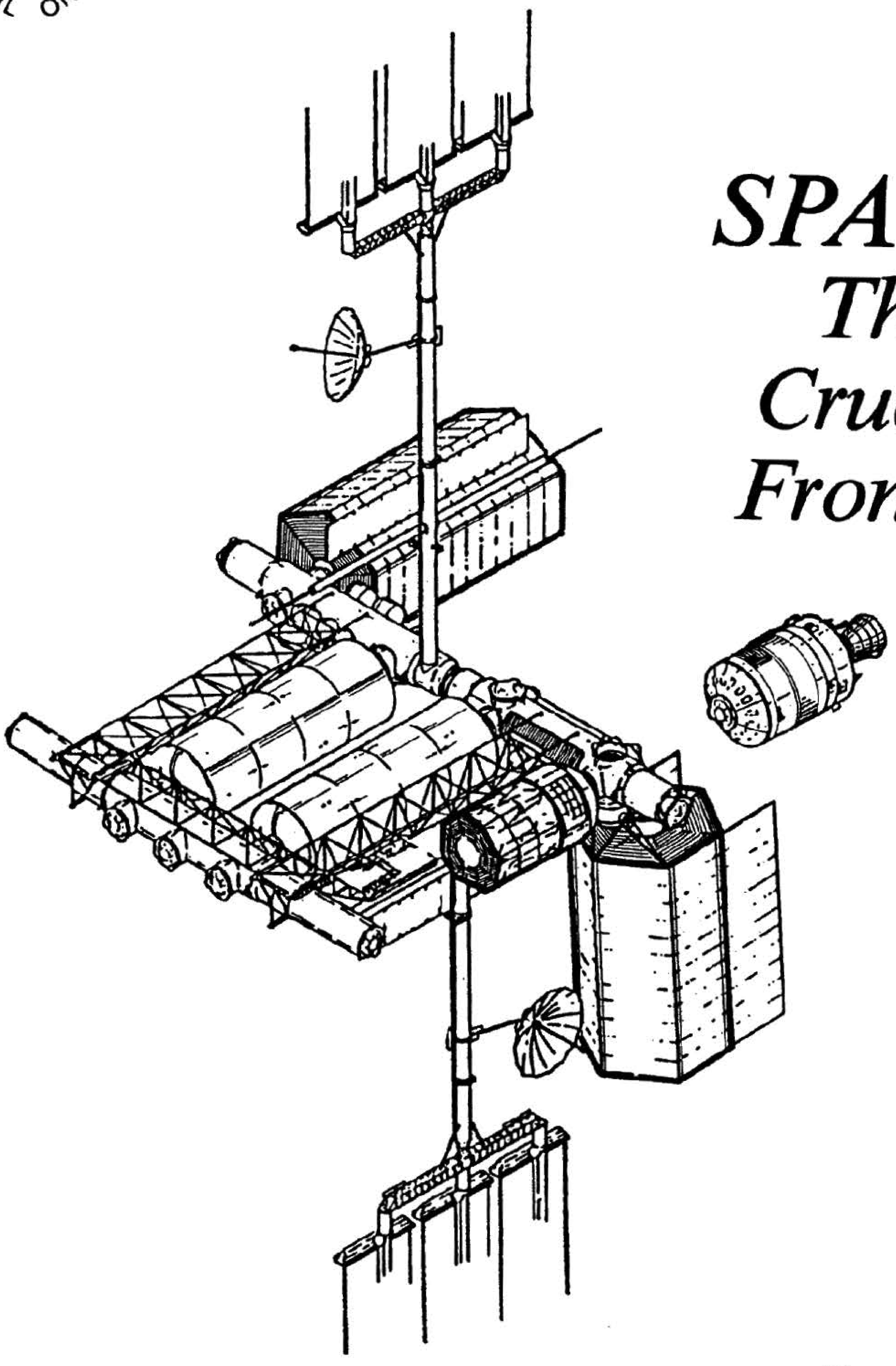
CITIZENS ADVISORY COUNCIL ON NATIONAL SPACE POLICY



SPACE: The Crucial Frontier

Spring 1981

The Citizens Advisory Council on National Space Policy was created by joint action of the American Astronautical Society and the L-5 Society for the purpose of developing a detailed and technically feasible space policy to further the national interest. Council activities are supported by the generosity of Council members, and by grants from the L-5 Society and the Vaughn Foundation.

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CITIZENS ADVISORY COUNCIL ON NATIONAL SPACE POLICY

REPORT OF THE SPRING, 1981 COUNCIL MEETING

SPACE:
THE CRUCIAL FRONTIER

PREAMBLE

Space is potentially our most valuable national resource. A properly developed space program can go far toward restoring national pride while developing significant and possibly decisive military and economic advantages.

In exploring space we will rediscover frontiers and more than frontiers; we can rediscover progress.

The exploitation of space will have far reaching historical significance. The statesmen who lead mankind permanently to space will be remembered when Isabella the Great and Columbus are long forgotten.

Jerry E. Pournelle, Ph.D., Chairman

CITIZENS ADVISORY COUNCIL ON NATIONAL SPACE POLICY

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TOWARD A NATIONAL SPACE POLICY

1. The **rediscovery of progress** is a reasonable and feasible national goal for the United States in the 1980's.

Progress is possible. We do not have to accept limits to growth; but we do need specific strategies for progress. Growth requires investment and continuous expansion of the resource base.

The United States has a world mission. We influence by example; we are the showplace of freedom; and in the present era we must also be the sword and shield of liberty. To fulfill this role we must do more than survive. We must remain militarily, economically, and ideologically strong.

We need visible goals: a reason for the nation to exist. If we have no dreams and goals, we have no nation.

Insuring progress for ourselves and the world is a reasonable and feasible goal for America. Space activities can be a significant part of our rediscovery of progress.

2. The vast majority of resources accessible to mankind are not here on Earth. The solar system abounds with minerals and energy. Other nations are even now claiming those resources and developing capabilities for using them. If the United States does not compete, we will have effectively abdicated economic leadership to those who do.

There is more at stake than that. Space has very great military potential. Many experts believe that strategically decisive weapons can be deployed in space, and no reasonable analyst can be certain that they can **not** be. Space based beam weapons may develop into reliable missile defenses. At the very least, the United States **must** retain the option to compete in space.

Space also has symbolic importance, if for no other reason than the United States made the "Moon race" critical to our national prestige. To abandon space after announcing its crucial importance hands the Soviets an unearned but enormously important ideological victory. It is obvious from their space activities that the Soviets realize this. We must, therefore, retain the option to move effectively and quickly into space.

Retaining that option is not simple. No one can be sure what capabilities will be needed. Our adversaries have more experience in the space environment than we do.

Since we cannot know which space capabilities may prove to be decisive, we cannot design robots or artificial intelligence systems in advance. The only truly versatile space system is man; and the only way to insure a capability to do a wide variety of tasks in space—including construction of the military systems that may be needed in the future—is to make entry to and operations in the space environment routine.

We must continue both manned and unmanned exploration of space. Our survival may depend on it.

3. The "Revolution of Rising Expectations" coincides with the "era of limits" to aggravate international instabilities. Most of the world will remain poor in the remaining years of this century—and this in a "global village". The wretched of the Earth are very much aware that everyone doesn't live their way. World economic growth is not merely desirable on ethical grounds; it is very much in the U.S. national interest.

Rapid economic growth is not easy. It requires investment. It also requires technological growth, and expanded resources. We cannot abandon technology; indeed, we must rapidly expand our entire technological and industrial base.

4. All the above factors combine to make space an important option. To preserve and increase capabilities for military activities in space we must expand our space activities. If we are to extend our technological base, we must actively seek renewed interest in the hard disciplines of science and engineering. The economic growth of the U.S. and the world will be enhanced by exploitation of the space environment. Ignoring space abandons the major resource base of the next century.

5. Retaining space options is time dependent. The lead time for space activities is long. Decisions made in 1981 have consequences stretching far into the future. Decisive actions must be undertaken quickly or many capabilities will be lost; and once lost, they cannot be regained without costly and wasteful crash programs. Much that we should accomplish before 1988 cannot be done without immediate changes in our national space policies.

6. The space question is crucial: if we do not preserve space options, we are betting national survival in order to save a miniscule fraction of the national budget. This is neither reasonable nor prudent.

7. It is also possible to make space pay for itself—indeed, to use space to feed a new period of rapid economic growth. The opportunities are there. The resources and energy are there. It is now obvious that some nations will gain great wealth from space. The only controversy is over the time scale.

8. If humanity survives—which we fully expect—then there is no doubt that civilizations in the centuries to come will spread across the entire solar system. As Arthur Clarke has said, except for a fleeting instant in the beginning of history, the word "ship" will mean space ship.

This generation can take mankind and freedom into the solar system. Much can be lost by delay; still more can be gained by beginning now. **The nation and statesmen who give mankind the planets will be remembered forever.**

HIGH GOALS FOR AMERICA

The United States must develop a comprehensive strategy for exploiting space. We must have a unified plan which abandons the artificial division of space into "military" and "civilian" programs.

We must also move quickly to develop space resources, so that space becomes a direct source of economic gain. Once space makes large, direct, and visible economic returns, the costs of government investment in civilian space technologies will diminish. True growth in U.S. capabilities in space will come when we release the creative engines of free enterprise.

Until that time, development must remain a partnership between government and private industry. In the past that partnership has been one-sided; there have been few ways that private firms can participate directly in space research, because they have had no direct access to the space environment.

The U.S. space strategy should, therefore, offer opportunities for entrepreneurial talents in space. Free institutions can insure U.S. superiority in space in the same way that the free market has given us superiority in computers.

One way that space can yield high return on investments is to use space resources—lunar or asteroid—as raw materials. This will require continued exploration of these potential resource bases; not merely exploration for scientific knowledge, but prospecting for opportunities of industrial exploitation.

Space is an international environment; but "internationalizing" space resources discourages investment in space. Regulation will be necessary; but we must be certain that we do not make legal commitments, such as the now-discredited U.N. Lunar Treaty, which unduly restrict our ability to make economic use of space resources.

At the same time, space development offers splendid opportunities for cooperative work with U.S. allies, and a means for assisting the developing nations without direct foreign aid. Technological benefits available to developing nations can include communications, education, and even energy assistance.

CONCLUSIONS

1. A vigorous space program is necessary for national security. Both military and commercial aspects of space are vital to U.S. national interests. Military weapons in space can be strategically decisive before 1990, and the economic resources of space will become increasingly important before the end of the century. **Development of space weapons and capture of the economic resources of space demands immediate action to implement a skillful long-range strategy.**

2. The United States must have a space policy which relates national goals and aspirations to a detailed space plan making optimum use of limited funds for space investment. **An optimum space strategy must begin with the recognition that NASA's primary task is the development of enabling technologies and capabilities: that technology is more important than missions.**

The NASA Charter should be amended to emphasize this principle, and the previous NASA policy of supporting technology studies primarily in support of approved missions must be severely modified.

3. National space policy should seek commercial exploitation of space, and include stimulation of economic return on space investment as a matter of the highest priority. **We must release the energy and vigor of the engines of free enterprise in this new frontier.**

Space exploitation should include information, communications, materials processing, and energy resource exploitation; materials processing should include extra-terrestrial resources.

The U.S. space plan must encourage private investment and entrepreneurial activities making use of the space environment.

4. The United States should immediately review all international agreements to which the U.S. is a party. **Any agreements which are counterproductive to commercial exploitation of space should be amended or abrogated.**

Any proposed international agreements on space should be studied by legal experts friendly to the cause of private exploitation of space resources.

5. The space plan here recommended concentrates on NASA and the "civilian" space budget. It must be supplemented by a carefully designed military space plan.

Although many space missions are clearly military, it is unreasonable to create artificial barriers between "military" and "civilian" programs. Nearly all activities in space gather experience which can be valuable to future military and economic missions.

It is impossible to specify in advance which space activities will be required by military considerations. It is therefore necessary that we expand nearly all space capabilities.

Commercial activities in space are thus in the national interest much as a strong merchant marine or civil air fleet is in the national interest. Moreover, commercial space facilities will provide observations useful for national intelligence. The example of the Soviet trawler fleet, which combines surveillance with profitable commercial fishing, should be remembered.

6. Geostationary Earth Orbits (GEO) are an enormously valuable but not unlimited resource. The United States must take all necessary actions—scientific, engineering, legal, and military—to insure access to and use of this vital "high ground".

7. Large Space Solar Power Systems (SPS) are technologically feasible, may be economically desirable, and could be militarily decisive. Given economic uncertainties, it would be unwise to make a national commitment to construct large Space Solar Power Systems at this time; but it is important that we acquire the technologies critical for SPS.

SPS is important as a potential source of electric power for military and industrial operations in orbit. SPS power delivered to Earth could become the cleanest and most economic source of renewable energy ever discovered. The technologies developed for SPS will be valuable for the entire space program.

8. Until a national space policy is formed and adopted, it is important that we retain a wide range of options, and that we develop the technologies required for the military and commercial exploitation of space. It is imperative that we retain all affordable means of

access to the space environment.

9. U.S. space technology centers form a part of our national treasure. Space policy must give due weight to retaining these centers of excellence. The Apollo experience demonstrated vividly that when these teams disperse, it is very difficult to reacquire their capabilities.

10. Space capabilities and technology can be significant insurance against energy and environmental disasters. A rational space policy will include developing a range of technologies applicable to many missions. Some of those missions may never be required; but the technologies developed for them will be useful in the general economy.

11. The constant goal of U.S. space policy must be to assure access to the space environment for our citizens. The priorities developed in this document should therefore be considered as part of an "open ended" space plan, and all space plans should be periodically revised as new requirements are identified, new tactical problems arise, and new opportunities present themselves.

Space will remain a crucial frontier throughout the foreseeable future.

RECOMMENDATIONS

1. This Council recommends that the President proclaim U.S. intent to resume our rightful place of leadership in space; and that this declaration include an offer of cooperation with U.S. friends and allies.

2. The United States should, as a matter of national priority, develop the technologies required for construction of large space structures, the facilities for industrial space processing, and the capability for using extra-terrestrial resources.

