INDUSTRIES IN SPACE TO BENEFIT MANKIND

A View Over The Next 30 Years

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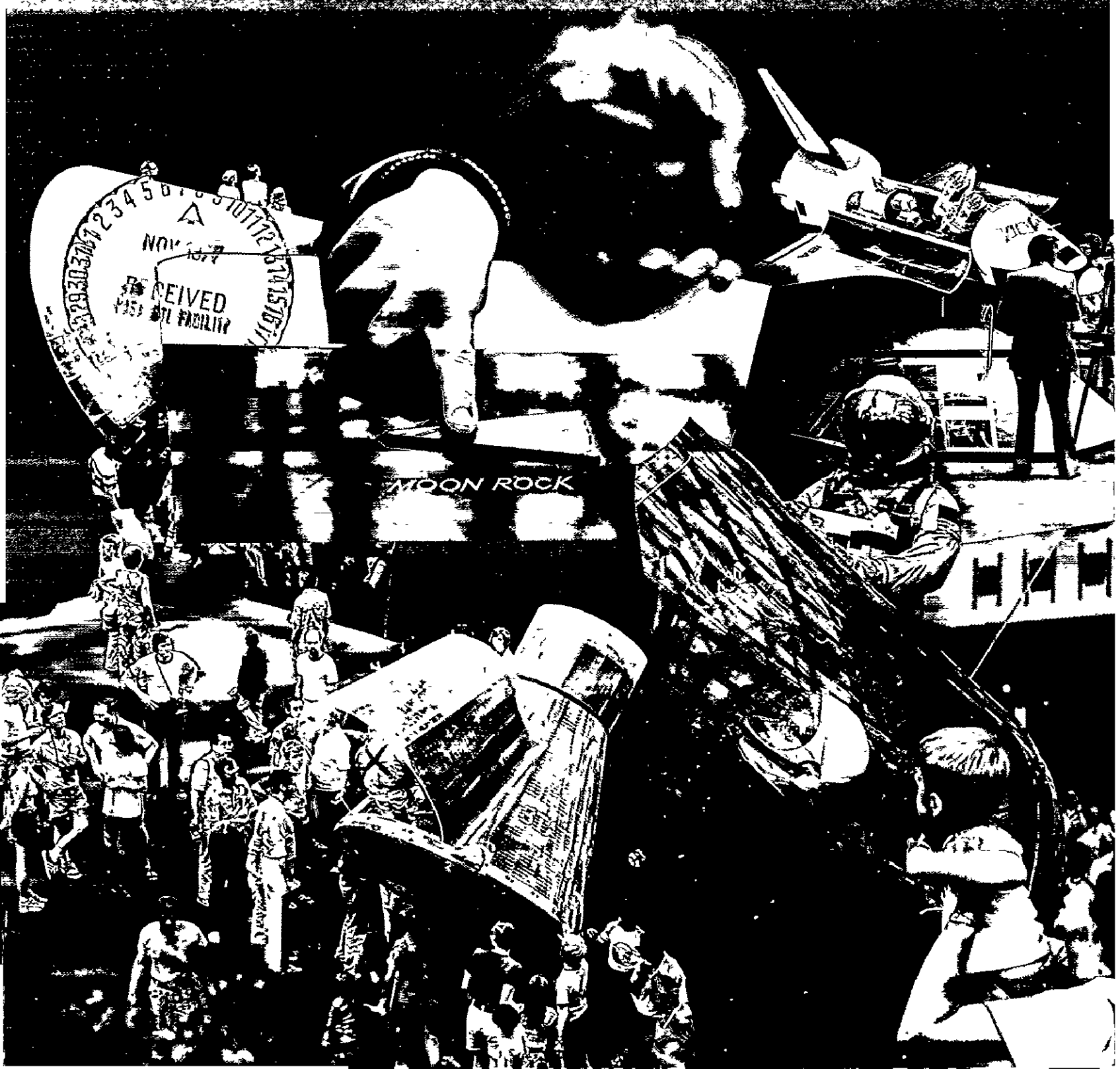

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[A glossary defining many of the specialized terms used in this document is on page 36.]

NASA

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Space Division

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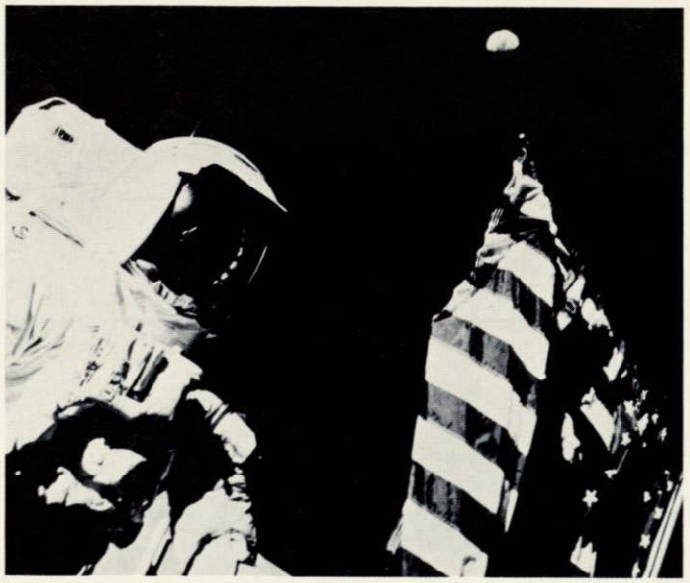
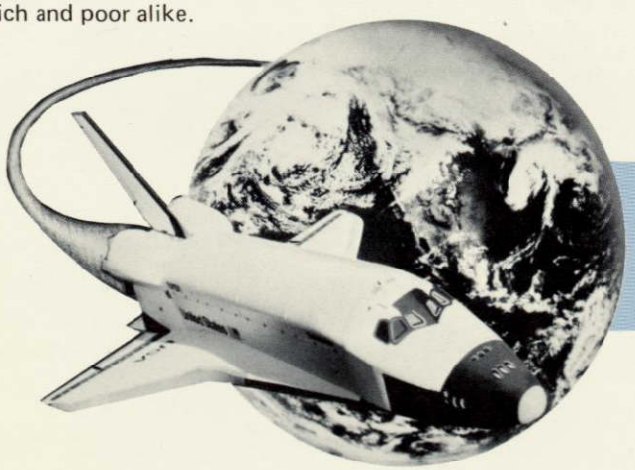


SPACE AND HUMAN DIVIDENDS

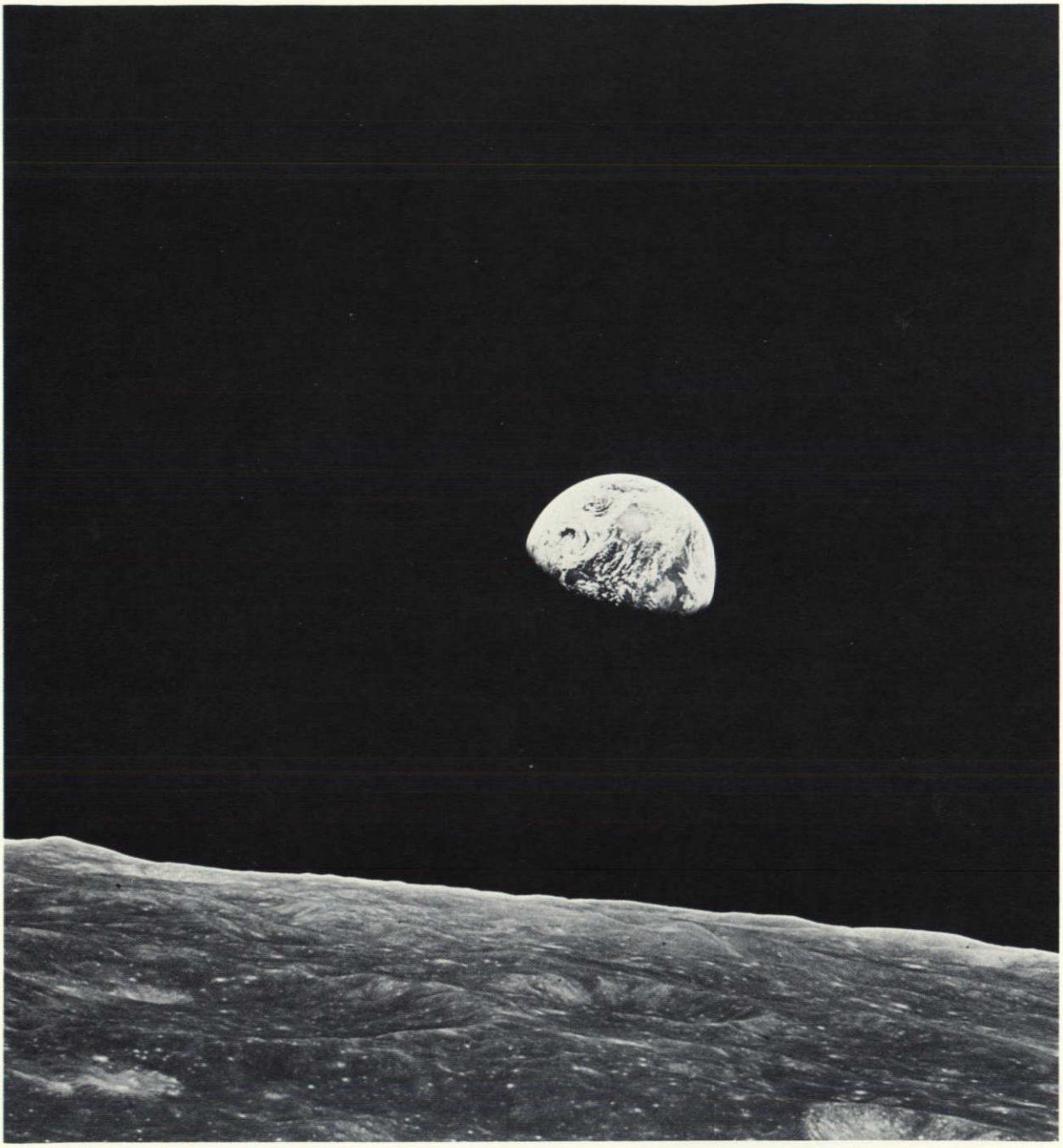
Earth has been called a spaceship without external supplies. Yet our environment depends upon energy supplies from the sun. Life crawled out of the primeval oceans on the sun's rays, creating the biosphere in which mankind arose. We are now beginning to recognize that external supplies are by no means restricted to the solar energy we presently use; nor are they restricted to energy, for that matter.

