary of major new initiatives NASA will implement to stimulate private investment in commercial space ventures.

Goals and Principles

The primary goals of NASA's Commercial Space Policy is to encourage and stimulate free enterprise in space.

Private investments in space, in turn, are expected to (a) yield important economic advantages; (b) advance

science and technology; (c) help maintain U.S. space leadership; and (d) enhance the nation's competitive position in international trade, thereby improving the U.S. balance of payments.

Implementation of the NASA Commercial Space Policy is to be guided by these five principles:

1. *The Government should reach out to and establish new links with the private sector.*

NASA will broaden its traditional links with the aerospace industry and the science community to include relationships with major non-aerospace firms, new entrepreneurial ventures, as well as the financial and academic communities.

2. *Regardless of the Government's view of a project's feasibility, it should not impede private efforts to undertake commercial space ventures.*

If the private sector is willing to make the necessary investment, the project's feasibility should be allowed to be determined by the marketplace and the creativity of the entrepreneur rather than the Government's opinion of its viability.

3. *If the private sector can operate a space venture more efficiently than the Government, then such commercialization should be encouraged.*

When developing new public space programs, the Government should actively consider the view of, and the potential effect on, private ventures.

4. *The Government should invest in high-leverage research and space facilities which encourage private investment. However, the Government should not expend tax dollars for endeavors the private sector is willing to underwrite.*

This will provide at least two benefits. First it will enable NASA to concentrate a greater percentage of its resources on advancing the technological state-of-the-art in areas where the investment is too great for the private sector. Second, it will engage the private sector's applications and marketing skills for getting space benefits to the people.

5. When a significant Government contribution to a commercial endeavor is requested, two requirements must be met. First, the private sector must have significant capital at risk, and second, there must be significant potential benefits for the nation.

In appraising the potential benefits from and determining appropriate Government contributions to commercial space proposals, NASA will use an equitable, consistent review process.

A possible exception to these principles would be a commercial venture intended to replace a service or displace a NASA R&D program and/or technology development program of paramount public importance now provided by the Government. In that case, the Government might require additional prerequisites before commercialization.

IMPLEMENTATION

In implementing this Policy, NASA will take an active role in supporting commercial space ventures in the following categories, listed in order of importance:

- New commercial high-technology ventures.
- New commercial applications of existing space technology.
- Commercial ventures resulting from the transfer of existing space programs to the private sector.

NASA will implement initiatives to reduce the technical, financial and institutional risks associated with doing business in space.

To reduce *technical risks*, NASA will:

Support research aimed at commercial applications; ease access to NASA experimental facilities; establish scheduled flight opportunities for commercial payloads; expand the availability of space technology information of commercial interest, and support the development of facilities necessary for commercial uses of space.

To reduce *financial risks*, NASA will:

Continue to offer reduced-rate space transportation for high-technology space endeavors; assist in integrating commercial equipment with the Shuttle; provide seed-funding to stimulate commercial space ventures; and, under certain circumstances, purchase commercial space products and services and offer some exclusivity.

To reduce *institutional risks*, NASA will:

Speed integration of commercial payloads into the Orbiter; shorten proposal evaluation time for NASA/private sector Joint Endeavor proposals; establish

procedures to encourage development of space hardware and services with private capital instead of Government funds; and introduce new institutional approaches for strengthening NASA's support of private investment in space.

A high-level Commercial Space Office will be formed within NASA as a focal point for commercial space matters. This Office will be responsible for implementing the NASA Policy to stimulate space commerce. It will have sufficient authority and resources to fully carry out this assignment.