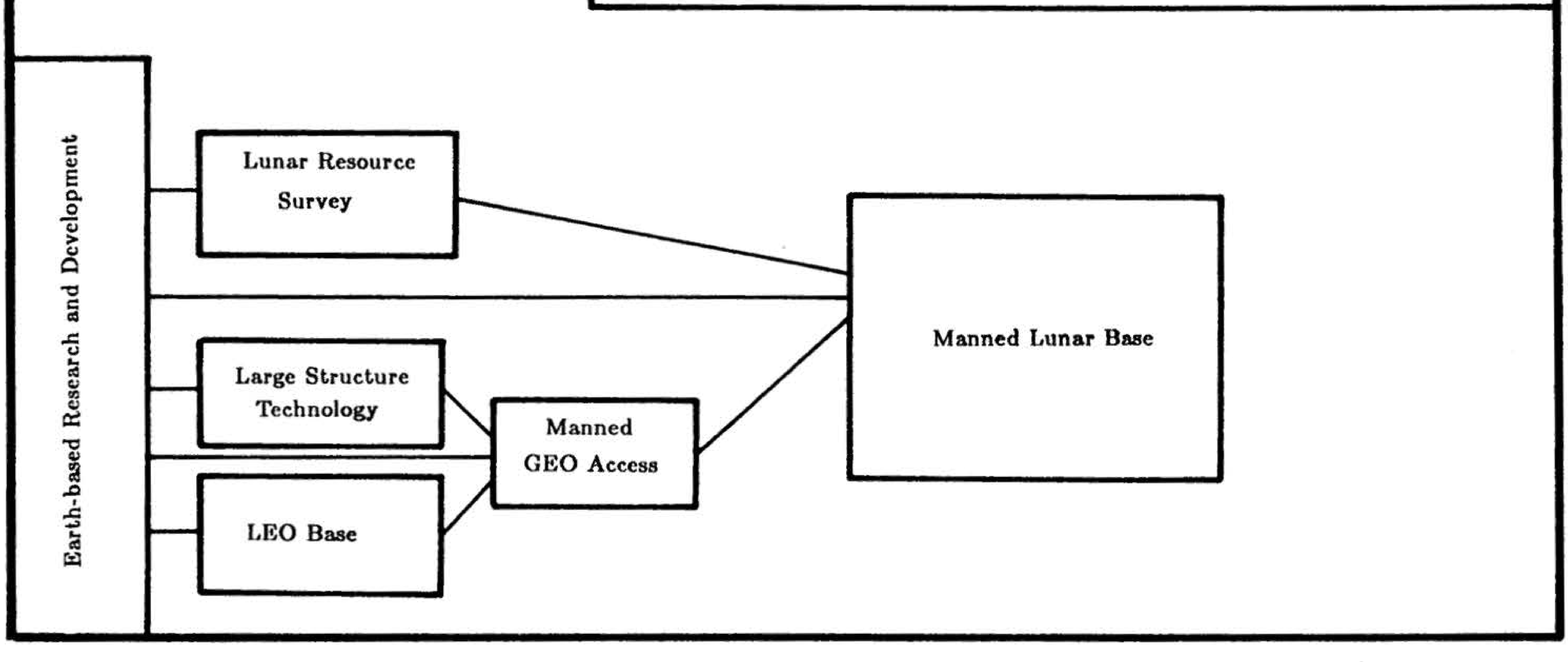
3. The United States must immediately establish a permanent manned presence in space. This should be done as a cooperative effort between government and private entrepreneurs, and is best accomplished through construction of a manned industrial research and production center in Low Earth Orbit (LEO). This LEO Base can and should be in position and partially completed before Fall of 1988.

We note that the LEO Base could be completed much earlier if given additional funding and high procurement priority, and we recommend that this option be examined before budgeting for FY 1983.

The LEO Base will provide "industrial park" facilities for private industries, and should rapidly develop profitable space-processed materials. This will lead to demand for cheaper sources of raw materials,

Table 1 — National Space Policy Goals

LEO Base established and manned	1988 – 1990
Large Space Structure Technology Acquired	1988 – 1990
Lunar Resource Survey (Lunar Polar Orbiter)	1984 – 1988
Manned GEO Access Acquired	1986 – 1990
Manned Lunar Base	1995 – 2000



and thus require a supply of extra-terrestrial resources.

We must also assure access to Geostationary Earth Orbit (GEO), by developing suitable space transportation systems.

The national space policy therefore should include the goals listed in Table 1.

These are reasonable, rational, and feasible goals for the United States and can be accomplished within affordable budgets.

4. The LEO Base (sometimes known as a Space Operations Center), including facilities for privately financed research and production modules, should be given highest priority and be so recognized in funding decisions.

5. The United States must adopt a national space policy. Mission planning must support this policy, and missions should be planned to maximize required new capabilities. Except for missions which directly contribute to accepted national goals, those missions which merely exploit existing technologies must have lowest priorities.

6. The Halley's Comet fly-by mission is low-risk and spectacular, and gives a solid accomplishment in a time when the Soviet Union will have a number of space accomplishments. The Halley mission should be examined for national prestige advantages, and if adopted should be considered a national security investment, since the flight develops little new technology. The Halley mission is unique in that it cannot be delayed; if the mission is desired at all, the new start must begin immediately. Otherwise, the program should be cancelled.

7. The reallocation of FY 82 funds as shown in Table 2 is vital.

In addition, NASA should be given authority to reallocate funds as may be needed to identify and acquire technologies critical for the LEO Base and inter-orbit transport system.

These programs are urgent and should proceed immediately, even if, due to budget limitations, this requires major changes in previously funded programs.

8. It should be noted that Resources Surveys—Lunar and Asteroidal—are the only major missions which can be completed prior to Fall of 1984. Early completion of the Lunar Resource Survey—an unmanned Lunar Polar mission—is desirable in that the information gained will simplify design of the Lunar Base. Completion of either mission during 1984 would require a $50 million commitment in FY 82, and thus may be impossible. These survey missions are important, but can be delayed by one or more years without fatal consequences.

9. The United States should create a review council, outside and independent of NASA, to advise the President and Congress on long-range space policy. Council members should include space professsionals, businessmen, journalists, scientists from relevent disciplines outside the space sciences, and informed citizens interested in space. The Council should meet at least annually, and should be charged with recommending national space goals and policies while giving due regard to economic and technological realities.

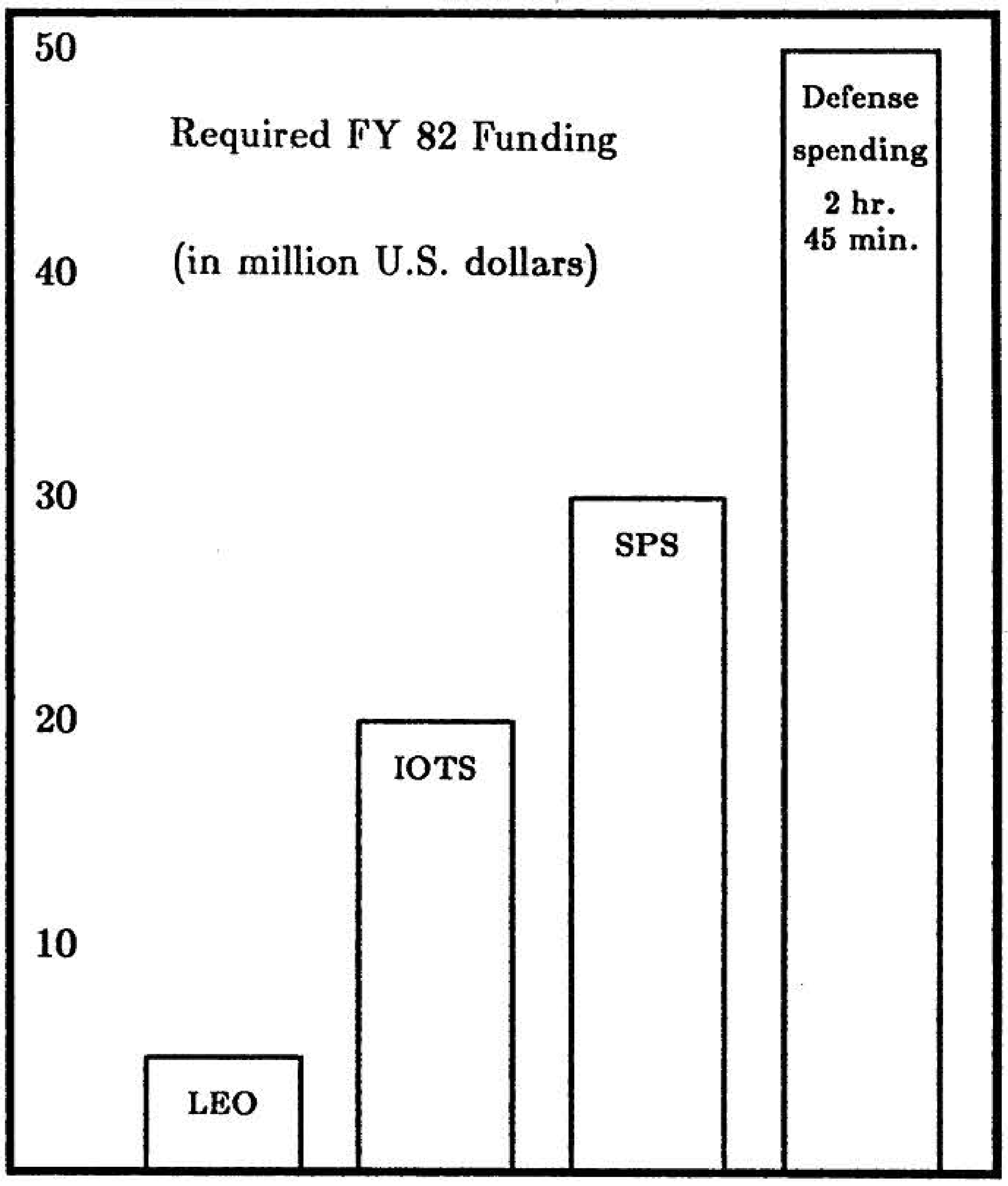


Table 2 — Required FY 82 Funding

LEO Base new start	$5 million
Inter-Orbit Transportation Systems (IOTS)	$20 million
Space Solar Power Technologies (SPS)	$30 million
Two hours, 45 minutes Defense Spending	$50 million

POSITION PAPER ON SPACE SOLAR POWER SYSTEMS

Report of the SPS Study Committee

RECOMMENDATION

The Council recommends that Space Solar Power technology studies be funded at a level of $30 million per year for the next five years.

CONCLUSIONS

Large Space Solar Power Systems (SPS) are technologically feasible, **may** be economically desirable, and could be militarily decisive.

Given present economic uncertainties, it would be unwise to make a national commitment to **construct** large Space Solar Power Systems at this time. However, it is important that we acquire the capability for building SPS, and that we continue serious development of technologies critical to SPS.

SPS has high psychological importance: SPS technical feasibility is already established and decisively refutes the notion that renewable non-polluting energy for industrial growth is impossible.

SPS is also important as a potential source of electric power for military and industrial operations in orbit. By 1990 space solar power systems may be decisive.

We therefore recommend SPS technology studies be funded at $30 million per year for five years. The data developed during that time will enable us to make a rational decision on SPS deployment; and the technologies gained from those studies will allow us to avoid costly crash programs if we find that SPS is economical and needed. The knowledge gained will be useful for development of alternative energy systems if SPS proves economically undesirable.

SPS **could** become the cleanest and most economical source of renewable power ever discovered; thus the potential payoff is very high. Meanwhile, the technologies developed in SPS studies will be valuable for the entire space program.

DISCUSSION

Solar Power Satellites (SPS) may at first look appear fantastic. They would be very large, tens of square kilometers and greater; on Earth, such large objects would be prohibitively massive. How, it is asked, could we possibly construct something as large as Roosevelt Lake in space?

However, SPS has been extensively studied, often by engineers initially highly skeptical to the entire concept; and no study has yet identified a "show stopper." As an example, the Congressional Office of Technological Assessment, after exhaustive studies, recently concluded that "The prospects for generating electricity from massive orbiting solar power satellites in the next century are comparable to the prospects for future electrical generation by magnetic fusion." The evidence continues to roll in, and the **technical** feasibility of SPS is no longer seriously questioned by those familiar with the studies.

Using SPS to deliver significant electric power to Earth may be economically desirable, as indicated by many well-conducted studies. Of course, any system for delivering the immense amounts of electric power this nation requires for sustained economic growth will be costly. **None** can be priced with certainty. SPS costs are within the range of uncertainty of all known conventional systems—that is, the lowest cost estimates for SPS are **lower** than the median costs predicted for coal and nuclear.

The economics of SPS depend on many factors. Some—such as OPEC prices and the stability of the Saudi Royal government—are beyond U.S. control. Others, including some critical technology costs, are difficult to estimate; while many feasible SPS designs remain unexamined.

SPS designers face a near embarrassment of riches. One study indicated nearly fifty technologically feasible alternative designs, ranging from composition of solar cells to power transmission techniques.

Thus, because SPS has been insufficiently studied, there is no widespread agreement on optimum design for SPS, or even on the most fundamental design considerations. One well-studied plan developed by NASA and DOE contemplates the construction of a large fleet of recoverable Heavy Lift Vehicles ("super-shuttles"). A second method championed by Dr. David Criswell of the University of California would construct a permanent lunar base with the present Shuttle, and construct Space Solar Power Systems from lunar materials. A third alternative is the use of asteroidal materials.