Earth and space interact in many ways. Only a few centuries ago, we began to understand this oneness in the context of natural laws; now in our lifetime we are experiencing it—going into space and returning at will. The time has come to strengthen this perennial bond further and extend our resource base beyond earth. We stand at the threshold of a great new adventure—the industrialization of the space frontier.

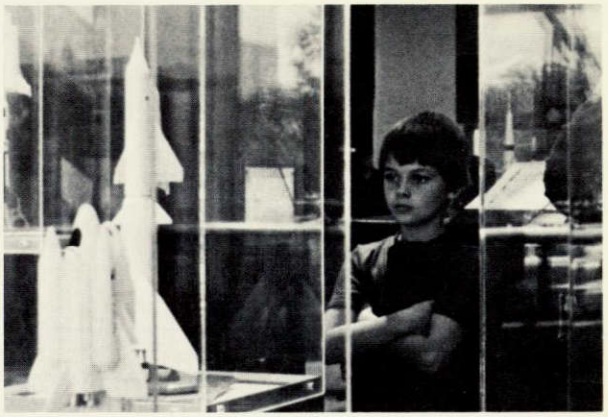
More industrialization? Some people believe we need less technology and industrialization. The truth is that we need more, not less. The nature of our present predicament is primarily social and institutional, not industrial, although industrial consequences are often more visible than their underlying socio-institutional causes. Remove technology and the problems remain; in fact, they get worse because, without continued technological advancement, our society and its social achievements could not survive. Hope for the developing countries would also quietly vanish without advanced technology. There will always be nations that lead, and whose vitality and growth spur the advances of others. In a declining world economy, this linkage breaks down; and when it does, people everywhere are hurt, rich and poor alike.



SPACE INDUSTRIALIZATION



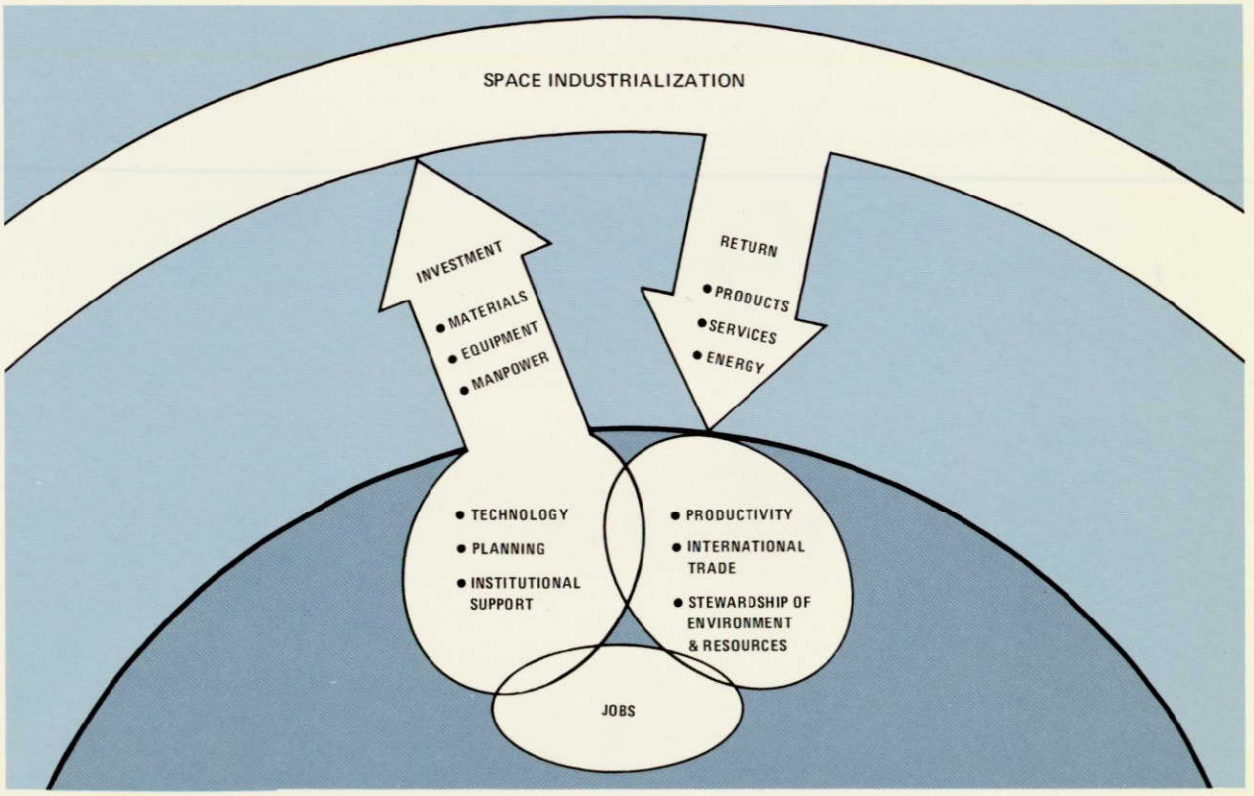
The problems we face today come down to a choice between two ways of life: organizing scarcity or creating wealth. Of course, the organization of scarcity is necessary under exceptional conditions. But the strength of a society is clearly revealed by the manner in which it manages and overcomes scarcity and want. A healthy society rejects the management of scarcity as a permanent way of life. Organized scarcity offers the "justice" of uniformity and of equality in denial. But such strict uniformity threatens liberty. Creating abundance and wealth is the natural state of life. In industrially developed societies, this process gives rise to human freedoms and social services that spark the incentives and set the goals of developing societies.



These practical uses of space will encourage the necessary financial investment; but, perhaps more importantly, the space frontier can help keep man's spirit of adventure alive. Although many challenges remain on earth, few capture the imagination of the young like the dream of someday living and working in space, with its fascination of a limitless future for generations to come.

Earth orbits, the moon, and the realms beyond are industrially inviting because they offer energy, raw materials, and productive space—the three basic ingredients of any industrial process. The fourth is human controlling intelligence, which puts it all together and makes it work.

At our distance from the sun, more radiation energy passes through a mere 64 square miles (about the size of Staten Island) annually than the electric energy consumed by the entire United States. Among the inner planets of the solar system, we alone have a planet-sized companion so close by that ships commuting between the earth and moon need less shuttle time than an oil tanker traveling from the Middle East to this country. Although the moon's mineral ores are not so rich as those on earth, they are rich enough to be industrially useful in the long run. And space itself—once thought to be a major obstacle to flight beyond the atmosphere—is our biggest asset.

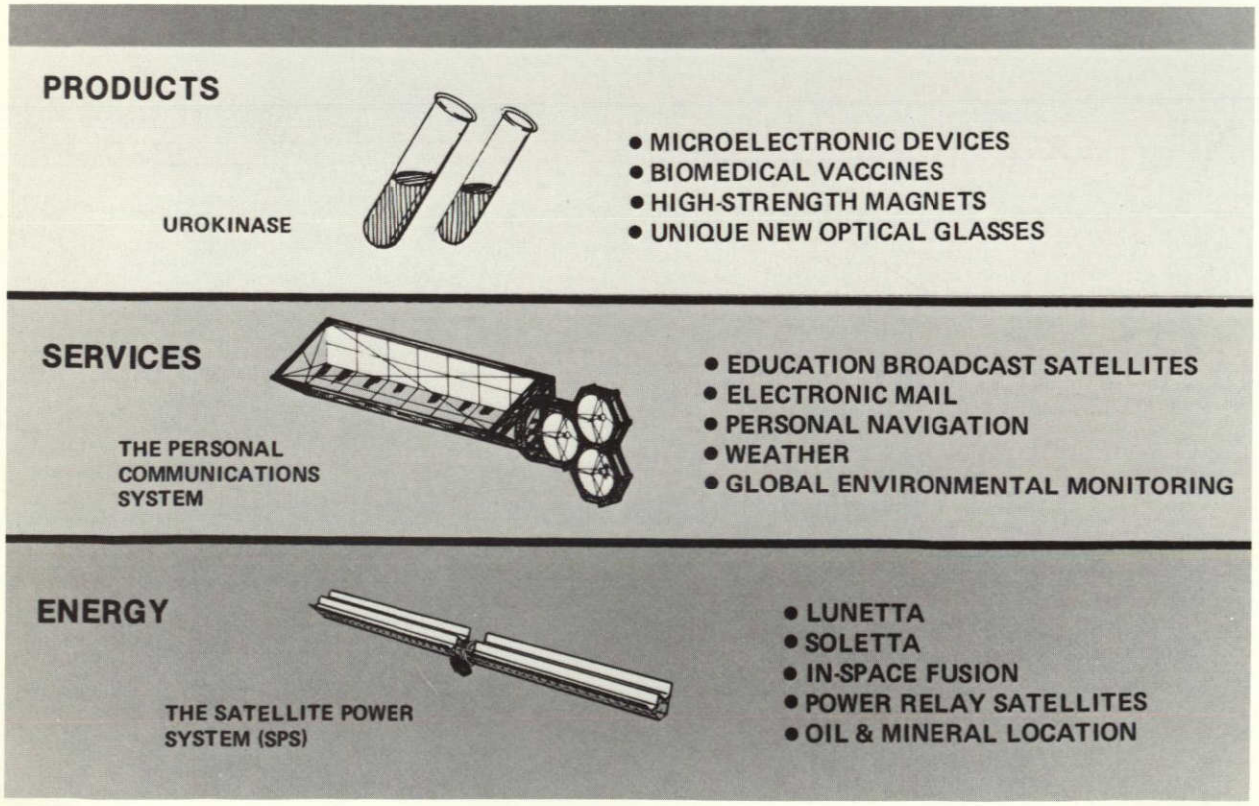


Space industrialization can improve the quality of industrial production so that human living standards can continue to advance while the burden on the terrestrial environment is lightened and the beauty of our planet is preserved. The benefits of space programs already permeate countless aspects of our lives through technology spin-offs and space applications that range from the daily weather forecasts on television to jobs, outdoor leisure equipment, and health care. Most of these breakthroughs were unthinkable only a decade ago. But we do not plan to stop here. This is only the beginning.