NASA COMMERCIAL SPACE POLICY (NCSP) SUMMARY OF POLICY INITIATIVES

The U.S. National Space Policy makes the development of a climate conducive to expanded private sector investment and involvement in civil space activities a national priority. In accordance with that priority, the National Aeronautics and Space Administration has established a Commercial Space Policy. Its major initiatives are summarized below:

- A. Initiatives to stimulate research and development;
 1. NASA will aggressively conduct research which enhances and encourages commercial space endeavors.
 2. NASA will stimulate private sector research directed toward commercial space ventures by providing seed-funding or private sector R&D initiatives.
 3. NASA will encourage the development by the private sector of new support hardware and space-related services which are not essential to maintaining its basic research and development. NASA shall invest in the development of facilities necessary for commercial uses of space.
 4. NASA will support the establishment of Industry/University/Government Advanced Research Institutes for research transferable to space uses and product development.
 5. NASA may agree to purchase a commercial space venture's product or service if NASA has a need for the product and if the private entity has significant capital at risk above that covered by the NASA purchase.
 6. NASA will expedite decisions regarding proposed NASA/Industry joint endeavors. Procedures for providing a decision within six months regarding such proposals will be established.

- B. Initiatives to facilitate access to NASA facilities and equipment:
1. NASA will provide reduced rates for Shuttle flights to commercial ventures during the Research and Development phase if desired by the private entity. NASA shall be entitled to a "quid pro quo"—to be negotiated with the private ventures.
 2. NASA will provide a capability to integrate and fly a "standard" commercial space payload no later than six months from the time of its entry into the integration process. This will require simplification of present integration processes and appropriate safety and interface design of the commercial payload.
 3. NASA will standardize and increase the number of interfaces in the Orbiter middeck and cargo bay to permit simpler and quicker integration and earlier flights.
 4. Unless national security requirements dictate otherwise, NASA will assure a flight for commercial payloads for which integration has been scheduled.
 5. NASA will reserve the following Orbiter facilities for commercial ventures: (a) a part of the middeck space and utilities on each civil Shuttle mission, to be held until 20 weeks before launch and then released for other use if no commercial need exists; (b) Orbiter cargo bay space and associated facilities every six months for commercial endeavors which are integrated with pallets or other carriers; (c) access to all or part of a pressurized module flight each year, beginning in 1986/87.
 6. NASA will make ground test facilities and equipment available at reduced prices for simulation of space environments by commercial endeavors.
- C. Procedural initiatives to support Space Commercialization:
1. NASA will *not* assume a regulatory role with respect to commercial space ventures.
 2. NASA will continue to support and assist Federal organizations in defining and apply regulations for commercial space endeavors.
 3. NASA will continue to encourage the use of NASA technology, including technology covered by NASA-owned patents in space commercial ventures.
 4. NASA will protect proprietary rights, and ask for privately-owned data only when necessary to carry out its responsibilities.
 5. During the Research and Development stage of a high-technology commercial venture carried out under a Joint Endeavor Agreement, NASA will *not* provide reduced-rate or free flights for other technically similar systems.
 6. NASA will *not* undertake development of the same technology which is being developed by U.S. industry for commercial markets under a Joint Endeavor Agreement.
- D. Organizational Initiatives to enhance industry access to NASA and focus for commercialization endeavors.
1. NASA will establish special offices at its headquarters and field centers to assist and encourage private sector involvement in space.
 2. NASA will support the establishment of industry advisory groups to provide advice regarding NASA applications-oriented research.
- E. Outreach Initiatives to establish new links with the private sector to stimulate private businesses in space.
1. NASA will provide means for developing a continuing dialogue and working relationships with industries and companies that appear most likely to establish commercial uses of the space environment.
 2. NASA will enhance links between itself, industry, and universities, and solicit the counsel of the financial and insurance communities in decisions regarding space commercialization activities.
 3. NASA will review its dissemination methods for science and technology data. With advice from industry, NASA will augment publications procedures to provide better support for the domestic private sector.
 4. NASA will encourage the use of specialized firms as intermediaries between the Government and industry to help encourage private involvement in commercial space ventures.
- F. NASA Support of the U.S. National Space Policy
1. NASA will initiate and facilitate actions supporting national commitments to the commercial use of space.

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