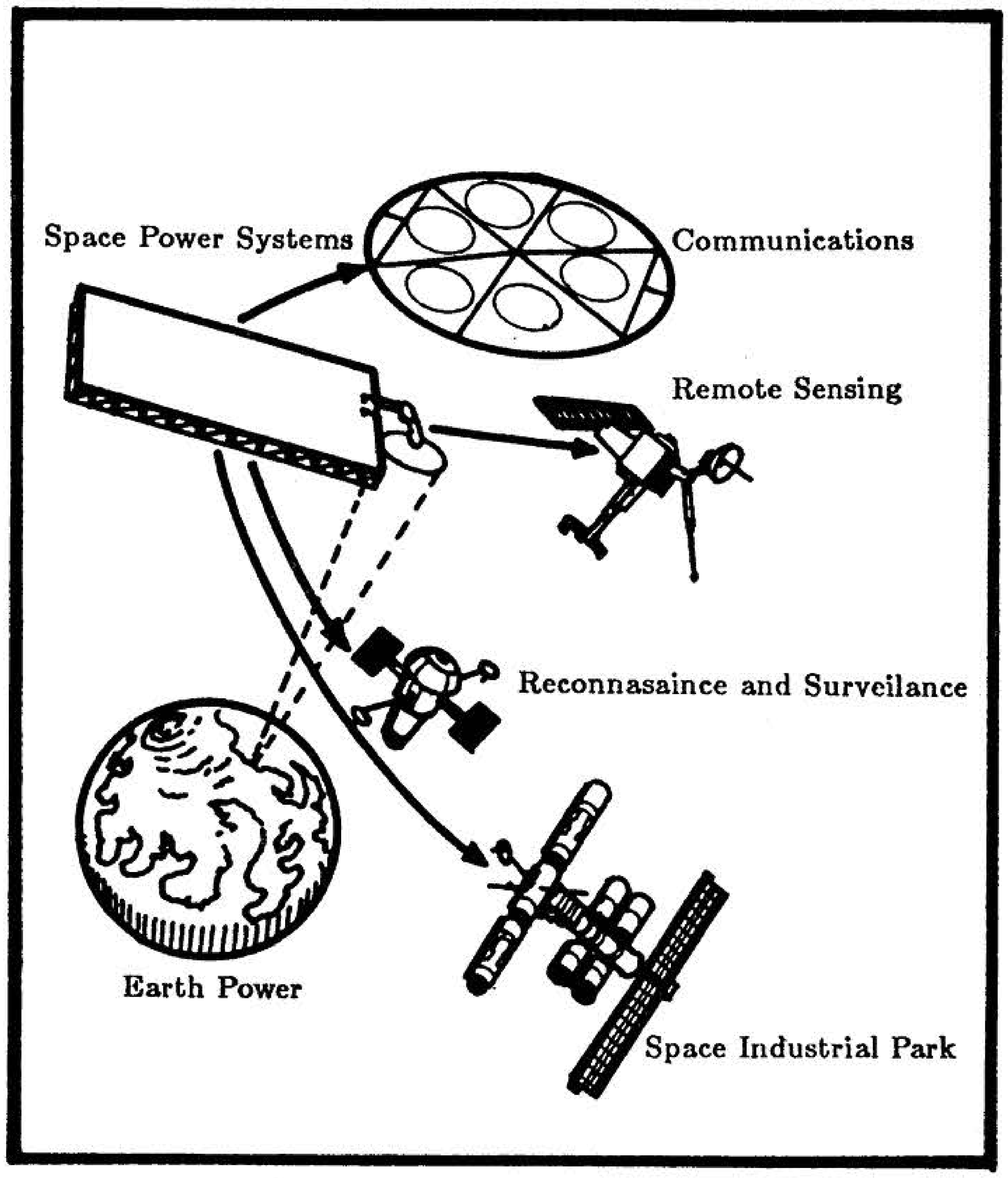
All of these alternative methodologies deserve serious attention. Each has an enormous payoff potential, and none can be dismissed lightly. All enjoy passionate support from highly qualified members of the technological community.

These basic uncertainties affect SPS system costs; but the plethora of alternatives guarantees that SPS is technologically feasible. The existence of a wide variety of attractive choices should not be used as an excuse for endless studies without technology development. While there are insufficient data to determine which method will be optimum, it is clear that the eventual use of large quantities of electric power by orbital and lunar industrial and military facilities is well-nigh inevitable.

We will require SPS for military and commercial needs in space even if we never beam power down to Earth. Thus the technologies are important for our economic exploitation of space—and may be vital to national security.

The SPS technology program can be a valuable insurance policy against the failure of more conventional energy systems. At the same time, SPS development will inevitably produce new insights into, and new uses for, the space environment. SPS is an "open" technology, likely to lead to unforeseen benefits.

Thus, although we cannot recommend **construction** of SPS as an immediate national goal, we do believe that an SPS technology program as insurance against energy disaster would also be a highly worthwhile investment in technologies required for economic exploitation and military applications in space.



HOW TO SAVE CIVILIZATION AND MAKE A LITTLE MONEY

Report of the Free Enterprise Committee

RECOMMENDATION

The most important goal is to make space self-sustaining, which means economically profitable.

We begin with the assumption that we wish to maximize freedom, in space as well as Earth; and that a fundamental human right is the right to have and use property.

FREE ENTERPRISE SHOULD DEVELOP SPACE RESOURCES

1. The President should make two clear statements of intent:

> "The United States of America must commit itself to extending free enterprise into space."

> "The Soviet Union has, and has repeatedly demonstrated, a **direct** interest in preventing free enterprise from entering space."

2. Various international treaties (in particular, the Moon Treaty) concerning the exploitation of space, must be carefully reviewed. The intended thrust of many past treaties has been to bar free enterprise from space.

3. It will not forever be necessary to subsidize space enterprises. Private investment in space industry should be encouraged by:

3.1 A 40% tax credit for all space-related investments.

3.2 A moratorium on taxes on the initial sale of goods and resources produced in space, through at least the year 2000 A.D. The tax credit and moratorium should cover techniques and hardware designed to **support** activity in space. Such incentives have been used in the past, by many nations, to good effect.

3.3 U.S. patent, copyright, and trade mark law should be extended to cover space-related hardware, software, and products.

3.4 A good many present regulations bid fair to cripple most small businesses on Earth, let alone a company trying to gain a foothold in space. We need new, simple, specific laws to cover space activities.

WITHDRAW FROM PRESENT SPACE LAW AGREEMENTS

In 1967 the U.N. accepted a *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.* This proposed treaty would have required that "all activites in space be conducted exclusively by states." The U.S. properly rejected this attempt to forbid private development of space resources. Note that the Communications Satellite Corporation, which is not an agency of the the U.S. government, was created to operate for profit in space. The proposed treaty would have left its status in doubt.

In 1967, compromise between the U.S. and Soviet Union on the Treaty on Principles placed two limitations on private companies. First, "activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate state party to the treaty." (Treaty Art. 6) Second, "each state party to the treaty that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each state party from whose territory or facility an object is launched, is internationally liable for damages to another state party to the treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space, or in outer space, including the Moon and other celestial bodies." (Treaty Art. 7)

This treaty has chilled the investment environment for private corporations interested in financing space activities. The treaty's requirements are without parallel in the private sector. For example, if a Pan-American Airways 747 crashes and damages foreign property or persons, then Pan-American and its insurers, not the U.S. government, are liable for the damage. However, if a space object owned by a U.S. corporation does exactly the same damage, the U.S. government is internationally liable to the government of the state in whose territory the damage occurred. The result has been government control where none is needed and extensive regulation where none is required.

Additionally, many important provisions of the 1967 Treaty on Principles are extremely vague. This vagueness does not affect investment by a government in space, but no potential investor could meaningfully predict the legal and economic risks of private space operations.

After the Treaty on Principles was ratified in 1967, about half the nations of the world acceded to it. Far fewer nations have ratified three later treaties passed by the U.N. These include a Convention on Rescue and Return of Astronauts, a Convention on International Liability for Damages Caused by Space Objects, and a Moon Treaty. Like the 1967 Treaty on Principles, each of these treaties is an academic exercise in international law made far in advance of the reality it purports to control. These treaties do not, and cannot, take into account the rapidly changing nature of space technology. They cannot be amended to reflect a nation's changing economy. They fail to address the legitimate needs of private corporations to own space resources and exploit them for profit. They are really more political statements by the Third World and the USSR than a workable set of legal rules for the initial development of space resources.

For example, these treaties declare that all space resources in the Solar System are "the common heritage of mankind," a phrase interpreted by most nations to mean "common property." This term is also found in the Law of the Sea Treaties. It is an example of how less developed nations are attempting to limit U.S. access to natural resources. This "common heritage" clause has already been used by the United Nations to impose an indefinite moratorium on deep sea-bed mining.

The U.S. should immediately act to withdraw from the 1967 Treaty on Principles and the 1972 International Liability Convention. The U.S. should carefully review the desirability of remaining in the Registration Convention and the Rescue Convention, and should consider, after thorough study, whether to withdraw from these international agreements.

The Reagan administration has several specific opportunities to reverse the recent weakness in U.S. international space policy. The following events in 1981–1983 are critical:

(A) The U.S. should ask *United Nations Committee on the Peaceful Uses of Outer Space* that the "Moon Treaty" be returned for renegotiation to safeguard private enterprise and human freedoms in space. The U.S. delegation should maintain constant vigilance over space activities at the United Nations.

(B) In 1982 the U.N. will host the *Second Conference on the Exploration and Peaceful Uses of Outer Space*. This meeting will be a trial run for at least the next decade of treaty negotiations and radio frequency allocations. The U.S. must submit its National Position Papers to the United Nations. The Reagan Administration should form a task force of space law experts who are known supporters of private enterprise and human freedoms in space to prepare these papers.

(C) In 1983 the Region 2 (Americas) of the *International Telecommunications Union* will hold an *Administrative Radio Conference - Space Broadcasting.* The Reagan Administration should resist the territorial claims of nations over geosynchronous orbit, stand up for U.S. rights to have direct broadcasting over any area of the Americas, and insist that solar power satellites be allowed to beam power back to the Earth.

POSITIVE STEPS TOWARD PRIVATE SECTOR INVOLVEMENT

In *Wealth of Nations* Adam Smith pointed out that South America has greater economic potential than North America. North America is more economically advanced because of the structure of its economy. This illustrates the need for a favorable matrix to foster a flourishing economy. The Reagan Administration should submit legislation to the Congress to create a favorable economic climate in space.

Favorable tax policies and a clarification of the legal conditions in which space ventures occur would be an important step forward and would require no governmental expenses beyond the costs necessary to enact the necessary legislation.

First, a 40% tax credit should be allowed on all high technology investment, including research and development, to direct our national strategy toward the creation of new industries, which could be expected to provide new sources of employment, taxes and foreign exchange. Naturally space industries would be included within the high technology sphere. Since this result would be at least as desirable as the production of power from solar energy, the 40% investment credit enacted to encourage solar energy investment should be expanded to include many other high technology research and development efforts.

Second, space is presently an **economically underdeveloped** environment. Many underdeveloped terrestrial nations have enacted tax moratoria to promote industrial development. Profits from the initial sale of space-produced goods and services, including **data** as a saleable commodity, should be exempted from taxes. Similarly, no customs duties should be assessed on products from space. This provision already applies to less developed nations on Earth. This moratorium from taxation and duties should last at least until 2000 A.D. to facilitate the founding of a wide spectrum of space industries.

Private space industry will require clearly defined laws. Private space activities under U.S. jurisdiction should be exempt from all federal and state regulations except for those specifically enacted to control space activities by the Congress of the U.S. on a case by case basis. For example, U.S. patent, trademark and copyright law should apply to U.S. business activities in space.

None of these moves are guaranteed to **create** American industries in space. The most the United States government can do, is to make the risk less fearsome, the profits more attractive.

THE HIGH GOAL

Report of the Committee on Long Range Goals

America is a frontier, and Americans are frontiersmen; but we have become a nation whose frontiers have vanished. Many of our goals vanished with them. Whereas we once automatically believed that the next generation would be better off than the last, we are now exposed to works that seek to convince us that civilization itself is doomed. The very idea of progress has fallen into disrepute.

We are told to accept limits rather than progress; to redistribute poverty rather than create wealth. The intelligent among our youth see that positions in government offer security and power; enterprise offers nothing but increased regulation and taxation.

The remedy for this malaise is obvious. We must rediscover progress. We must make hope respectable again.

We must open new frontiers. Space will be the most important of these. Space already provides profits from information processing. In the next decades, space industries will become increasingly important, as we find new opportunities for exploitation of the space environment.

The space frontier is important to the entire nation, and to the next generation as much as to this one. It is entirely appropriate that space exploration be supported by the nation as a whole. It is the historic mission of government to provide roads to the new frontier and protect the early settlers.

The first goal should be to establish a permanent manned presence in space—a base in Low Earth Orbit (LEO). The LEO Base will give us the necessary exposure to the space environment; we can learn what is possible and what is valuable.

We know that space has unique conditions: easily accessible extremes of heat and cold; vacuum; and something unique and never before experienced by humans, a gravity gradient. The opportunities for materials processing experiments stagger the imagination. There is simply no chance that we will not be able profitably to exploit this environment.

Space activities can be self-supporting and return benefits to Earth. This requires use of extra-terrestrial resources. The United States can and should return to and permanently occupy the Moon. Industrial exploitation of the Moon will be of great benefit to both the United States and all of humanity. We now possess the knowledge and skills to use lunar resources. We have already paid for most of the necessary research.

Both the Lunar Base and LEO Base can be accomplished within realistic funding limits; and the Lunar Base offers a means of rapid, perhaps exponential growth, through processing of Moon materials. Wealth created on the Moon will be new wealth, exploiting no one, benefiting all on Earth. Both projects can be completed before the end of this century; and the Lunar Base will assure these United States of raw materials through the next century. Our grandchildren will bless our memory.

These are feasible goals. Their costs will be modest in comparison to the potential gains. Many of those gains are intangible, others unpredictable at present. However, even the most conservative forecast, drawing only on information we possess today, shows huge profits, both material and social, for the American people. Among these will be permanent facilities developed from space resources. Mankind's resource base will no longer be Earth alone.

After five centuries, the names of Ferdinand and Isabella live in memory around this planet, because they sent forth Columbus. Those who send humans into space to stay will live in memory as long as humanity does.

This Council believes that America must breathe new life into her faltering space endeavor. We have set forth a number of proposals toward that end. The most important basic idea, though by no means the only important one, is that a vigorous program of manned missions is essential to a sensible space program.

Apollo showed that narrowly restricting objectives can doom vital projects. The achievements of the Lunar landing endeavor were magnificent, and much of the utmost value was learned along the way. However, before the first spacecraft had set down, the project began to dwindle until it was no more. Decisions made in 1964 and reinforced by subsequent administrations prevented continuous growth and exploitation of our Lunar capabilities. The organization that had done this magnificent thing rapidly lost strength, and much of it vanished. The sheer wastefulness of dispersing the most technically competent group in human history is almost beyond imagination.