WHAT IS SPACE INDUSTRIALIZATION?

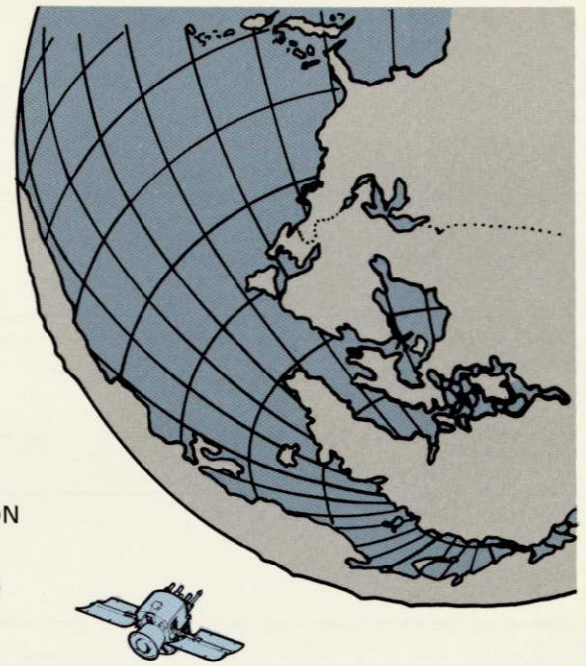
Through space *exploration*, we gain new knowledge and a better understanding of space, earth, and other worlds. Through space *industrialization*, we put new environments to productive use in a pragmatic and cost-effective manner, and improve the utilization of our own planet. Our efforts are aimed at the most pressing problems—energy, jobs, health care, safety, dwindling resources, soaring costs, and ever-increasing deficits in our balance of payments. In solving these problems, we lay the foundation for a richer, less crisis ridden life for those who come after us.

Space industrialization offers three kinds of benefits: new products, new services, and new sources of energy. By pursuing these benefits in space, we can generate new jobs, strengthen our resource base, and keep our economy healthy and growing. Moreover, the use of space can be an important step in extending and "opening" our world by adding new environments to our productive capacity. For the first time, we will be able to say, "We don't want this or that industrial process on earth anymore because it burdens our environment or is too dangerous. Let's put it into orbit or on the moon."



THE USEFUL ATTRIBUTES OF SPACE

- ZERO-G ENVIRONMENT
- HARD VACUUM
  - FREEDOM FROM HARMFUL VIBRATION & CONVECTION CURRENTS
  - DISTORTION-FREE OBSERVATIONS
- WIDE-ANGLE VIEW OF SPACESHIP EARTH
- ISOLATION FROM THE EARTH'S BIOSPHERE
  - FOR HAZARDOUS PROCESSES
  - FOR SAFE AND EFFECTIVE WASTE DISPOSAL
- VIRTUALLY UNINTERRUPTED SOLAR ILLUMINATION (FOR LIGHT, HEAT, AND POWER)
- INFINITE HEAT SINK (SUPER-COLD TEMPERATURES)
- UNLIMITED VOLUME
- EXTRATERRESTRIAL RAW MATERIALS



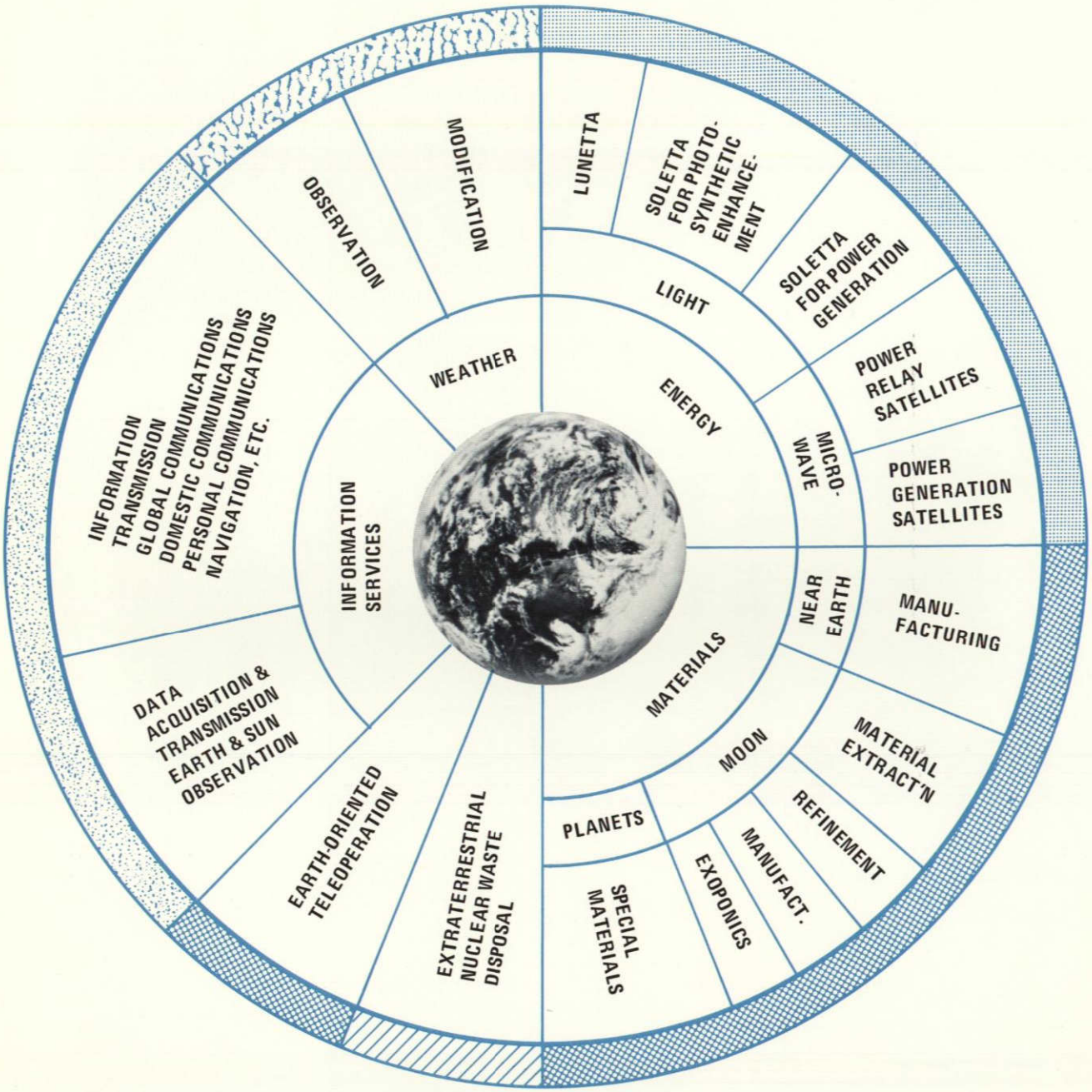
Because space is a vacuum, distance does not impede our vision. We can stand back from our planet and observe the atmosphere, the oceans, land, crops, fresh water run-offs, and geological formations in ways never before possible. We can manage the impact we have on our own environment with knowledge and from a comprehensive point of view.

Information can be transmitted in the vacuum of space almost without regard to distance. Energy can be transmitted over tens of thousands of miles from space to earth at a smaller loss than it experiences in a few hundred miles of overland lines. (Losses arise only with entry into the atmosphere.)

And because of the vacuum in space, products can be manufactured at cleanliness and purity levels that would be unthinkable on earth. In addition, an orbiting factory would be virtually vibration-free. The factory would "fall" freely in orbit, rendering itself and everything in it almost completely weightless. Cleanliness, purity, hard vacuum, and weightlessness are unique to space. Each adds to the quality of production and makes possible new products for our economy and our welfare. By combining these features in various ways, we can offer mankind many new and exciting products and services.

Of course, one of the major ingredients in all industrial processes is human intelligence. Man will be involved; but economy and cost-effectiveness, without which the benefits of space industries would not be affordable by most people, demand the judicious use of personnel in space.

Space industry will bring the technological and economic benefits of space to people on earth. In the past, we nourished our economy by investing in businesses and new enterprises, many of which grew into large industries and gave their stockholders a fair return on their investments. In the case of space industrialization, NASA and various aerospace companies will blaze the trail for a new space-based economy that will be sustained by many earth-bound enterprises and public services. Shortly thereafter, the space industrialization process will begin to rely not on taxpayers' money, but on private enterprises financed by the investments of citizens. These investments, properly put to work with our intelligence and our machines in space, will allow us to generate a maximum number of new jobs for people living on earth.