We can no longer afford such waste. Space resources will be vital to the next century's economy, and will probably be important within this century. The nation that siezes those resources will have an enormous competitive advantage. Few nations think ahead twenty-five years; but this is not to say that none do. The lead times to operational capabilities in space are very long; decisions made now will have effects lasting two generations.

Thus if we are to go to space, we must have a program which we cannot and will not wish to abandon; a program leading to recognizable goals, with prospects of economic return within a reasonable time.

We believe that our program of an immediate Low Earth Orbit industrial base--a space industrial park—together with a return to the Moon is an optimal path to space development, sufficiently bold to attract the bold, yet sound enough to attract investors through the promise of learning to use space resources for economic return.

The present report will briefly explain the reasons for that belief. First it will consider the proposal itself, offering estimates of costs and benefits as well as a tentative schedule. Afterward it will touch on some more indirect but equally real benefits to the United States in particular and the world in general.

LEO

By "Low Earth Orbit" (LEO) we mean an orbit high enough that the atmosphere will not cause drag that brings the station down again in any time short enough to worry about—yet sufficiently low that it is beneath the dangerous radiation of the Van Allen Belt. The range is from about 300 to 700 kilometers (200 - 400 miles).

The LEO Base will have multiple benefits, some unforseen. Certain important uses are already clear, as demonstrated by Skylab and the Soviet Salyut. A station in orbit has a unique feature which cannot be duplicated on any planet: weightlessness. Experiments under this condition hold immense promise for new discoveries in such fields as chemistry and metallurgy, and quite likely new industrial processes. As important will be advances in our understanding of biology, with all that this implies for medicine and agriculture. Numerous other scientific research projects, such as in astronomy and solar physics, can also make excellent use of this platform.

Other nations have already planned space industrial research facilities. The Soviets will have their large space station in orbit well before we can establish ours. However, if we begin planning and design now, we need not continue to lag far behind the Soviet Union;

and we can recapture our lost leadership in space science and technology—a leadership lost years ago.

The LEO Base should serve not only as a government research station, but as a space industrial park for private enterprise—a means for liberating the force of American ingenuity and focussing American knowledge onto the problems of operating in the space environment. If we unleash private enterprise, it should take no great time to overtake and surpass the Soviet research establishment.

We have identified a number of products—such as ethical drugs, high coercive strength magnets, and other high value per unit mass goods—which appear attractive for space enterprises. There are none—at this time—which would by themselves justify construction of the LEO Base; but a judicious combination of products may well generate sufficient products to make the LEO Base profitable.

They should certainly generate income. Meanwhile, the nation will reap the collateral benefits—such as increased interest in technical education, high technology exports, and new technological productivity—of our space investment.

GEOSTATIONARY EARTH ORBIT — GEO

Geostationary orbits are not an unlimited resource. The United States can by-pass much of the Soviet advantages gained from their exploitation of LEO by going rapidly to GEO.

Human activity in GEO is much more difficult than work in LEO, because GEO is some 22,000 miles above Earth—and thus above the Van Allen Belts. Spacecraft below the Van Allen Belts are protected from the deadly radiation of solar flares. Those above them are not, and must rely on shielding. Even shielded satellites do not offer complete crew protection, because solar flares happen without warning and peak rapidly to dangerous radiation levels.

The ability to work in GEO will be well rewarded. One of the best ways to provide shielding to GEO spacecraft is through use of lunar materials. Lunar "dirt" would be ideal for passive protection against solar flares (or enemy military attack).

MOON COLONY AND LEO

The Moon is desirable real estate. Doubtless there are many good reasons which are still unknown to us;

Lunar Resources (Apollo 15 Mare)

Element	Major Use	Abundance (%)
Oxygen (O)	Building Materials	41.3
Silicon (Si)		24.158
Calcium (Ca)		6.96
Carbon (C)		0.0095
Iron	Metals	15.35
Aluminum		5.46
Magnesium		6.81
(a)		0.0022
(b)		1.89
Potassium (K)	Agriculture	0.08
Phosphorus (P)		0.05
Nitrogen (N)		0.008
Sodium (Na)	Chemical processing elements	0.08
Sulfur (S)		0.06
Chlorine (Cl)		0.00076
Hydrogen (H)	Plastics	0.007

(a) Copper, zinc and lead
(b) Manganese, titanium, chromium, barium, fluorine, nickel, argon, tin, bromine, zirconium, and boron (mostly titanium and manganese)

(Reference; "Summer Workshop on Near-Earth Resources", NASA Convercence Publication 2031, 1978, p.107, D.R. Criswell, "Demandite, Lunar Materials and Space Industrialization", *Space Manufacturing and Space Colonies*, 1977, American Institute of Aeronautics and Astronautics) but enough are already clear.

1. The Moon is a major source of raw materials. Although—at least in the low latitudes from which we have all our samples to date—some important elements (hydrogen, chlorine, nitrogen, carbon, copper, zinc, and platinum) are in short supply, approximately 90% of the non-hydrocarbon, non-renewable chemical elements used to form the products of American industry can be extracted from the Lunar soil using solar energy.

It will be surprisingly easy to obtain and use these resources. They are quite homogeneously distributed in the dust and finely divided rock (regolith) which covers most of the surface. (The best picture of typical lunar materials is not sand or gravel, but face powder.) Strip mining techniques are therefore suitable. These have low requirements for both capital and power and should be readily adaptable to the Lunar environment. Naturally it will be necessary to concentrate the desired elements (the rather ugly technical term for this is "beneficiation"), but fluids are not essential for this in the Lunar environment. Instead, it is possible to use such techniques as magnetic, electrostatic, and physical separation procedures.

We can make a very wide range of glass and ceramic products from Lunar soils. Economically viable prototypes of chemical processing plants could be developed within five years or less and deployed on the Moon. Appropriate personnel to begin developing "seed" facilities to place there are already on hand.

2. Given high volume production, we can begin to return products to Earth orbit and to Earth itself. Transportation costs can be reduced to reasonable levels through use of non-terrestrial resources. Powered by free, abundant solar energy—for there is no air on the Moon to impede sunlight, and a day is two weeks long—electric launchers will lift cargo capsules from the weak gravity. The capsules will make aerodynamic descents, guided from the ground, to their destinations on Earth. Other lunar materials will remain in Earth orbit, as construction materials, expendables (such as oxygen), and raw material for orbital factories. This will drive the costs of space operations steadily downward.

Preliminary analysis indicates that mining and refining of some materials, such as titanium, may be cheaper on the Moon than at home. We can expect such savings to apply to many other products as our experience and capabilities grow.

Lunar-made products can include goods in 64 standard industrial categories of the 1972 U.S. economy, requiring some 8% of the U.S. electrical output (44 Gw-yr). Goods in another 166 categories can be produced in part from Lunar resources, using the energy available in space. Note that these materials will not be made on Earth. They are new wealth, not dependent on foreign suppliers, and producing no pollution of our home planet.

Although the initial costs of a Lunar base will be high, increased use of Lunar materials and orbital processing will bring the costs per delivered tonne inexorably downward. Although no one can with any confidence predict all of the technological means which will be employed by Lunar entrepreneurs, some possibilities are already clear. For example, most of the fuels needed for traffic between Earth orbit and the Lunar surface will come from the oxygen-rich Moon itself. In terms of costs to Earth they are free. Other and more exotic systems, including centrifugal slingers and electromagnetic cannon have been studied.

It is not necessary to return to the Moon before we can invent the machines and techniques to exploit it. Research and development can begin at once, here at home. Building on the immense national treasure of the Apollo data, we can simulate lunar materials—in tonne lots—for experimental industrial development.

3. There has been much discussion of solar power satellites as a means of helping solve our energy problems. Located in space where there is no night, these would collect solar energy and beam it down to Earth. SPS systems are covered in another section of this report. However, it is worth noting that similar collectors and beamcasters could be built on the Moon, using native materials. They might prove cheaper and more effective than satellites, and their construction could begin with lower capital investment. Certainly the concept deserves serious study.

4. With its resources and low gravity, the Moon will be a major base for the exploration and industrialization of the rest of the Solar System. After the Moon itself, the asteroids appear to be the most immediately promising bodies for industry.

In order to return to the Moon and stay there, we need not re-create the splendid, but costly Saturn vehicles. We can do it much more simply and cheaply, with the help of a manned station in low Earth orbit.

In addition, LEO will be a refuelling depot and jumping off place for missions to the Moon and beyond. As Robert Heinlein has put it, "When you're in Earth orbit, you're halfway to anywhere"—meaning that the energy needed to go anywhere else in the universe is not significantly greater than the energy needed to climb so high in our planet's gravity well. Thus we can operate with smaller and simpler spacecraft than we would otherwise need, even for quite ambitious missions.

The Citizen's Advisory Council wishes to emphasize that there is nothing fantastic about these proposals. Although complex, they are based on science and engineering principles already understood—and our knowledge of the Moon's resources comes not simply from astronomy and the Apollo landings, but from more than 15,000 work-years of documented scientific research on Lunar samples. It is certain that more resources exist on the Moon than we are aware of at present, but we do not base our proposals on any such assumption. The proven reserves are sufficient.

The initial scale and cost of the necessary operations turn out to be surprisingly modest. Even the total cost does. Likewise does the time scale until development has advanced so far that private enterprise can start taking over an increasing share of the task. That task will be highly profitable because it will be highly beneficial to mankind.

Let us sketch out a possible timetable, with cost estimates, for the founding of LEO and the industrial Lunar colony.

Admittedly, these costs and schedules are only estimates. However, men of long experience in the field have made them. Taken at face value, they give us the Moon—forever—and a key to the whole Solar System, at a cost to the U.S. government of $60 to $70 billion over a period of some 20 years, or about $3 billion per year on the average (1981 dollars). This is an almost insignificant fraction of the total federal budget. Even if the expense proves twice as great, it is still comparatively small. Meanwhile, we have good reason to believe that space facilities may return economic profits within the 1990's—and they will certainly have enhanced national prestige and contributed knowledge valuable for our national security.

(For comparison: the United States spent about 5% of the national budget for a dozen years in creating the Panama Canal. Few would argue that this was not profitable; the Canal was a clear case of doing well by doing good.

The potential profits to the U.S. and to all mankind from Lunar operations will make the Panama Canal look small; yet we do not require any 5% of the national budget for years.)

Please note that outlay for the first several years is especially modest. We need to make no large commitment until experience has proven to us that it will be worthwhile.

Once private industry is able to take over entirely,

1981–88:	Engineering development, construction, launch, and manning of LEO. About $1 billion/year average.
1981–86:	Concurrent process development, in its ground-based phase. $100 million/year.
1986–92:	Process development, in its space-hardware phase. $1 billion/year.
1981–90:	Transportation upgrade. At first, improved vehicles supplement the Space Shuttle; eventually they replace it. There will also be other vehicles not intended to land on Earth, only to commute between LEO and the Moon. By the time these systems are completed, they should already have begun to see commercial use. $1 billion/year.
1986–94:	Establishment of the Lunar base. $2 billion/year.
1990–96:	Production buildup on the Moon and using lunar materials in LEO. In due course, facilities existing there will be able to produce more facilities, and geometric growth of industry will begin. $2 billion/year.
1993–99:	Commencement of Lunar operations in earnest. $2 billion/year.
1995:	Commencement of commercial Lunar operations.

there should be few further costs to the government. Indeed, there should be a rich return in taxes, as well as in material wealth—wealth which never before existed, from effectively inexhaustible resources never before available—to the people of the United States and of the world.

BENEFITS

It is romantic to speak of conquering the planets and going on to the stars. One might also philosophize about human destiny, or observe that a humankind which has colonized space will survive any catastrophe that may strike Earth. Such thoughts are not nonsense. They fire the imagination, especially of youth, and they may well have a great deal of truth in them.

However, we who live in the here and now must justify what we do in terms of the here and now. We must ask ourselves what the benefits will be to us and our children, and we must first ask this in a hard, practical spirit. Later, perhaps, we can consider the intangibles.

With reason rather than blind faith, this Citizen's Advisory Council believes that the occupation of the Moon by way of LEO is more than a desirable objective for our country. It is of the highest importance.

In no particular order, because all are vital, let us consider four areas of the national life which such a project will deeply affect. They are (1) the economy; (2) foreign policy; (3) national security; (4) domestic politics—which means a good deal more than the label suggests.

THE ECONOMY

1. It is a historical fact that national undertakings on the scale we are envisaging stimulate the national economy, which at present is sadly in decline. Yet we are not advocating any boondoggle, but a program realistically aimed at increasing the productive and technological capabilities of this country, at a cost which is slight compared to that of many existing programs whose value is in question.

For several years, the government seems to have felt that its purpose must be to "manage scarcity." We, instead, urge a return to the rediscovery of progress and the ideal of growth. This growth will draw, more and more as time passes, on the boundless energy and mineral resources of space. The very prospect of it should, from the first, help restore the traditional American spirit of hopefulness and enterprise.

Such a project will provide employment for far more people than a few engineers. It will call on every part of society, just as Apollo did. A conspicuous beneficiary will be our now underemployed construction industry.

2. Today the U.S. is fast losing technological leadership to Western Europe and Japan. (We will discuss the Soviet Union under the "national security" heading.) A Moon-LEO project would almost immediately re-establish that leadership, by marshalling our skills and ingenuity and then putting these to work.

Exaggerated claims have been made for the "spinoff benefits" of space, which have often been dismissed as "Teflon frying pans". This can not disguise the real benefits of space technology: from computers to management techniques, medical electronics to firefighting technology, which daily impact on our lives. The LEO Base and Lunar Base can do no less.

3. In the productive capacity and technological advances required for the project, we have a key to the reindustrialization of the United States itself.

At present we can say with too much truth that ours has become an underdeveloped country, living off past and passing knowledge and riches. We are dependent for any number of essential materials, from oil to manganese, on foreign nations whose friendship or stability are uncertain at best. Even in the automotive field, where we were once the marvel of the world, we are being out-produced by Japan. It is all too easy to multiply examples. It is not a situation to make the old among us envy the young.

A serious program for the occupation and use of space could change all this. It would revitalize our economy almost from the first. Eventually it would give us unlimited resources, as well as an immeasurably expanded territory for our endeavors. The program will lift the United States above the competitive arena of Earth.

4. For too long, government and business have been in an adversary position, with government enjoying a superiority which has become crushing. A program such as we advocate would create an environment in which the traditional partnership between the public sector and private enterprise could be renewed.

FOREIGN POLICY

1. As we have just noted, the space program would contribute to U.S. independence of other nations for strategic materials and energy. The implications are obvious. In fact, from the beginning such a project would put the rest of the world on notice about our intentions. This should, for example, motivate OPEC to keep down the price of oil that before too long will not be in urgent demand.

2. The sheer magnitude of the vision, let alone the actual accomplishment, should help re-establish American leadership of the free world and influence over the rest of mankind. It will uniquely appeal to the youth of the world who wish to build and explore.

3. At the same time, this is not any call for imperialism. The possible diplomatic difficulties have been considered elsewhere in these reports. They can be overcome, if we have the will to overcome them. Yet Americans will have no wish to ride roughshod over the rights and aspirations of others.

In the near future, a major space project offers us the chance to set up active partnership with friendly nations—not the token cooperation of the Soviets with their puppets. We could even invite them to form a consortium with us for the colonization of the Moon. To the extent that we share the enterprise, we will gain in international stability, security, and prosperity.

In the longer perspective, through trade, aid, or both, we can share the wealth of space with all mankind.

NATIONAL SECURITY

1. The Soviet space effort is devoted, very nearly exclusively, to military ends. It has come ominously far.

A renewed and growing American space program could neutralize this threat. Through the technological and organizational advances that it entails, it could also help counter other threats here on Earth.

2. Elimination of the pernicious "limits to growth" ideology would alone enhance national security. The impoverished majority of mankind need not be driven to desperate measures. They would have new hope, and that hope would come from America.

3. Our share of extraterrestrial resources would enormously increase our military strength. This in turn would give weight to our diplomacy in its quest for a genuine peace. Granted, we could not start reaping these rewards overnight—but we will never have this resource base without foresighted investment; and the very prospect of our expanded resource base should have significant effects. Economic growth in space can in principle be much faster than on Earth. The winner of the race for extraterrestrial resources may have won forever.

The LEO Base offers opportunities for profit. It is at the same time a watch tower, an observation post above the Soviet Union; a source of intelligence and warning. The Soviets often employ such dual purpose systems—the profitable trawler fleet comes instantly to mind.

LEO Base develops skills, technologies, and trained personnel required for military space operations.

DOMESTIC POLITICS

"Politics" has unfortunately become a malodorous word. It means, or should mean, simply the way in which people go about their public business. (To the classical Greeks, an "idiot" was one who took no part in public affairs.) Let us then suggest a few consequences that an American program to put man permanently in space will have for American politics.

We recall how the first Lunar landing gave us back pride, and prestige in the eyes of the world, for one brief moment in what was otherwise a terribly unhappy period of our history. Today we are still in the

Products Likely to be Manufactured using Lunar Resources and Solar Energy

Complete guided missiles	Electronic components	Primary aluminum
Industrial patterns	Machine tools – metal cutting type	Primary non-ferrous materials
Optical, Radio, TV and sighting equipment	Surgical appliances and supplies	Semiconductors
Porcelain electrical supplies	Telephone and telegraph apparatus	Electron tubes
Calculating, accounting, office machines	Special dies, tools and acc.	Hand saws & saw blades
Electronic computing parts	Cutlery	Aircraft engines and engine parts
Vitreous china food utensils	Pumps and compressors	Costume jewelry
Engineering and scientific instruments	Aluminum castings	Aluminum rolling and drawing
Mechanical measuring devices	Non-ferrous rolling and drawing	Measuring & dispensing pumps
Industrial controls	Hand & edge tools	Watches, watch cases and clocks
Small arms	Ball & roller bearings	Surgical & medical instruments
Jewlers finding and materials, lapidary	Engine electrical equipments	Non-clay refactories
X-ray apparatus & tubes	Pens & mechanical pencils	Ammunition (No small)
Radio & TV receiving sets	Power transmission equipment	Abrasive products
Fine Earthenware food utensils	Internal combustion engines	Needles, pens & fasteners
	Machine tools – metal forming type	

Standard Industrial Categories (SIC) more likely to be producible from Lunar materials or to take advantage of solar energy. ("Economic Considerations in Space Industrialization" *Space Manufacturing Facilities III*, 1979. p. 209–221, NASA Contract NSR 09–051–001) aftermath of that unhappiness. We lack a sense of national unity and purpose.

Benign and majestic, infinitely exciting and infinitely promising, the LEO-Lunar-planetary undertaking could go far toward giving us back our morale. It would affirm the mottos of "A New Beginning" and "Let's Rebuild America," in the most realistic, believable way. It would tell us, and tell us truly, that we are again in the vanguard of humanity, and this time pioneering whole new worlds.

The generation and leaders that began this task would forever stand high in history.

WHAT SPACE CAN DO FOR THE REST OF THE WORLD

Report of the Foreign Policy Committee

PREFACE

Dr. Stefan Possony suggests that since each President must, eventually, make a major policy address to the United Nations, this Council should draft such a speech, in which President Reagan discusses a new U.S. Space Policy, and its effects on the world.

Realistically, such a speech—and policy!—could have a highly beneficial effect. SPS systems can be used to deliver Grand Coulee Dam levels of power to remote areas of the world. Space communications systems might be used to bring not only information, but computing power, anywhere on Earth. Doubtless other possibilities suggest themselves.

The Council has a draft of this speech under consideration, and a special committee has been formed to examine our capabilities to make a meaningful contribution.

THE ISSUES

The economies of the United States and its allies are inextricably linked with the economies of the Third World nations. The nations of the world are split between East and West, between North and South, all struggling for their shares of resources, power, and political influence. Freedom itself is at stake in these struggles, which the Soviet Union (among others) is determined to win. Aggressive use of the space technologies which the United States has already developed, and which it can develop in the next few years, could tip the balance in favor of the democratic nations of the world and the United States in particular.

Nations pressed by famines, ignorance, massive rural and urban unemployment, inadequate or undeveloped resources, severe import/export deficits, and poor access to essential economic resources, contribute to international instability and aggression and provide a breeding ground for terrorism and guerilla warfare. Such nations are looking for leadership which will preserve their integrity yet sponsor their growth. By vigorously applying the possibilities of space to the solution of major problems in the Third World, we can preserve and expand the economic and political options for them and for ourselves. In helping the poorest of the world achieve a decent standard of living, we will help ourselves as well.

SUGGESTED ACTION

Toward these goals, the United States should embark upon a vigorous program in cooperation with developing nations to advance their economic development by suitable applications of space technology in a modern equivalent of the Marshall Plan. The technological developments which emerge from programs geared to domestic American applications can be used in such international assistance programs as well, **at no additional cost**. Many of these capabilities have great, even vital, significance in developing countries.

We therefore recommend that most communications platforms lofted into orbit by the United States should have **overcapacity** in an operationally separable form. The United States will then have excess information-relay and information-storage capacity on hand at all times. Suppose that a less-developed nation attempting to improve its standard of living finds a need for an orbital television relay, or information storage, or whatever. The United States (either the government or a private company) could provide this capability immediately, for sale, lease, or grant. What a friendly government promises its people, we can deliver at once, making both that government and the United States look good.

For example, if a direct television broadcast satellite over the Western Hemisphere had excess capacity with steerable beams, we could deliver educational television programming to every village in Mexico, less than one year after negotiation of an agreement between the U.S. and Mexico. Operational control of the system, and of its programming content, would be fully **local**.

Similarly, Landsat-type information could be provided to assist national planning agencies in development of highway, rail, harbor, and water control systems, as well as in the geological exploration of their own territory for new mineral resources, and in planning land use on a regional and national scale. The cost of providing such services **with a very rapid response time** upon request by a developing country would be miniscule, due to the excess capacity built into space hardware and into interpretation facilities on the ground—all developed and built for domestic American use. Moreover, **all the actual money would be spent in the United States**. Decisions on what to do with the borrowed capabilities would, of course, be the sole responsibility of the host country.

Costs of such programs should not be borne by private companies such as COMSAT, since this would amount to a hidden tax impeding space investments. Foreign aid is obviously a government concern, and the costs of foreign aid should be borne by government.

To support this kind of international development assistance program, it would be useful (and highly visible internationally) to place a "space technology attaché" in each American embassy in the Third World, alongside the traditional cultural affairs, economic, and military attachés. With satellite data links to extensive data bases here in the U.S., the space technology attaché could readily acquire detailed technical information, as needed, to work with national planning agencies in the host country. Financing of the new space systems ordinarily could be paid for by the host countries (since the hardware and operating costs are very modest), by grants or loans from international development agencies such as the World Bank, or as outright foreign aid from the United States, on a highly cost-effective basis.

PROGRAM COSTS

Total estimated cost of such a program over ten years is about $2 billion over and above the costs of presently planned U.S. programs, with all expenditures spent domestically. Revenues for operating hardware and for operations of the systems after deployment would make a positive contribution to the U.S. balance of payments.

U.S. LEADERSHIP

By the end of the century, global population will increase by at least two billion people, while accumulated technological, scientific, agricultural, and economic information will have increased ten- or a hundred-fold. Space technology affords by far the most rapid, effective, and inexpensive means of providing access to this vast information resource to the growing population of the Earth. The market for these information services is virtually unlimited, and it is both technologically ready and politically immediate.

Leadership and profit will be the prize if we can grasp these opportunities. The current U.S. lead will evaporate within the decade without active measures based on a cooperative and imaginative collaboration between the U.S. government and industry.

THE SOVIET STRATEGIC THREAT FROM SPACE

Report of the Committee on Space War

CONCLUSION

Space activities add a new dimension to strategic capabilities. Truly decisive strategic warfare may be possible before the end of this century. The Soviet strategic threat is real and ominous, and strategic weapons making use of the space environment have serious implications for the survival of the United States.

BACKGROUND

In order to compensate for severe inferiority in guidance technology for its first generation ICBMs, the Soviets during the 60s and early 70s developed very high yield hydrogen bombs which didn't need to land close to their targets to accomplish their mission. These weapons were massive, and Soviet rocket engineers designed and built very large boosters to carry them over intercontinental distances. To close the "Missile Gap" of the early 60s—which was then strongly in favor of the U.S.—the Soviets built up four independent ICBM production complexes, all of which are running full blast through the present time. They continued to improve their relatively poor guidance technology to the point that the latest generation of their large ICBMs, the SS-20, has at least as accurate guidance as does the most recently deployed generation of U.S. ICBM—the Minuteman III.

During the 1960's, the United States chose to halt strategic missile production and deployment. Some theorists believed that the Soviet Union suffered from a psychological inferiority complex which would vanish when Soviet strategic forces achieved equality with those of the United States. This theory held that Soviet strategic weapon production would halt when equality was achieved.

Instead, the Soviets took the opportunity to achieve numerical parity but with much larger boosters; and when parity was achieved, showed little inclination to halt weapon development and deployment.

PRESENT SITUATION

All evidence leads us to believe that continued rapid growth in Soviet strategic weapons forces may be expected for the foreseeable future.

Due to their habit of building very high capacity boosters and because their ICBM warheads can now be as accurately targeted as our most modern deployed systems, the Soviets are now able to "fractionate" their four-fold advantage in "throw-weight"—the aggregate warhead launching capacity of their ICBM forces—into a four-fold advantage in number of nuclear warheads with which they can attack the U.S.. The most serious near-term threat which the Soviets pose to the U.S. is therefore the likelihood that they will put 15000–25000 medium-yield warheads (e.g., of at least the yield of Minuteman III warheads) in their large number of huge missiles to replace the 4000–4500 multi-megaton warheads which they presently have in place. With two or three times as many warheads on missiles as the U.S. has—all of them of substantially higher yield and comparable targeting accuracy as the U.S. ones—the Soviets will be able to wipe out all U.S. land-based forces (including all 4000 MX aim-points) with well under half of their ICBM order-of-battle.

Nuclear reactor-powered Soviet naval reconnaissance satellite capability has posed a major threat to U.S. seapower for most of the past decade. What is little-recognized is that these intensively powered (100 kilowatt level), massive military satellites also provide an ideal platform for rapid, entirely covert deployment of advanced anti-submarine warfare (ASW) systems, exploiting a wide variety of radar, optical, and other non-acoustic technological advances of the last several years. The U.S. has no analagous capabilities—either operational or in serious development. The Soviets, on the other hand, have not slowed the deployment of this class of satellites after the de-orbiting into Canada of one of them two years ago. How thoroughly they value such space capabilities may be gauged by their refusal to even discuss President Carter's urgent calls to ban nuclear reactors in orbit.

The U.S. cannot put a 10kW electric power supply of any kind into orbit until the mid-80s, (and only if development begins promptly could we do so then), but the Soviets have had a routinely exercized order-of-magnitude greater capability since the mid-70s. They were unwilling to give up the large military advantages these space power systems confer, so it was hardly surprising that Carter's diplomatic efforts were unsuccessful.

This large and growing fleet of nuclear-powered satellites provides the Soviets with a qualitatively superior capability to locate America's strategic missile-launching submarines, as well as our hunter-killer subs searching for Soviet missile-launching subs, and to direct land-, airplane-, ship-, or sub-based nuclear-tipped missile fire upon them—all of which have been observed in practice operation during Soviet naval exercises during the late 70s. There is no credible evidence which suggests that the Soviets would hesitate to use such demonstrated capabilities to wage space-directed nuclear war-at-sea against U.S. military forces, even if the geopolitical situation were substantially short of all-out war; indeed, all available evidence supports the thesis that the Soviets consider U.S. Navy forces to be "pure" military targets, useful for demonstrations of Soviet strength and resolution in times of crisis without generating the massive civilian casualties which would require a U.S. president to escalate or capitulate.

Soviet anti-satellite capabilities also have no analog in U.S. capacities. As was widely publicized two years ago, the Soviets have demonstrated a capability to attack (or at least effectively confuse) our strategic warning satellites. These satellites give warning of a ballistic missile attack against the United States by detecting the very strong infrared radiation signals given off by the exhaust plumes of ICBMs rising through the atmosphere from their silos. According to open literature accounts, the Soviets were able to blind them and thus negate their warning capability.

The Soviets have also repeatedly demonstrated the ability to use "killer satellites" to intercept and detroy essentially any type of satellite in reasonably low Earth orbit. These attacks are typically carried out with a shotgun-type weapon carried by a killer satellite launched with no warning.