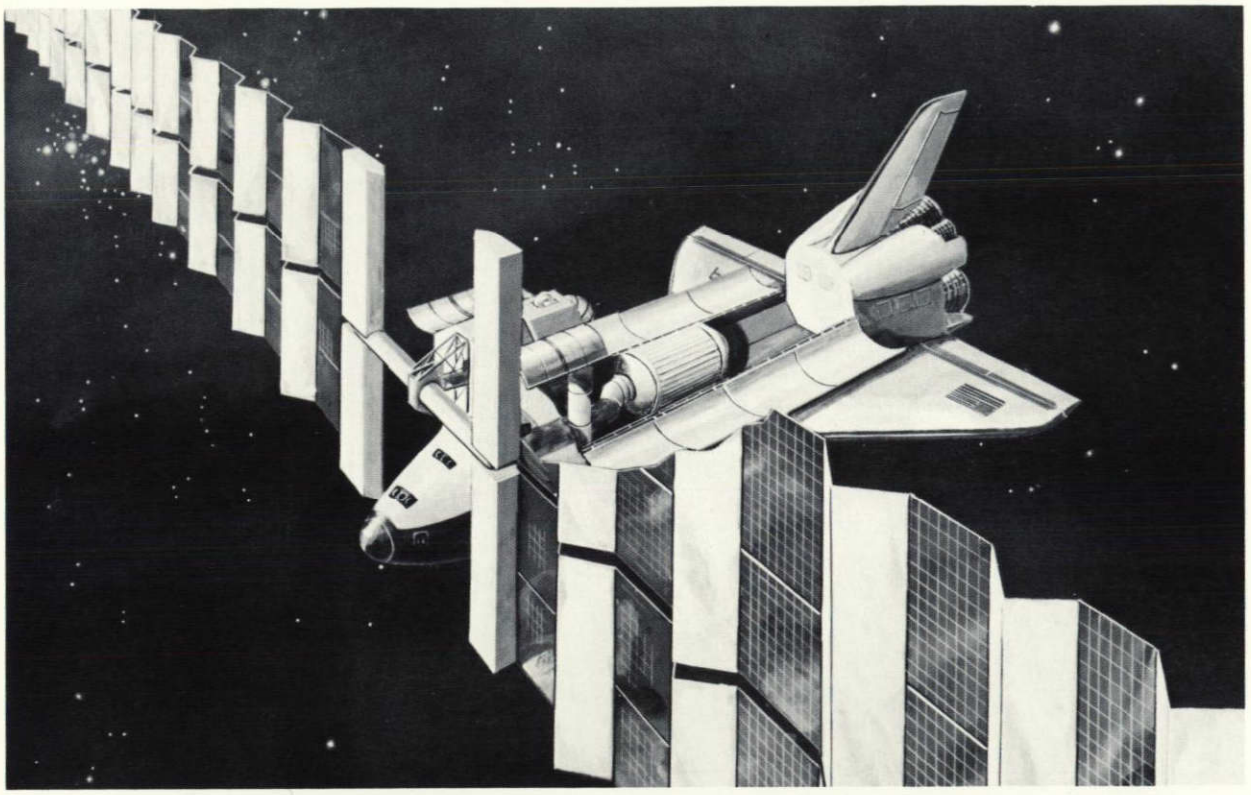
Space industries can create a stronger economy, benefits at home, and new miracles in medical achievements. Some of these will be sponsored by our government or foreign countries; others will be sponsored by profit-making companies that employ our people and help pay our taxes. These new productive capabilities will stimulate competitive industrial progress on earth. They will elevate our lives and brighten our horizons. But they must be developed first. The promise of the American wilderness was not fulfilled easily or quickly. We must pioneer again. Just as we did then, we must utilize this domain in a step-by-step manner, making sure that each step not only makes sound economic sense in its day but also leads toward a better world for tomorrow.

As we shall see, some benefits from space will be available in the 1980's, others in the 1990's, and still others in ever-growing numbers in the first decade of the next century. Although these dates sound like the distant future, they are no farther ahead than the 1940's are behind us; and, to some of us, the 1940's are almost like yesterday!

THE SHUTTLE TO AND FROM SPACE

If it is to be practical, space industrialization must be cost-effective. If it costs more than it's worth, we shouldn't do it. So the lower we can keep the costs, the greater the promise space holds.

The reusable Space Shuttle will lower the cost of getting things into orbit by giving us the opportunity to reuse most of the launch vehicle rather than expend a new one for each flight. It can also bring things back if they don't work properly or if they are intended for use on earth.



Moreover, the Shuttle will be manned and can stay in space for many days; therefore, large and complicated devices can be assembled and checked out in the space environment. This feature is especially important for building large, extremely lightweight (spider web) structures. (Large space structures are the key to many space advances, such as intercepting sunlight and converting it to electricity or building large antennas in space to work with thousands of small, low-cost antennas on earth.)

As we do more useful things in space, we may want to stay longer and keep some materials, tools, etc. in orbit. This could lead to extending the Shuttle orbiter capability, putting a solar power plant permanently in space to support orbiter extended operations, and eventually putting permanent facilities for man in orbit.

Of course, the lower we can keep the costs, the more we can do. Our step-by-step plan is to proceed so that each step returns benefits that help space programs pay their own way. Already, private businesses here and in Europe have begun arrangements to buy space aboard the Shuttle.

HOW TO CONSUME LESS ENERGY AND ENJOY LIFE MORE

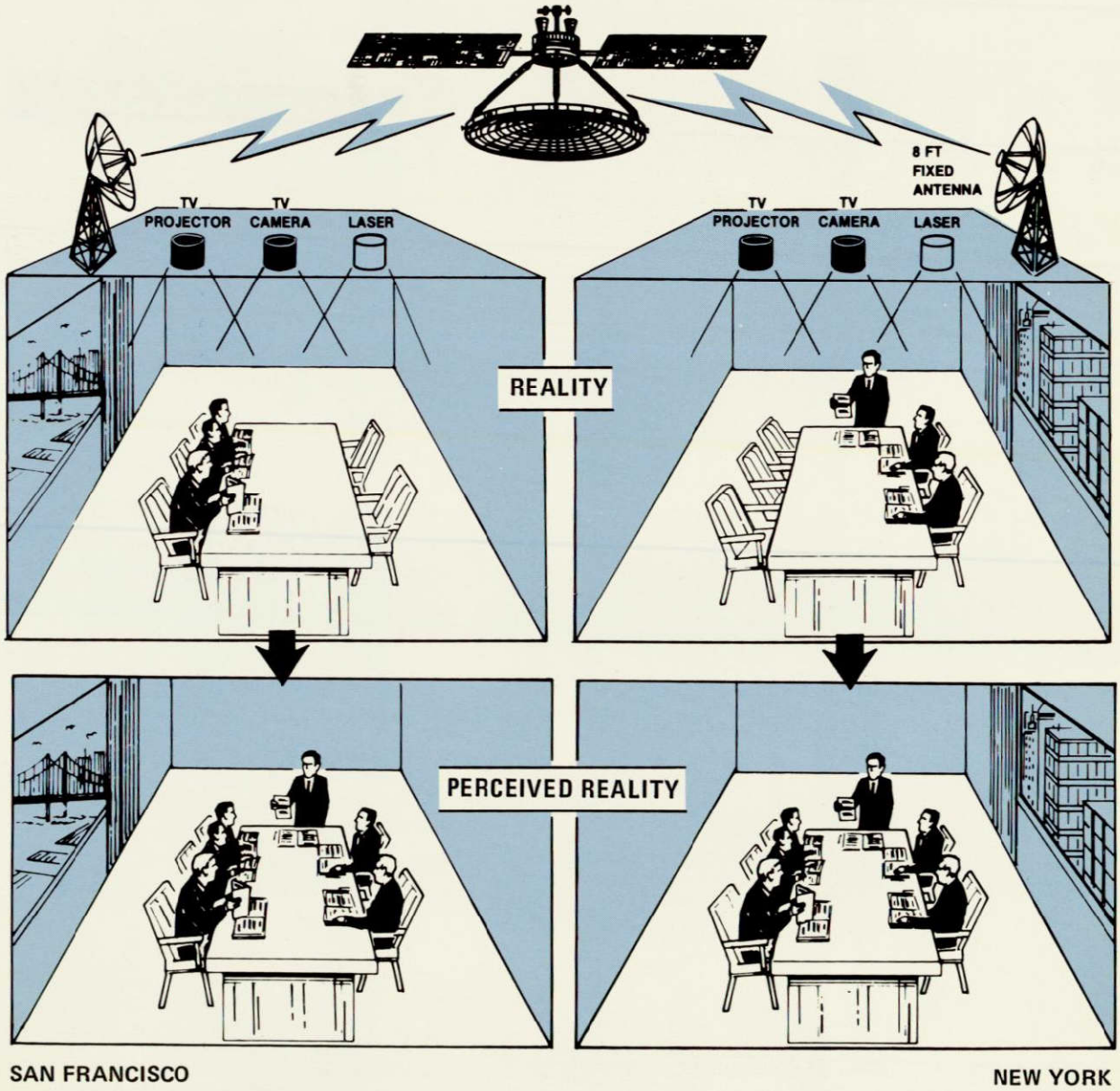
In the long run, as we shall see, space industrialization will provide unique new ways to harness the sun's bountiful energy supplies. In the shorter term, energy conservation can be greatly enhanced by space technology. Let's look at a few specific examples.

Last year, Americans spent $6 billion for gasoline to commute to work. With *electronic telecommuting*, many of these expenditures could be substantially reduced; and our lives would be much less hectic. In an electronic telecommuting system, the workers would be linked to their offices by high-quality communication channels. Such a system would save fuel, transportation costs, and commuting time. And workers could live anywhere they choose

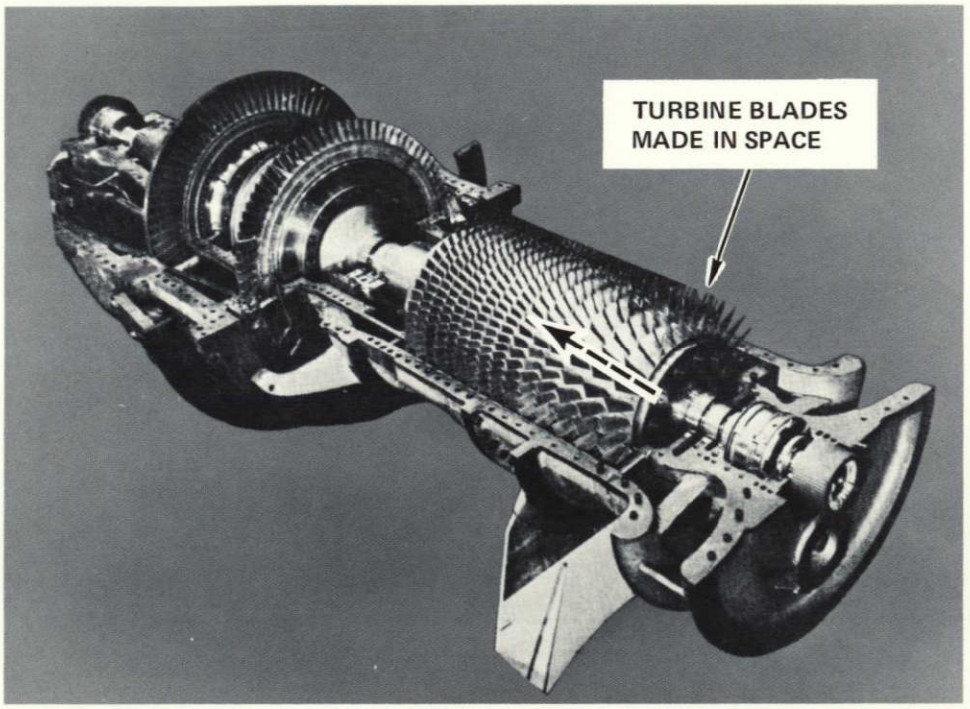
while holding jobs that are essentially urban. This approach is so attractive economically that a Los Angeles insurance company has already set up a simple electronic telecommuting system that uses conventional land-line links.