In-space attacks are likely as a prelude to war on not only U.S. strategic reconnaissance satellites, but also on command, control, communications, and intelligence satellites which are increasingly vital to the ability of the National Command Authority to direct U.S. forces in the event of hostilities. Unlike the Soviet Union, the U.S. has committed a critically large fraction of its war-waging assets to the space environment. However, we have not taken commensurate action to defend these assets from any but implausibly trivial types and levels of threats—and the Soviets know it.

FUTURE THREATS FROM SPACE

The strategic threats from space likely to arise during the next two decades are qualitatively and quantitatively more serious than the major ones already existing. They include the ability to compromise or destroy the American strategic force during nominal peacetime without warning and without nuclear weapons utilization.

SPACE BEAM WEAPONS

The best-known of these emerging threats, merely because it is the one closest to initial realization, is that posed by beam weapons—'death rays', as they are commonly known. These systems all share the feature of bringing militarily useful quantities of energy to bear on targets at very great distances, often directing it to targets at the speed of light (making countermeasures difficult at best). One major class of them use laser radiation of one type or another—beams of pure energy, either continuous or pulsed in time. The other major class is that involving the projection of mass, often subatomic particles such as electrons and protons, at speeds ranging from those not greatly in excess of the fastest artillery shells to ones just below that of light.

In continuous operational modes, beam weapons typically bring to bear on their targets energy intensities at least as high as that of the most powerful welding torches; the targets typically have at least fist-sized holes burned through them (usually with lethal results) in a second or less. When operating in pulsed mode, beam weapons load the surfaces of their targets with destructive amounts of energy on time scales of a millionth of a second or less; the surfaces evaporate with forces far greater than that of a comparable thickness of TNT, usually destroying the structures under them in the process.

Beam weapons energized by the burning of special chemicals are being considered for deployment in space during the 80s by both the Soviet Union and the U.S.; such laser beam weapons have already been used to shoot down military aircraft and have been operated from airplanes. Deployed in high Earth orbit, one such station could potentially burn down all the missiles launched from whatever locations by one side during an all-out nuclear war, and then leisurely burn down all enemy bombers for an encore. The side owning the space laser battle station would come through the war untouched, and would own the world thereafter; the other side would be annhilated. If such a space laser battle station could defend itself from all types of attack which enemies of its owners could direct against it, its ownership would confer the prize of a planet--just as soon as it was put into orbit.

However, it appears that only the naive would launch missiles which could be destroyed by the space laser battle stations presently being considered for deployment. As with many other new military technologies, countermeasures to the first generation version of the burner-type space lasers appear not only feasible but easy and economical to implement. Furthermore, space battle stations defended only with such lasers would apparently be veritable sitting ducks for a variety of attacks.

On the other hand, pulsed space lasers energized by nuclear weapons exploding nearby—lasers which have been demonstrated by the U.S. in underground tests and in whose development the Soviet Union is widely believed to be several years ahead—may be effectively impossible to countermeasure. They deliver too much energy of too penetrating nature in too short a period of time to defend against by any means known at present.

These defensive weapons are kept in hardened silos, to be launched as soon as an enemy ICBM attack is detected. Such nuclear weapon pumped laser systems could fire lethal bolts of energy at dozens to hundreds of enemy missiles and warheads simultaneously, but would not have to defend themselves from attack beforehand. A dozen such bomb-energized laser systems—each launched by a single booster—could shield their owner's home territory from enemy attack for the half-hour period necessary for its owner's ICBMs to be launched at, fly to, and destroy the enemy's missile and bomber fields.

A PIVOT-POINT IN WORLD HISTORY

Strategic-scale war in the closing sixth of this century is thus likely to conclude with the total and quite bloodless triumph by the nation owning the space laser system(s); the winner's ICBM fields are part-empty, while the loser's missiles and bombers are totally destroyed. The loser's cities are held hostage for the surrender of his submarine force, whose remaining missiles are impotent against the space laser weapons of the winner in any event. The least certain consideration in such scenarios concerns the identities of the winner and the loser; it presently seems very likely that at least one side will build and deploy an effective space beam weapons system during the later 1980s.

The large present and near-term Soviet advantage in the ability to place large payloads into a variety of Earth orbits and to generate large amounts of electric power with space nuclear power systems may well be decisive in the on-going race to first deploy the first-generation space beam weapon battle stations. Countermeasure development by the U.S. during the next few years of definitive American inferiority in space warfare capability-in-being will therefore determine whether the Soviets will need to make second generation developments in this area.

OPEN SKIES IMPLICATIONS

Advanced satellite observation systems may profoundly affect the evolving strategic balance. Orbiting systems could bring the Eisenhower Open Skies doctrine much nearer to reality. These systems can give warning of buildups of conventional forces; they can also provide warning of ICBM attack.

These warning systems will be highly attractive targets for the Soviet Union. Their defense is not easy, but is probably possible given sufficient U.S. presence in the space environment.

SUMMARY

The U.S. ability to sucessfully wage war-in-space during the 80s and 90s will necessarily develop from its present comprehensively inferior position relative to the capabilities of the Soviet Union. Failure to rapidly gain at least parity with the advancing Soviet space warfare capabilities appears likely to doom the United States by the mid-90s; if this occurs, beam weapons systems deployed on Soviet space battle stations circling the Earth seem likely to be the lethal instruments.

Advanced reconnaissance satellites may contribute significantly to the stabilization of peace between the superpowers in the late 80s and 90s, if war-waging capabilities become comparable in that period. These satellites will be valuable but vulnerable. Space defenses are possible, but only for those who have a presence in space.

U.S. space capabilities may therefore be crucial for U.S. survival.

APPENDICES

The following signed papers have not been reviewed by the Council. They are included as background material, and must not be considered official statements by the Council. Signed papers are included at the discretion of the Chairman or Vice Chairman.

RENEWING THE SPACE PROGRAM

John McCarthy
Computer Science Department
Stanford University

Goals

Much of the justification of the space program has been from two considerations — scientific discovery and practical return. Since space activities are very expensive, it has had to compete with other means of advancing science and getting useful technology, and the Congress has often been skeptical.

Many Americans are disappointed that the space program has slowed down after its initial fast start, but it is neither a lack of scientific discovery nor a lack of economic return that disturbs us.

Rather we are disappointed that there is no permanent space station yet, that there has been no manned expedition to a planet, and perhaps most of all that it appears that only space professionals will be able to visit even low Earth orbit in our lifetimes.

In short, part of our space goals are exploration as distinct from scientific discovery, the possibility of colonization and the creation of a new frontier, and the possibility of personally experiencing weightlessness and the other phenomena of a space environment. Besides that, we are glad to take part in the achievement of the goal of space exploration.

I believe that enough Americans share these goals (or can be persuaded to do so) to support a space program much larger than can be justified by scientific or practical considerations alone. Therefore, it is important to express these goals explicitly in appealing for public and Congressional support. Moreover, part of the recent change in public mood is likely to make it more receptive to such nationally assertive goals than in the recent past.

More concretely, the public should be asked

1. Do you want space colonies in your lifetime?

2. Do you want the opportunity to visit a space station?

3. Do you think that humanity should be more dispersed in space, so it will survive even if the Earth is damaged by war?

4. Should there be a frontier in space where people and groups can lead less regulated lives.

Technology

The NASA policy of supporting only technology that is needed for approved missions has been robbing the future for very short term considerations. There needs to be a strong program in basic space technology not tied to present missions. A billion dollars a year could be profitably so spent, especially since it would have substantial secondary applications. Examples of such technologies are ion and other electrical rockets, nuclear rockets, a single stage to orbit rocket, laser powered rockets, maximally austere life support systems, maximally austere colonization systems.

Mission Style

The space program might have accomplished more if it were more adventurous. Astronauts would accept the situation of an eighteenth or nineteenth century explorer, which may become a more appropriate model than the situation of a test pilot of a new aircraft.

We should consider one-way missions. It would seem that the resources that delivered two men to the moon and provided for their immediate return could have sent enough mass to the moon so that one or two men could live there for many years — supplied by smaller rockets until the technology advanced to the point where it was convenient to bring them back. Thus we might only now be bringing back the first moon expedition.

The O'Neill proposals have attracted much support to the space program. However, at least in their original form they were at the extreme of luxury — proposing to put enormous mass into space so that people could live idyllic rural lives. The other extreme needs to be explored first. Namely, what is the minimum mass required to support a man in a self-sustaining way. I know no proof that it is an order of magnitude more than the mass of the man himself — if only survival with the ability to work is required.

Remote and Automatic Control

We cannot count on replacing human decision-making ability in space by computer controlled robots in the next twenty to fifty years. Basic scientific discoveries are needed before computer programs can be made with and degree of "common sense". Nevertheless, the present state of the art of remote control and artificial intelligence can make large contributions to the exploration of the planets and other difficult environments.

As Minsky and I advocated in 1965, it is necessary to change the notion of a planetary probe from a collection of experiments sharing transportation, power and communication to a notion of a computer with sensors and effectors, i.e. a robot. According to the new notion, an experiment is a program using the sensors and effectors, and new programs can be made on the basis of the results of the first programs.

Mobility of landers is important, could have been achieved in the Viking mission, and would have enhanced it greatly. It would have only required that the arm be able to extend an anchor connected to a winch.

Private Enterprise

Once profitable private investments in manned space are possible, then the rate of progress can be increased greatly. The proposed Solar Power Satellite may provide one such opportunity. The orbital hotel has the advantage that it will provide motivation to many more people than turn out to be able to actually afford it.

Conclusion

The ideas in this memorandum don't pretend to constitute a program and are presented more concretely than they would be if there were time to generalize them. The object has been to indicate that a future space program might well be quite different than a simple continuation of the immediate past.

John McCarthy

NON-TERRESTRIAL MATERIALS (NTMs) UTILIZATION

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The many 1959-80 space accomplishments have been embodied in an average mass flow off-earth of approximately 40kg/hr (propellant) and 20kg/hr (hardware). Space shuttle transport into LEO will likely be less in the 1980's. There is a growing conviction by some researchers that far higher rates of introduction of useful (and more flexible) mass off-earth can be obtained by sending systems of production (machines and people) to other solar system objects. Facilities and products would be made predominantly from local resources. In this manner limitations of the rocket equation, terrestrial funding restrictions and capabilities preconceptions could be attenuated. Growing resources and facilities could be created off-earth.

A vigorous pre-Apollo program of lunar utilization was precluded in 1964 by decisions of the Johnson Administration to not pursue an extensive Apollo Applications program in which larger Apollo style missions would be mounted from the moon and possibly Mars[1]. Lack of 1970-80's inexpensive microcomputers and the associated experience and philosophy of industrial production using machine-monitored systems certainly must have contributed to 1960's opinions that space exploitation would require enormous resources on earth for any use of the non-terrestrial resources (NTMs). Lack of detailed knowledge of future space operations capabilities, costs and of the materials to be used also forces early concepts of utilizations to be general and often focused on inappropriate topics[2]. However, detailed examinations of the returned lunar samples now allow much more precise selections of lunar options[3,4]. Rapidly increasing knowledge of the asteroids and their relation to meteorites examined on earth permit some delimiting of the options for the use of asteroids[5]. Additional motivations arose from investigations of the construction of habitats in space[6] and by arguments[7] that lunar resources could be used to achieve more economical and larger scale production of solar power stations in space[8] to provide power on earth.

In 1975 an ASEE/NASA[9] summer study examined the use of lunar materials in the construction of a permanent (10 million ton) human habitat to be located in cis-lunar space. It was concluded that a large fraction of the materials could be obtained from the moon and that much of the technology for such an undertaking was definable. The 1976 study[10] focused on ejection of materials off the moon by electromagnetic mass drivers with power provided by solar energy; a survey of lunar raw materials and general examination of their use in glass/ceramic products and a scheme (subsequently found unsatisfactory) for the thermochemical processing of lunar soil; and a survey of the design features of a space manufacturing facility which utilized many parallel production units each of which could be manufactured in part from lunar materials.

The 1977 study[11] was of a larger scale (40 full time professional researchers and 20 NASA participants). Five major themes were examined: life support systems (regenerative); habitat designs; mass driver; asteroid resources; and NTM processing. The major aspects were analyzed for obtaining 240,000 tons/year of materials from the moon for the construction in space of a facility (3,000 people) to manufacture 2.4 SPS/year each with 10 Gigawatts of capacity. This study is especially significant as a baseline. It assists in understanding alternative approaches, uncovered many research needs and was used to define three subsequent detailed studies.