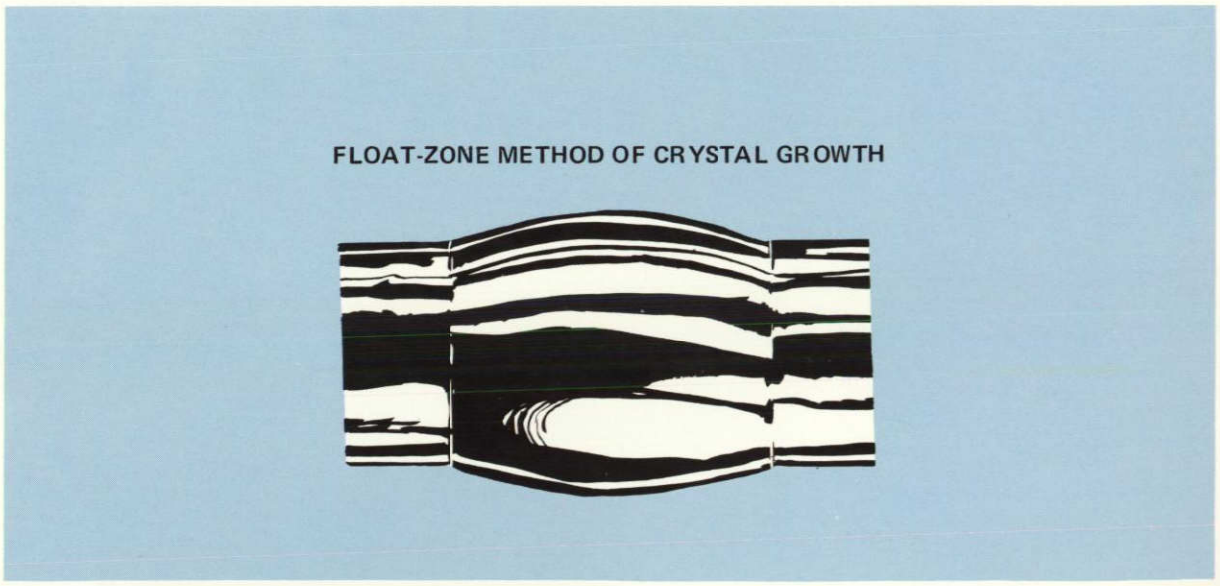
Electronic teleconferencing is another possibility that could save large amounts of fuel. Busy executives could avoid travel by using solid-state devices to transmit their images to distant locations. Holographic techniques would make these images nearly indistinguishable from the real thing (except when the participants try to shake hands!). And the potential savings are not insignificant. In 1975, Americans spent $12 billion for airline tickets, $5 billion of which went for business travel. As we spend less energy on business travel, we can use some of the energy we save for leisure travel, recreation, and education.

ELECTRONIC TELECONFERENCING

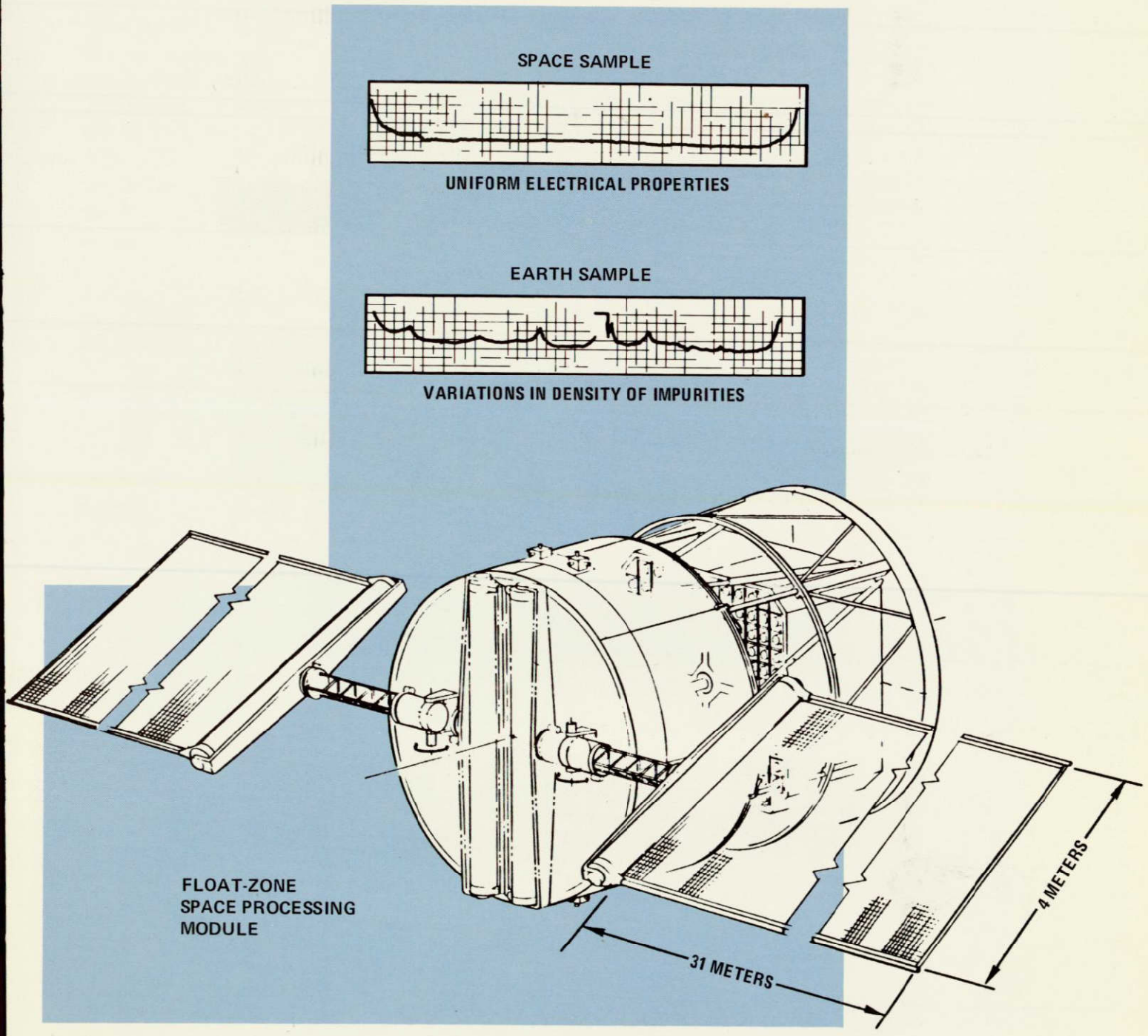


Some of the commercial products made in space would also reduce energy consumption. For example, orbiting factories could produce *higher temperature turbine blades* to allow jet planes and thermal power plants to operate much more efficiently. One recent study found that the resulting savings for airplanes alone over a 10-year interval could amount to as much as $6.6 billion and 6.5 billion gallons of aviation fuel.





We could also make *large perfect crystals* of sufficient size to convert huge quantities of electricity from alternating current (ac) to direct current (dc) and back again to ac. In dc form, power could be transmitted thousands of miles over ordinary high-voltage wires to allow load-sharing across time zones and weather patterns. This would allow the power companies to use their most efficient base-load equipment most of the time instead of fuel-hungry, peak-load devices.



SPACE AND YOUR MIND

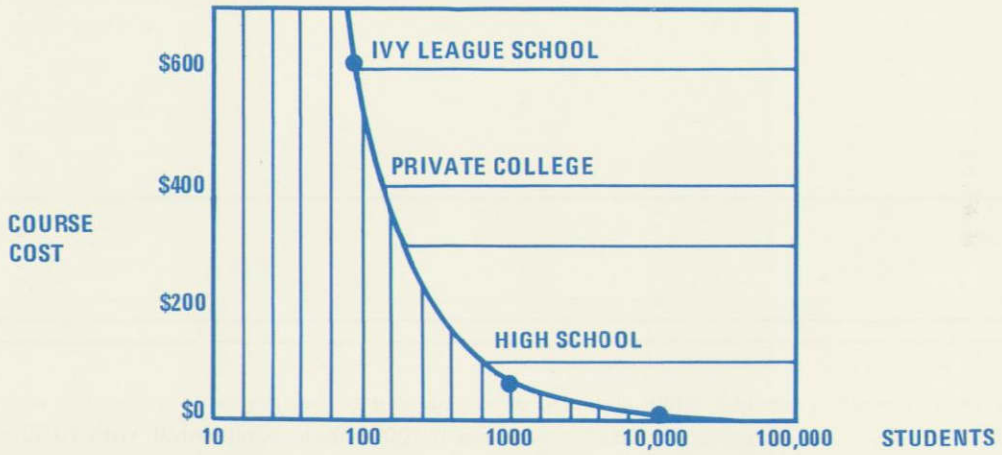
In the era of space industrialization, new space technologies will allow people in the United States and other countries to expand their life experiences and continue their education in new and exciting ways. These new technologies will also provide new modes of travel and communication.

Fourteen million deaf Americans live in a world of silence—a world often filled with loneliness and despair. Some services are available to the urban deaf; but not all deaf people live where help is near, since deafness doesn't fall within any particular geographical region.

We can help these people. *Direct satellite broadcasts* to roof-top antennas could bring new hope and stimulation into the lives of the deaf. The signals would reach all 48 continental states 24 hours a day on Channels 74 and 76. Job retraining, educational films, entertainment and culture, and the latest movies could be shown—all with captions and sign language superimposed on the screen. The technology is available to enrich their lives and enhance their productivity. And we could do it in a few years, for a few dollars each.

Of course, direct-broadcast satellites could also help other segments of our population. Televised instructional courses would be less expensive than typical high school courses if 1000 people would enroll. With 10,000, the cost of a course would drop to less than $6.00 per student. People in the smallest towns could become local experts in a variety of skills. And no one would have to move to a big city to study in a new field.

THE COST OF BROADCAST EDUCATION



But does it work? Do people really learn from educational television? Thirty comparative studies were recently surveyed with the following conclusion: "There is no significant difference between the effectiveness of educational television and conventional classroom instruction."

But what about motivation? With a choice of hundreds of courses and with the inexpensive worldwide communications that space offers, our options would be greatly expanded. This is particularly important in adult education because the world is constantly changing and increasing in specialization. For example, some courses could be especially helpful to the businessman who is starting a small company. He could get much of the specialized training he needs right in his own home during off-hours.

Would effective educational television be popular? We think it would. Channel 28 in Los Angeles draws 7000 to 20,000 enrollees for a typical educational course—more than enough to pay its own way. *The Adams Chronicles, Civilization*, and other quality documentaries draw 75,000 even on a poor night and 200,000 on a good night.

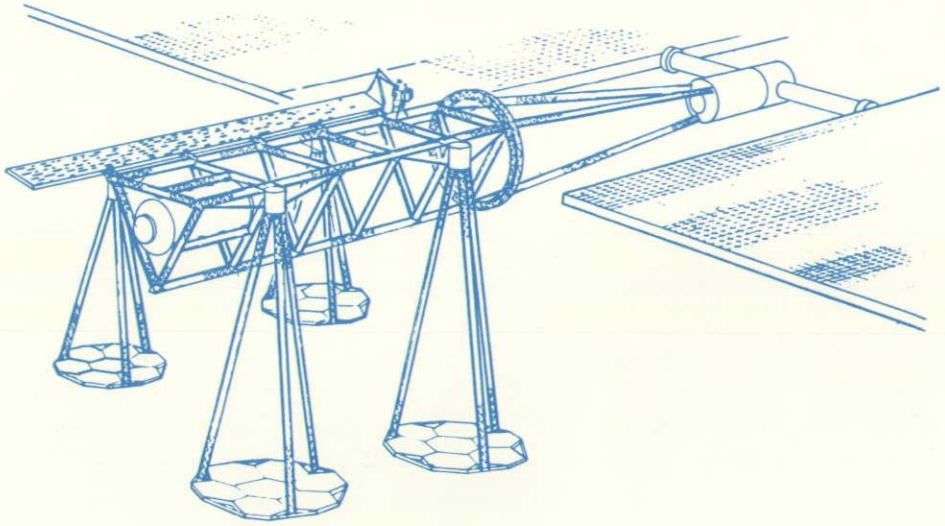
Within a few years, space industrialization will give the American people a revolutionary new kind *of personal communication system*. In effect, it is a portable telephone that will be strapped to your wrist or carried in your pocket. Push-button dialing will allow you to call your associates, even if you don't know where they are located.

The personal communication system will make you and your family feel much safer. In an emergency, you can use it to call the police, the fire department, or the local hospital at any time, from any place, simply by pushing a few buttons.

A personal communication system of this type will remove many of the geographical barriers from your everyday life. It will cost the same amount to call anywhere in the country. For this reason, services that are now handled locally can become national, or international. For example, if a business is too specialized to be profitable locally, it could be offered nationwide. Or instead of calling the reference librarian in your own community, you could just as easily call the one at the Library of Congress.

As usage increases, services will expand. Twenty-four-hour responses, full-time experts, computer search procedures, nationwide paging services, and many other benefits will quickly become practical. And these new services will mean new jobs and higher productivity.

Electronic mail is a promising possibility. With such a system, your letters would be delivered electronically via satellite relay links by means of facsimile scanning techniques. Cost savings, higher reliability, and faster delivery are among the potential advantages of such an advanced electronic system.



IMPROVING YOUR HEALTH

New medical advances in the era of space industrialization will offer Americans greater longevity. And the extra years we live should be healthier and more productive.

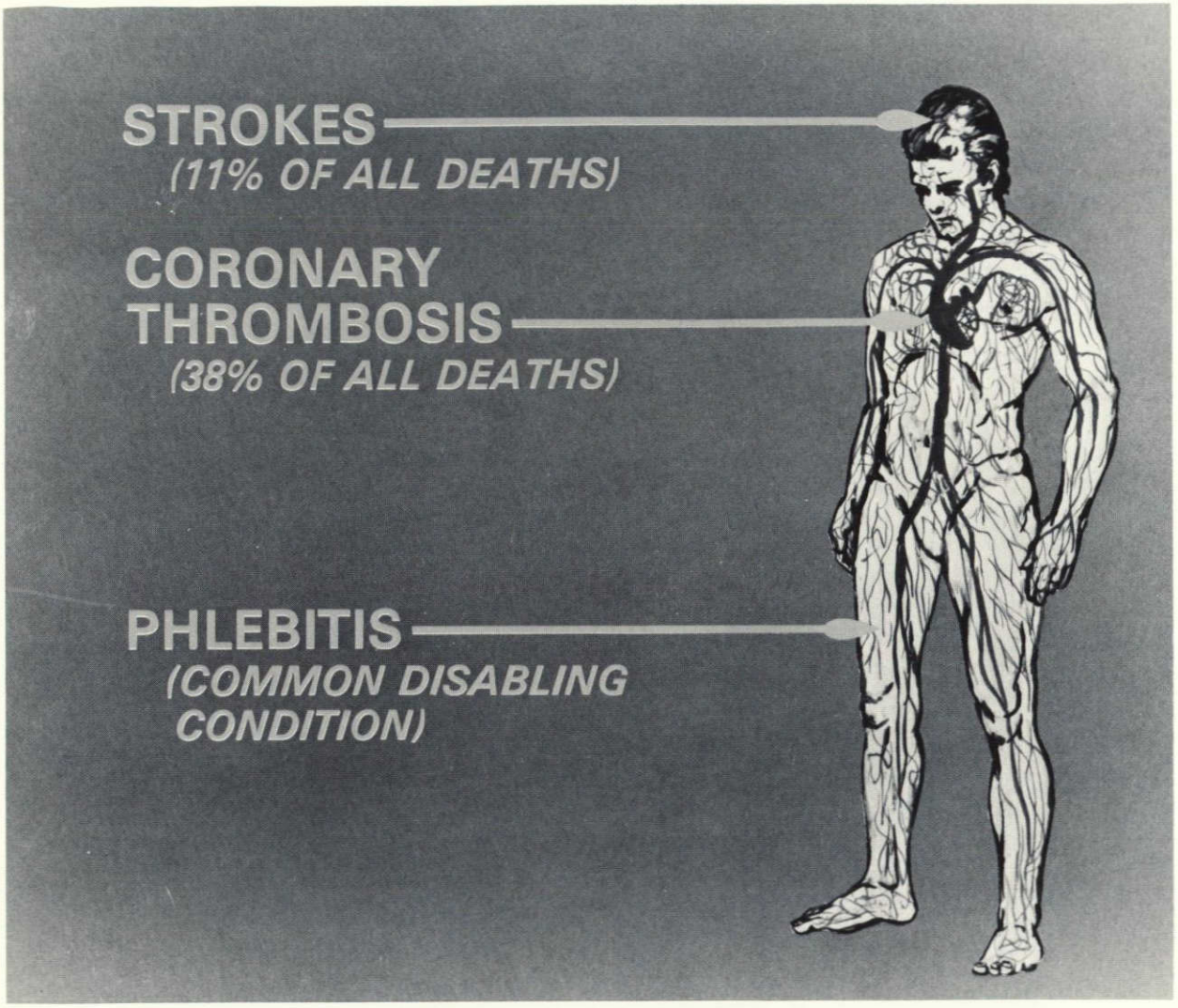
Reducing the amount of time we spend in hospitals could pay handsome dividends. A recent study by *U.S. News and World Report* arrived at the following conclusion: "A reduction in the hospital stay of each patient by a single day . . . would produce savings of $500 million each year."

The last few days in the hospital are mainly for observation—playing it safe—in case any complications should arise. But there is an alternative: Attach instruments to the patient to measure his vital signs. Send him home to his own family. Relay the signals through a medical satellite back to a central facility staffed with experts. Watch the patient electronically. In most cases, the next few days will be uneventful. But should the readings show a problem, the family would be told exactly what to do.

Effective traumatic care—that is, care immediately following a serious attack or injury—would also have an important impact on our general health. Strokes, heart attacks, accidents, and respiratory diseases are all responsive to early traumatic treatment. If the victim manages to survive the first few hours, he often enjoys many years of productive life.

A proposed system would work like this: Trained paramedics in mobile units or permanent facilities would perform emergency treatment under the direction of skilled medical doctors. Expert advice, prescriptions, and special instructions would be communicated to the paramedics via satellite relay links. Pictures of the patient and signals defining his metabolic state could be sent to the supervising doctors.

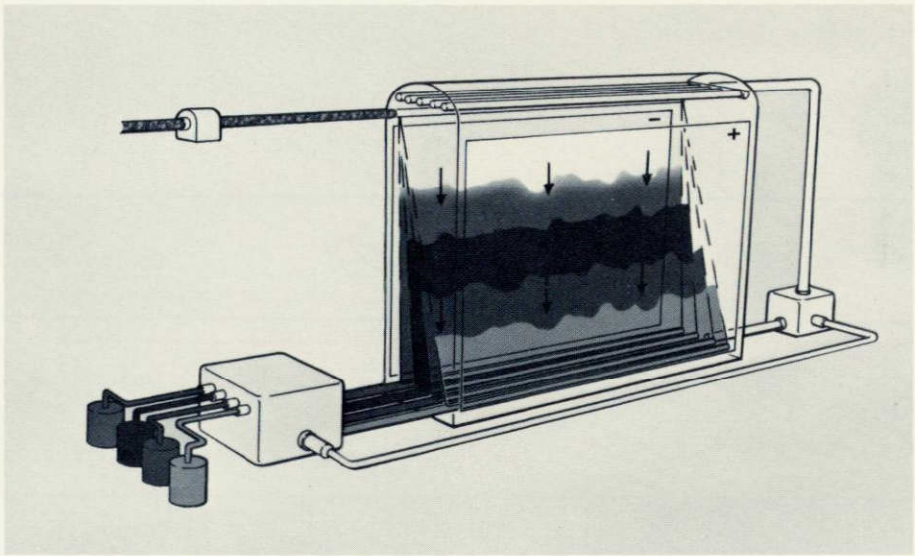
Satellite relay links could provide primary care in remote areas of our country and throughout the world. In Afghanistan, there is only one doctor for every 20,000 persons. Indonesia has even fewer doctors per capita—one for every 25,000 citizens. Within a few months, local midwives and paramedics could be trained to operate the communication equipment, make simple diagnostic tests, and perform minor medical procedures. This approach would provide jobs for local people and better health care for the population. And, of course, healthy people are productive people.