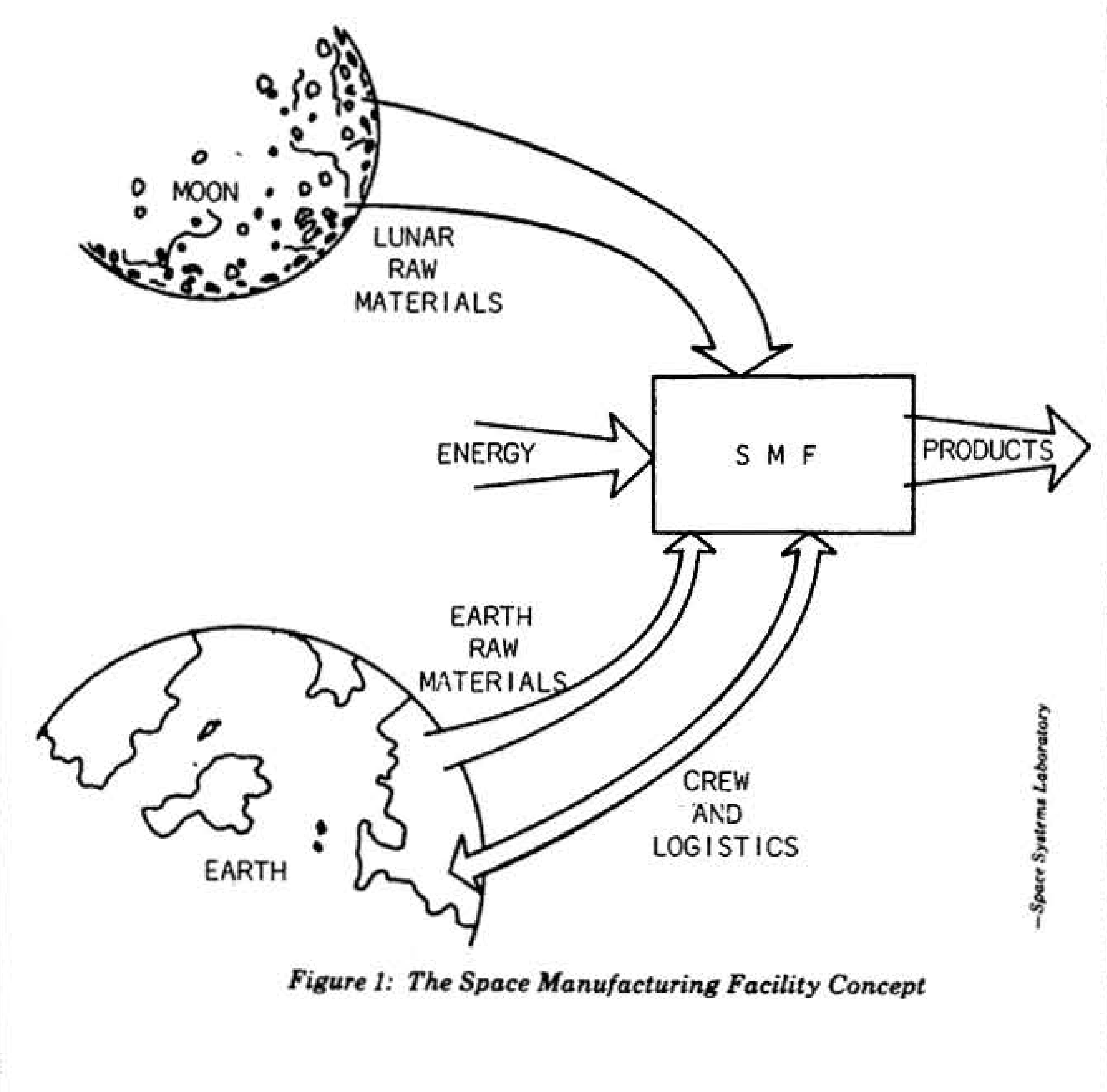


Figure 1: The Space Manufacturing Facility Concept

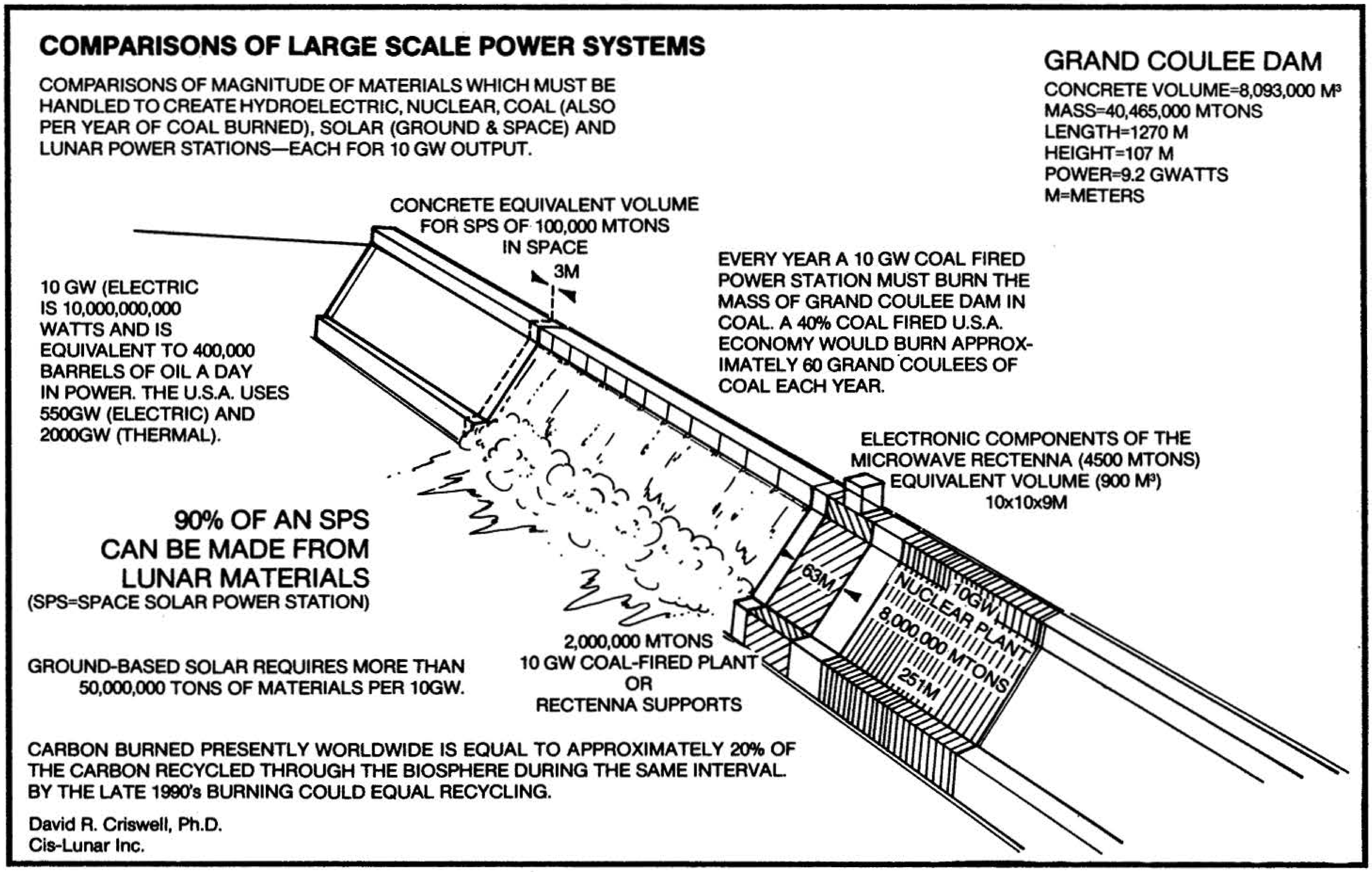
REFERENCE SMF INPUTS[13]

From the Moon	
Aluminum	44000 tons
Iron	1700 tons
Silicon	27000 tons
S-Glass	1500 tons
Silica	50000 tons
Natural Lunar Glass	18000 tons
Magnesium	180 tons
Subtotal	143000 tons
From the Earth	
Klystron Parts	3500 tons
DC-DC Converter Parts	700 tons
Kapton Tape	420 tons
Foaming Agents	240 tons
Dopants	21 tons
Subtotal	4900 tons

Total Mass of Material Inputs: 150000 Tons

Extensive analysis of the primary materials processing procedures of excavation, beneficiation, glass/ceramic production and chemical processing by means of solvent systems utilizing recycled process chemicals have revealed that much terrestrial technology can be applied to the creation of growing industries on the moon or in space[12]. Extensive but precise research needs were listed for the further development of terrestrial technologies applicable to NTM's. Many concepts for processing specialized to the lunar environment were proposed (ex-enhancing trace elements in melt ponds by controlled devitrification).

Massachusetts Institute of Technology[13] conducted design studies of the manufacture in space of SPS from non-terrestrial feedstocks. The space manufacturing facility (SMF) was found to be technically feasible, capable of versatile and flexible production, offered production advantages (ex-direct vapor deposition of solar cells and other complex patterns) and considered to offer economic advantages (compared to earth production) by permitting SPS designs optimized for space conditions. General Dynamics[14] conducted an extensive systems analysis of the construction of one 10 Gigawatt SPS/year over a 30 year period by means of 128,000 tons of facilities deployed completely from earth in 3 years. Approximately 90% of the SPS con-



struction materials were to be obtained from the moon. Under these ground rules it was concluded that a massive product, such as SPS, would be required to justify NTM use; significant economic benefits derived by NTM use due to lower transportation costs and by space manufacturing; NTM based production of SPS was highly probable to be more attractive than deployment of systems from earth after 30 units (possibly competitive from the first unit). The rapid deployment of massive facilities from earth required the creation of a facilities and launch vehicles development effort almost as large as envisioned for deployment of SPS from earth. The semi-annual Princeton conferences on space manufacturing provide documentation of the evolution of these concepts[15].

Massive ($150-300 billion) investments over 10 to 30 year time scales for the deployment of major manufacturing facilities on the moon and in space encouraged exploration of alternative approaches. One approach is to make use of parallelism in production. Construct the smallest reasonable sizes of initial lunar bases and initial construction facilities in space. Then concentrate the initial productive output on the rapid growth of lunar/space facilities. One study[16] indicated that a 40 ton lunar base scaled to manufacture 240 tons/year of additional base and initially supply 2,400 tons/year of lunar materials to a 70 ton SMF would be capable of doubling in system throughput every 90 days. Earth launch requirements would be paced by supplying 10% of the facilities components and fluids from earth. The system would grow in approximately two years to the 300,000 tons/year throughput level comparable with SPS production. Initial investment could be low ($5-10 billion). A small space shuttle fleet could be adequate for the early transportation needs.

A 1980 ASEE/NASA summer study concentrated on two aspects of starting NTM industries with small initial installations[17]. First, 200 terrestrial means (tools) of production were examined with respect to their usefulness in the space environment, advantageous use of solar energy, possibility of creating additional tools from local (NTM) materials (closure problem), and applicability to automation and/or remote control. Twenty-three of the basic manufacturing processes were identified which encompassed the four fundamental manufacturing processes (casting and molding, deformation, machining, joining). Eight production techniques unique to space were identified. Two difference "starting kits" were then described which could use powder metallurgy techniques to replicate themselves or create a full hierarchy of the other tools of production. "Starting kits" offer the possibility of small packages which could be deployed on the moon or an asteroid and operated remotely to construct much larger and/or more versatile facilities. The uses of cast basalts (from native soils) and mineral separation by means of electrophoresis were also examined. A second team considered the general aspects of systems which could be placed on the moon (100 tons initially) and replicate themselves using only local materials and solar power. Basic theory of automata allows this possibility. A scenario was developed of the general approach and a hierarchy of research needs was outlined.

Limited experimental work is in progress on direct electrolysis of lunar like silicate melts (Haskin & Lindstrom in ref 15), glass and ceramic production (Mackinzie in ref 15) and anticipated by Rockwell International and CAL SPACE on previously proposed chemical process schemes (as in ref 4). Gravity swing-bys of planets to modify trajectories and aerobraking[18] of spacecraft in planetary atmospheres can use NTMs to significantly increase mission capabilities to the planets. Obtaining propellants from NTM could also tremendously increase payload return from other planets and moons[19] (Erstfeld et al. in ref 15). NTM use could assist moon/space-based (radio) astronomy, solar photosphere (Sun Driver) probes, creation of hazardous "hot labs" in space, planetary surface exploration, and many other missions[20].

NASA[21] anticipates creation in 1981 of a program to utilize NTMs. Such a program could be the creative confluence of our available (and future) knowledge of the moon and other solar system resources and the full range of terrestrial technologies. From this program could flow the ability to send appropriate information and minimal hardware to other solar system objects and use local resources to organize some of the environment to our needs.

David R. Criswell

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A NEW NATIONAL SPACE POLICY: "TURN IT OVER TO INDUSTRY!"

John T. Bosma

Executive Summary

– The Reagan Administration has a chance to put a private enterprise stamp on the American space program, one that could see a historic transition from government initiative to private sector initiative.

– The industry best positioned to go quickly and profitably into space is the communications industry. The Reagan-sponsored action by the Federal Communications Commission (FCC) to let COMSAT Corporation go ahead with a direct-broadcast satellite (DBS) service *was designed to deregulate that industry* and bring in new industrial "players".

– The space-communications industry has gotten the signals: in five months the FCC has given the go-ahead to ventures that will *triple* the number of on-orbit channels. Space is thus turning out to be a perfect testing ground for Republican initiatives to deregulate industry, revitalize our most innovative industry, and use private market forces to develop technically demanding markets.

– In communications *alone*, the markets are lucrative enough and the players are numerous enough to yield a space program as big as Apollo, if not larger. But it will have been developed *by the private sector* in technical partnership with NASA. However, unless we give NASA more support for some of its technology "seed efforts," we could lose the chance to get private industry involved early in the game.

Why is the Space Shuttle a Blue Chip Investment?

Now that the shuttle has gone up into space, the average citizen has a right to ask: What's in it for me?

Why has the federal government spent my money on that program?

But a quick look at what our spending on space could do for us would show the following:

– NASA spending is viewed by a number of analysts as being a high-leverage economic investment, with payback ratios of 7 or 14 to 1, if not even higher. Unlike most other federal interventions in the economy, this one ends up paying its way nicely.

– Telephone traffic would be more expensive if it weren't for satellite communications. But TV programming would be even more powerfully affected. The introduction of "direct-broadcast satellites," which can beam TV programs directly to the individual home or office and can bring in 100 programs where there used to be five, would be simply impossible without the space program and the shuttle. The DBS builds on antenna and "downlink" technology pioneered on 16 years of commercial satellite operations. But it is possible to build such "super satellites" only because our shuttle exists to carry them up to orbit.

– The cost of satellite channels contradicts the "iron law" of pocketbook economics — the one that says everything goes up in price. Satellite costs per channel have *dropped* since the first "bird" in 1965, and will get even cheaper with bigger and more sophisticated satellites in orbit. For example, Intelsat's 1981 cost for transatlantic circuits is only 15% of what it first charged in 1965!

– A 1975 study of the payoffs from just *four* areas of NASA's work — a very small fraction — showed that the estimated dollar benefits from this technical development far exceeded NASA's annual budget.

– The benefits to agriculture of improved weather prediction through meteorological satellites cannot be measured. It is very likely in the billions every year. Modern agriculture is very heavily dependent on statistical predictability. Our weather satellites have helped to create that kind of predictability, which is critical when crops are harvested and exported overseas six months after planting decisions.

– Thanks to the shuttle, it will be cheaper to transmit domestic phone calls by satellite directly to inexpensive ground antennas. The shuttle's capacity will let us put large, costly switching networks into space and essentially forget about digging up streets or putting in telephone poles. The backyard or rooftop dish represents for consumers today what the TV antenna represented back in 1949.

The flight of the shuttle *Columbia* will accelerate the trends and payoffs described above. Already, NASA expects to fall 25% *short* in total launch capacity between now and 1986 thanks to a surge in demand for the shuttle. NASA's 1980 "traffic forecast" for payloads is running over twice what OMB anticipated in its own analysis in 1977 — and this was *before* FCC's deregulation of the broadcasting industry to permit direct-broadcast satellite (DBS) service!