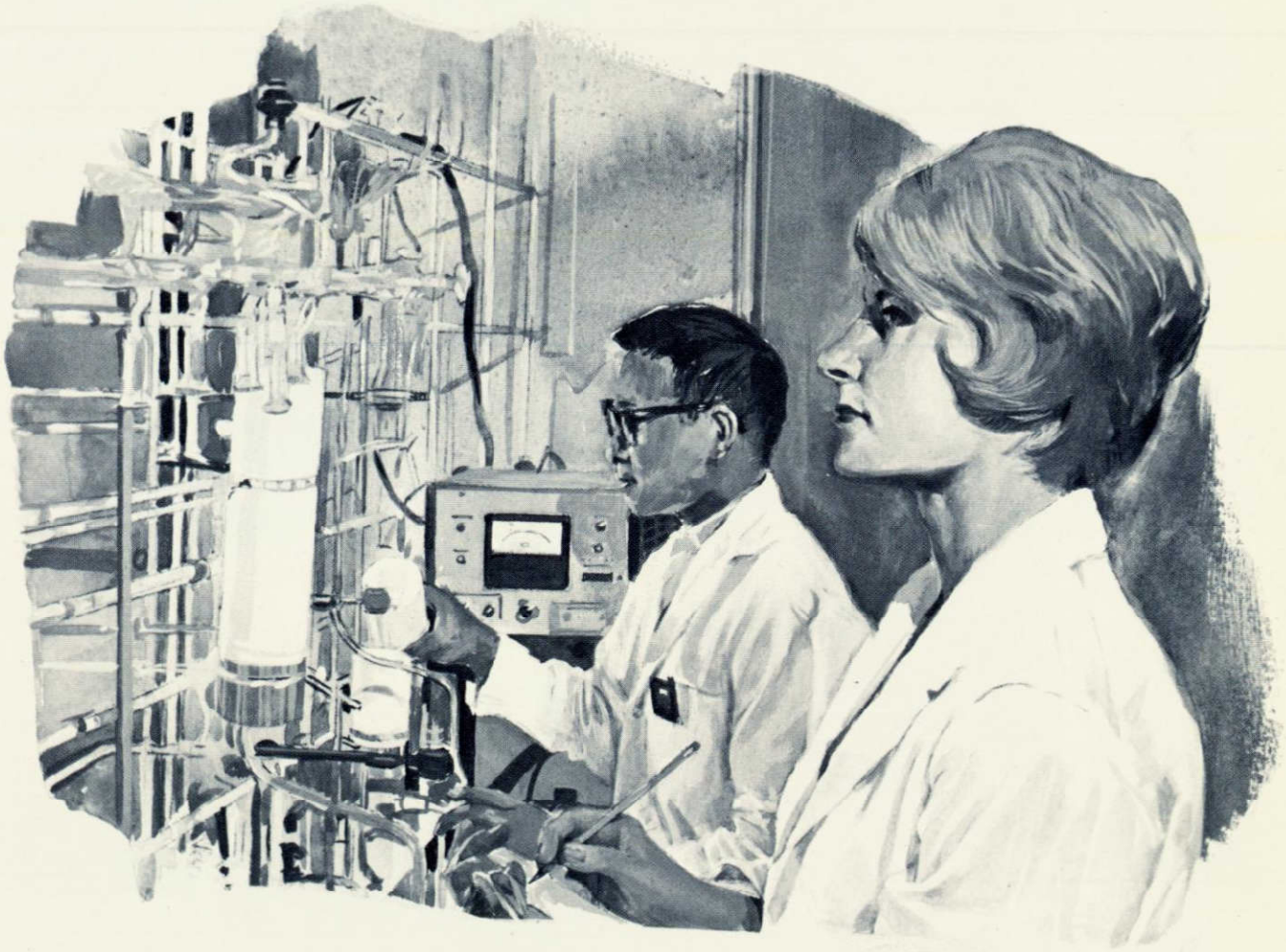


In the 1980's, pharmaceuticals produced in space will begin to have an important effect on our health. The first medication produced in space is likely to be urokinase, an enzyme that causes the human body to dissolve hazardous blood clots. Generally speaking, the clotting of blood is beneficial; however, a blood clot that floats through the bloodstream can be deadly. Coronary thrombosis, phlebitis, strokes, and pulmonary embolisms are often caused by free-floating blood clots.

Urokinase is enormously helpful in treating these conditions, but scientists must refine 400 gallons of human urine to get a single dose. Since half a thimbleful costs about $1200, only experimental quantities are available today.

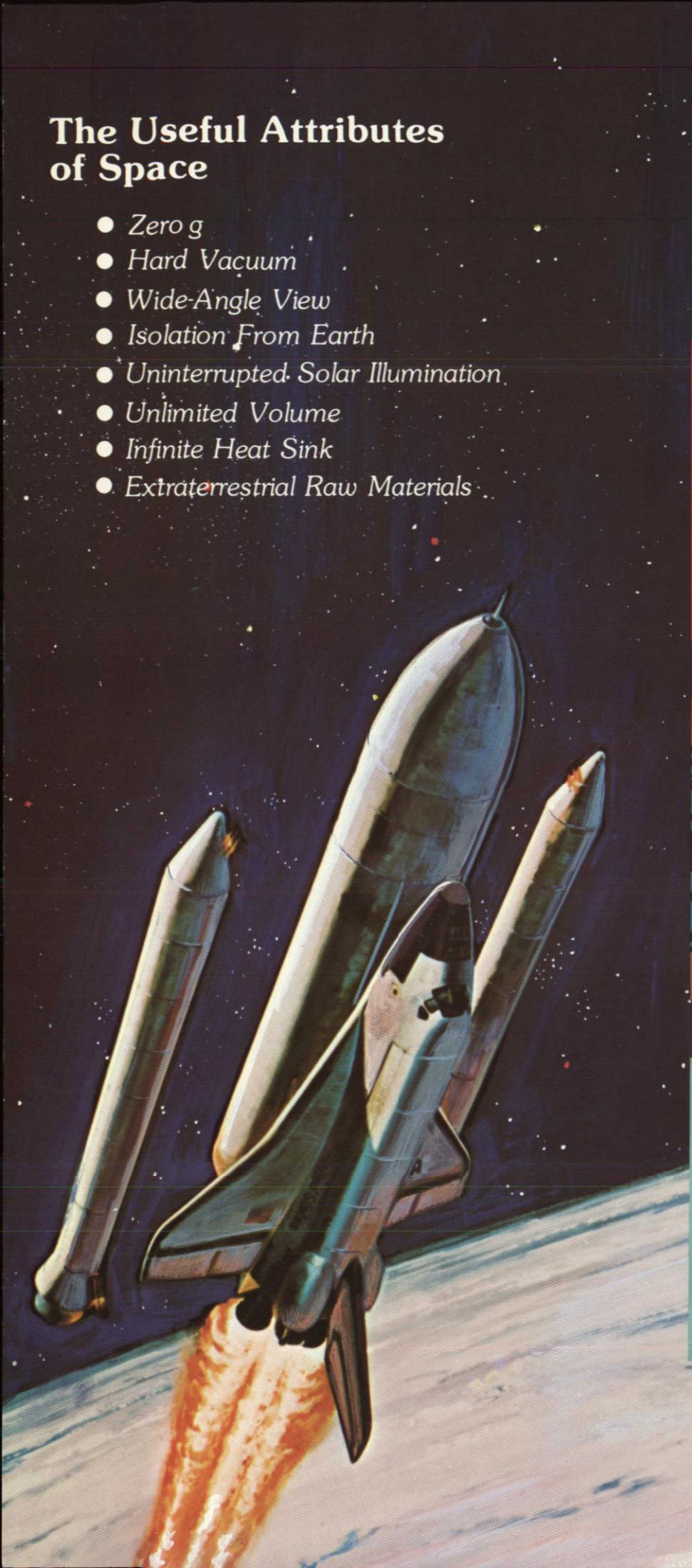
In the weightlessness of outer space, kidney cultures can be easily grown; and small electrical forces can separate quantities of urokinase at a much lower cost. Space tests, most recently those conducted in the Skylab experimental space station, have largely verified this theory. The quantities doctors need are not large; two or three Space Shuttle flights could supply the entire world for a decade or more. And the economic aspect looks favorable. Drug companies have already expressed interest in sharing the bill, provided their proprietary rights can be protected.





The Useful Attributes of Space

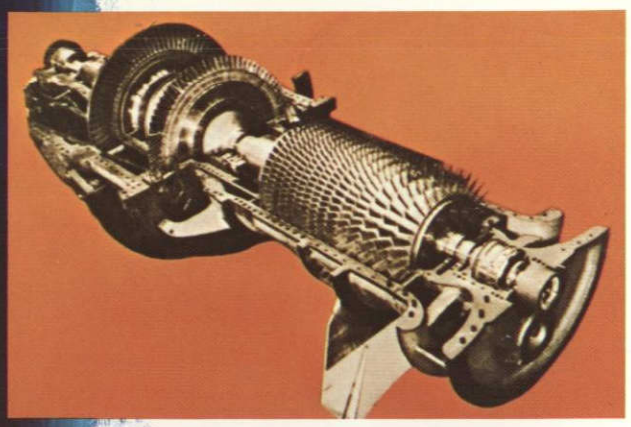
- *Zero g*
- *Hard Vacuum*
- *Wide-Angle View*
- *Isolation From Earth*
- *Uninterrupted Solar Illumination*
- *Unlimited Volume*
- *Infinite Heat Sink*
- *Extraterrestrial Raw Materials*