The success of the *Columbia* has handed the Reagan Administration a marvelous opportunity to put together a national space program that could be the centerpiece of a new industrial policy. The President's fortunes have been remarkable: the first shuttle flew "on *his* watch." On top of that, this success occurred at just the time when deregulation of the communications industry is spurring more and more companies to look at an array of services in space that the shuttle will open up to them.

The benefits of operating commercially in space are beginning to sound feasible to many hardboiled investors, if the recent rush of companies to apply for new space telecommunications services mean anything. A recent *Business Week* (April 6, 1981) article viewed it in the following terms:

– business spend $30 billion annually for telephone service, plus all other communications carried on phone lines (such as computers, data processors, etc.);

– demand for new services, such as videoconferencing, "telecommuting," and high-speed data traffic, is expected to boom, with growth rates of *20–40%* annually (versus *8%* for conventional phone service);

– total demand for communications service will hit $150 billion by 1990 (a figure some observers now regard as a serious *underestimate*); since December the Federal Communications Commission gave nine companies a go-ahead on 24 separate satellites over the next five years, which will triple satellite capacity;

– *most* of these new services will bypass AT&T's ground network, providing as much an advance in personal and business communications as the short-wave radio was over the telephone pole. U.S. businesses today spend between $600 and $700 billion per year on "people communications" (80% of which is salary time spent phoning, writing letters, traveling, etc). But the cost of satellite channels continues to lower the capital investment needed to add new communications, enabling this salaried time to be used more efficiently.

What the FCC has done most recently, however, is even more significant than the mundane extension of "existing technologies" described above. On April 21, the FCC decided to let COMSAT *inaugurate direct broadcast satellite service* — a move taken with strong Administration support. In the Reagan Administration's first major statement of telecommunications policy (April 15), Commerce Secretary Malcom Baldrige wrote the FCC to urge approval of the direct-broadcast service, arguing that deregulation of the industry should continue to enable such DBS services to move into the marketplace as quickly as possible.

But what is a direct-broadcast satellite? Why do experts use terms such as "explosive new markets" and other hyperbole in describing what DBS could do for Americans? A quick look will outline what the implications of such space services could mean.

Direct-Broadcast Satellites Will Turn the Communication Industry Upside Down

At present the satellite communications industry uses satellites essentially as very efficient *relay* stations, as "auxiliaries" to the large "trunk capacity" on the ground. An earth station relays a signal to a satellite, which then bounces it back to the ground. (More specifically, this is done by routing it through a "transponder" on the satellite, which can carry many simultaneous conversations).

This returned signal is weak and tends to scatter, even with a highly directional "down link" antenna on the satellite. At present, the industry relies on large ground stations to pick up these signals and channel them back into ordinary ground lines or, in the case of TV, through cablevision networks. Thus, the communications industry uses technology that makes it an intermediary — a *distributor* — between the source and an individual home.

But something is happening on the private market that has taken industry by surprise: even with today's satellite technology, it is possible to use a cheap ground dish to pick up these signals *directly from the satellite*, instead of waiting for them to be routed to you through conventional lines! Already there is a flourishing private market in this so-called "pirate market" — as an annual trade show of private-dish entrepreneurs in Washington D.C., last month made clear. It is possible to buy a good dish for $10,000 (with the necessary electronics), and the price is dropping fast. But to really break open this market, industry needs to put up satellites rigged totally for direct broadcast to numerous individual ground stations. This will require a tremendous amount of power on the satellite, plus some very directional "downlinks" (transmitting antennas on the satellite) to keep different beams from wandering into each other and causing distortion on the ground.

It is not surprising that the broadcast industry is in an uproar over this new competition to their programming monopoly. Up to now *they* have been the distributors of programs — but only because our technology made this necessary. DBS would easily threaten to close down every cable TV operation. Why go to the trouble of putting in a ground cable (the old "conventional technology" built around a big earth station) when you can put a simple dish up on the roof?

Several industry observers argue that the DBS market could quickly supplant or transform completely the following industries if the Reagan Administration doesn't allow it to be held back:

- cablevision operators, initially in remote areas but with DBS quickly moving into the lucrative urban markets and providing several hundred TV channels for individual viewers;

- *all services now provided over ground telephone lines*, including voice computer traffic, data processing, electronic mail, and teleconferencing.

- videoconferencing and its recent offspring, "telecommuting" (whereby people can work at home or in remote stations and tie in by satellite to computers, data processors, or other workers). Several studies suggest that business video conferencing can displace *15%* of commercial air travel. In fact, they also show that the growth in demands for transponders in space (which is how the satellite industry does its reckoning) could multiply total demand by factors of *5–10*, if videoconferencing comes in.

The only problem with DBS satellites is that they are large, bulky and heavy. As a result, they would best ride on the shuttle. Another bonus is as they age they can be retrieved, repaired, and relaunched — *or* they could be serviced in orbit. But a more important factor is that the DBS market will move so fast that it will quickly outstrip whatever capacity we would gain if we stayed with individual "free-flyer" satellites. In other words, the market that DBS is tapping would *bypass* all the ground lines that AT&T has been putting in for decades. It is the prospect of "replacing" this capacity by putting it *in space* that could bring in the telecommunications industry as the new driving force behind a new American space program.

To meet the demand for DBS markets the industry will have to locate large platforms in space — so-called "orbiting antenna farms" (OAFs). This is necessary to improve utilization of the special orbit designated for comsats. Instead of putting up free-flying satellites, which tend to drift into each other's "downlink arcs" and thus cause distortion when their beams overlap on the ground, this concept entails packing the equivalent of 60-90 satellites on a big OAF.

With the amount of power available on such platforms, the originating stations will be able to transmit to dishes as small as 3-5 feet and still provide enough power to get a solid signal. The implications are potent — the dish could quickly displace the average home's TV antenna.

Now, Look What This Does for the American Space Program

One remarkable fact is that *in order to break into these markets the space telecommunications industry is going to need exactly the kinds of space technologies that NASA has been trying to develop on a shoestring for over a decade. But it's going to need them much more quickly than NASA's schedule could provide.* A brief inventory of what industry will need once the DBS, business communications and videoconferencing markets really take off might look like this:

– *more powerful and reusable "upper stages".* The shuttle is actually just a big freighter; it takes cargo from the earth's surface to a "parking orbit" near the earth, which is the most dangerous and demanding portion of flying into space. (or it could equally efficiently retrieve payloads brought back down to the parking orbit from further out, delivering them back on the ground for refurbishment, modernization, etc.) But the communications industry has to operate 23-24,000 miles out, in "geosynchronous" orbit (known in the trade as "GEO"). That's where all our comsats operate today, and that's where DBS "birds" would have to orbit also. To place satellites in that orbit smaller rockets must be attached to the bottom of the satellites to move them from parking orbit out to GEO. McDonnell-Douglas has two small upper stages under private development, which fit payloads previously sent up on expendable *Thor* and *Atlas-Centaur* rockets. But for heavier payloads we'll need more propulsive power than that.

We have one upper stage for such jobs under NASA Air Force development today, but it won't do all we need to do. It's been designed to fit on both the shuttle *and* on the "throwaway" Titan rocket — and thus its design was necessarily compromised. It is also a throwaway itself (a so-called "one-way" system). While it's good for the military and scientific payloads we're planning for the 1980-1990 period, the needs of the communication industry are moving quickly toward a *two-way* (in other words, reusable) upper stage with much better performance. Development of this "orbital transfer vehicle" (or OTV) has fared poorly on NASA's budget, but it looks like it will be needed sooner than we expected. If industry wants to retrieve its very costly DBS satellites, it's going to need a reliable two-way upper stage to go out to GEO and back.

– *orbital servicers, remote manipulators, power-generating packages.* The shuttle has consumed so much of NASA's budget in the last four years that very little work has been done on these technologies. Yet, if we're going to go into space for commercial or military purposes, we're going to end up needing entire families of such technologies. These remote servicers will be attached to upper stages and sent out to geo to work on satellites or OAFs. The "power packs" could be used on OAFs or space radars.

A DBS operator is *not* going to put $200 million into a bird that is rendered inoperable because a switch fails prematurely and can't be repaired in orbit. Nor will he want to put up a brand new satellite every time his competition introduces a lucrative new service. He'll want to recover his satellites or perhaps even modify them while they're in orbit (especially if they're sent up for installation on a big antenna farm). BUT, you can't use costly orbital servicers on a "one-way" upper stage and expect a welcome from your banker the next time around.

– *better electronics in space.* Developing electronics for prolonged use in space is a tricky and expensive game. But the commercial payoffs are very high. With more on-board processing of data (for example, putting an entire telephone exchange into orbit), you don't have to spend so much effort controlling every satellite function from the ground. Again, this area has been "crunched" by the demands which the shuttle has placed on NASA and by the cancellation of several planetary probes, which have pioneered much of this critical technology.

– *large structures in space, assembly operations in space, "work stations" in orbit.* Once the first DBS system gets going, it is safe to say that traffic demands will quickly encourage larger satellites or even small platforms that "pool" such DBS services for more efficiency. But it is necessary to be able to assemble them in orbit close to the earth, which is the the best place to work on them. Then satellites will need a low-thrust engine installed on their structures to carefully repositions them to geosynchronous. We'll need work stations in low earth orbit for this.

Industries that spend $600-700 billion per year *just for "people communications"* in business will be willing to pay the price for more efficient satellites. If a company is willing to pay $100,000 in air fares and hotel bills for monthly executive gatherings, it's going to be interested very quickly in working much more cheaply through videoconferencing by way of bigger satellites. The videoconferencing traffic will support development of orbiting antenna farms plus the working stations needed in parking orbit to put these platforms and their payloads together. NASA has developed very clever technology for expandable structures that can be packed into a shuttle bay. This technology awaits further development for such "super satellites" Again, further development has been held down while more immediate shuttle needs have come first.

Where Does This Leave the Reagan Administration in 1981?

If there is one thing that the above list of technologies makes clear, it is this:

(1) By deregulating the communications industry, *the Reagan Administration has opened up and industry whose earliest commercial indicators show all the classic signs of a "high-technology takeoff" pattern of growth.* This industry is well positioned to open up new markets, but it hasn't done enough technology development for it. NASA has done a small amount but by no means enough. The operators are there, the markets are too, but the technology isn't complete.

(2) We have to develop as soon as possible *a risk-sharing partnership between NASA and those new operators* (whether these are spun off from industry giants like AT&T or are new entrepreneurs). We need a *technology-transfer program* to encourage the COMSAT Corporations to start talking with the Rockwells, the Boeings, and the Grummans of aerospace industry. The aerospace industries have technologies or research programs developed from previous NASA or military programs, but don't yet have a *commercial* market for them. Upper stages and power packages are an example. But these don't come cheap. Still, the potential profitability of space communications such as DBS is high enough that private industry could develop almost all the technology it needs off the formal NASA budget.

(3) The federal government has to support a "transition program" like this. Unfortunately, NASA now comes to OMB's attention line item by line item. If the budgeting method isn't revamped, we could end up wastefully stretching out the programs for upper stages, servicers, and power modules that we need in order for industry to start moving out on its own and pumping high-tech investments back into the economy.

(4) The most important contributor is a radical, innovative new *policy* starting with a Reagan that encourages such a NASA-to-industry transition in developing space technologies. *What Reagan is looking at potentially is a replay of the Apollo program — but carried entirely by private markets.*

(5) We are going to need all of these technologies anyway if we set up a new arms-control regime in space, one that promotes directed-energy weapons for killing Soviet missiles. We need to "denuclearize" strategic warfare and put our emphasis on "deterrence through *denial*" instead of "deterrence through *retaliation*". We can reduce the cost of putting these new strategic defenses in space if we share their development risks with the commercial sector.

We'll also have to defend the expensive new "national sovereignty" we'd create in space. In fact, a full-blooded commercial push into space will probably look like the oil industry's move into deep-water offshore operations from 1964 on. This earlier industrial transition involved much tougher operating conditions, far higher dynamic stresses and pressures, costlier equipment and higher investment risks than the space-commercial transition we're looking at for the 1980-1990 period. The offshores industry's accomplishments almost read like science fiction — and yet they succeeded technologically with hardly a *dime* of federal money! The high-profit uses to which "raw" transponder capacity in space can be put to surpass the value of chemicals and fuels that can be cooked out of a "raw" barrel of oil pumped out on a drilling platform. And yet the profitability of oil sold at the low prices that prevailed from 1964 to 1973 was enough to trigger heavy investments in drillships, underwater trenchers and 540,000-ton supertankers. The "return-on-investment" (ROI) of transponders in space will make them one of the hottest, most highly leveraged investments on the stock market. We could even see a "futures market" in transponders once DBS and other shuttle-related markets get going. Historically, our Navy was created to defend maritime commerce. A new-technology, arms-control regime built around X-ray lasers and beam weapons would also be available to protect the investments going into space.

... And This is Only ONE Market in Space

We haven't even mentioned *processing* in space, an area where the Japanese, the Soviets, and especially the Europeans are ahead of us. Potentially, processing could offer the same fast returns we already see in communications, and it could rival communications as another industrial "tier" working with the shuttle. Remote sensing is another commercial area, as is customized weather forecasting. There are other lucrative markets that could develop once we initiate large structures operating in space.

The first flight of the shuttle has happened "on Reagan's watch", as noted previously. But unless the Administration pays more attention to the "follow-through" phase, NASA could still lose out and the transition to commercial operations (which was a focal point in NASA's 1958 charter) would never transpire. Space is not an economically marginal area. NASA's activity without commercial spinoff has been regarded by several outstanding analysts (Chase Econometrics Associates, Mathematica, Inc.) as one of the most highly leveraged federal investments, with payback rations in economic activity of 14:1 and higher.

The Republicans have a unique opportunity to deregulate communications, to move space technology development into the private sector and to promote a host of "downstream industries" in high technology. Traditionally, it is the industries with the fastest "rise times" that have been the most innovative — and space commercial operations show every potential of moving in that direction already. Space could become the centerpiece of a Republican industrial policy — but *only* if we turn it over to the entrepreneurs in the private sector and give them the technical backing they'll need.

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