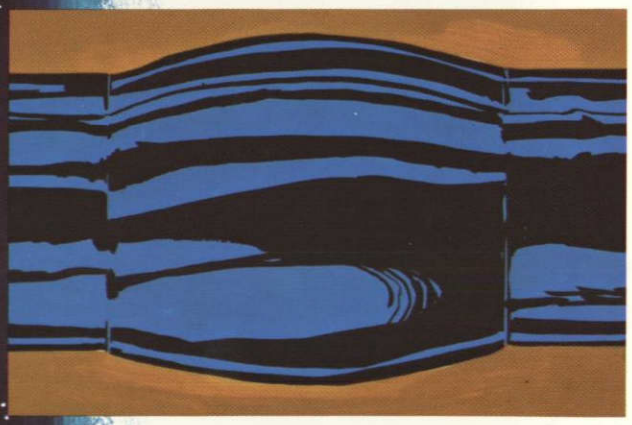
The opportunities in

The Benefits

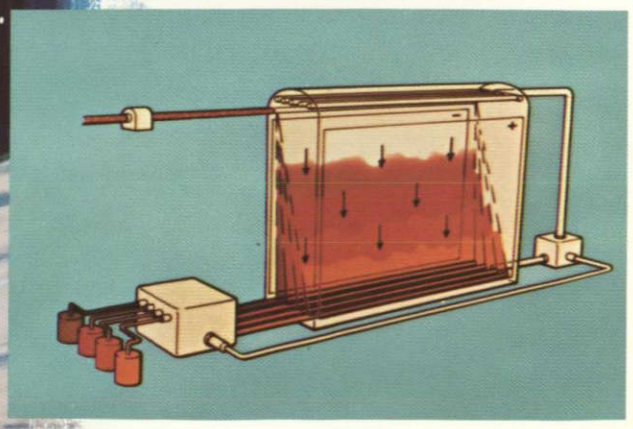
PRODUCTS



High-Temperature Turbine Blades



Large DC Crystals



Urokinase

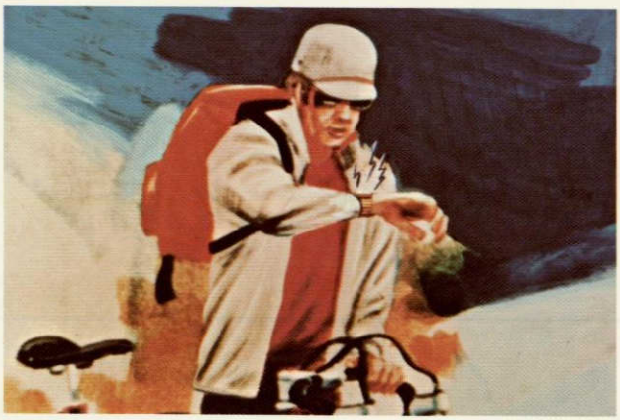
Space Industrialization

space are as limitless as space itself.

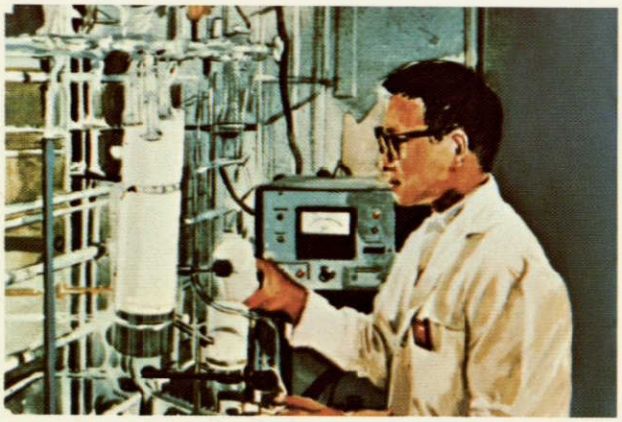
From Space Industrialization

SERVICES

Educational Broadcast for the Deaf

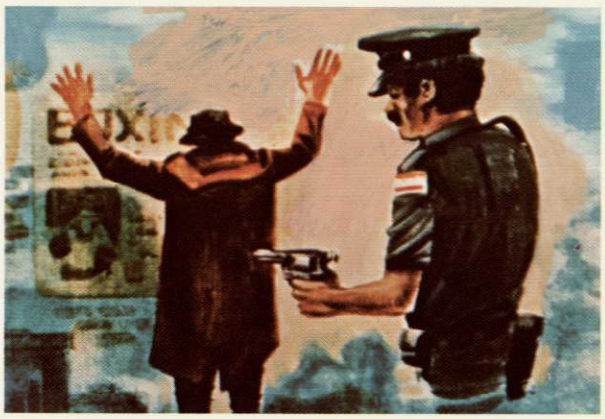


Personal Communication Systems

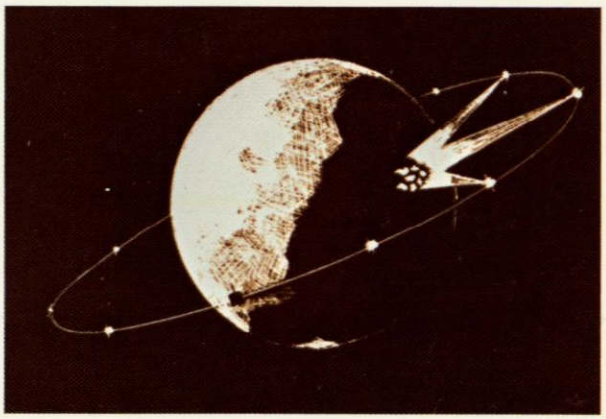


World Medical Care

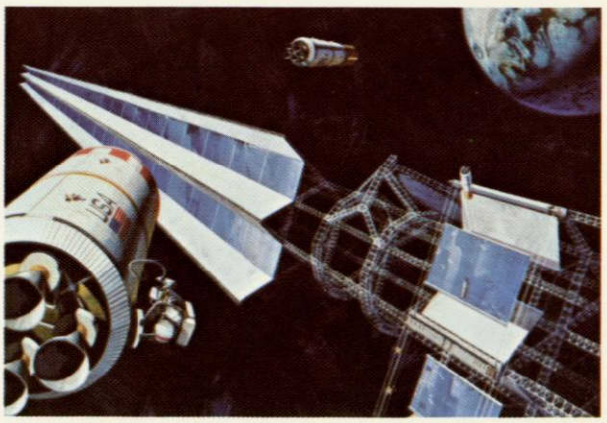
ENERGY



The Lunetta



The Soletta



The SPS

can create new wealth and opportunities for all mankind.

SPACE AND OUR ENVIRONMENT

As the astronauts looked down on earth from space, they had a feeling of oneness with mankind. International boundaries and differences seemed to diminish in importance, and the environment enveloping the earth's surface seemed integrated with the globe, yet so thin and fragile. On the earth's surface, features that were unnoticed before suddenly became apparent. Some of these first pictures from space have shown us where to look for new natural resouces; and others now tell us about weather, crops, and pollution on a day-to-day basis.

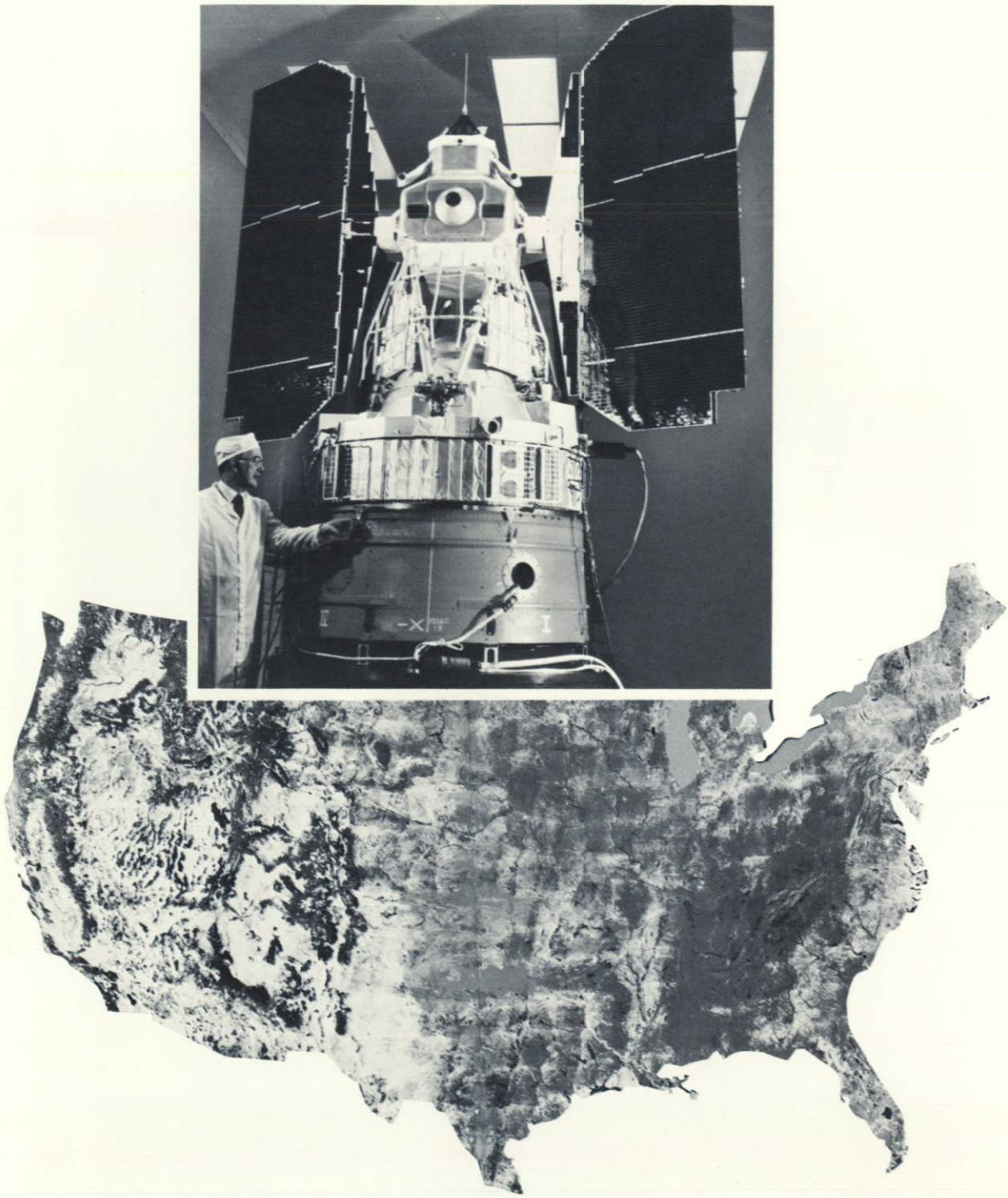
But this is just the beginning. There is so much we need to know. Are we really on the threshold of a devastating climatic change? Some scientists think so. Can we predict the overall climate by observing and predicting solar activities? Are we changing our climate significantly by our industrial activities? We need quick, accurate answers to these important questions. Space provides the ideal vantage point to study both the sun and the earth, and the interaction between the two.

If we can understand the processes, surely we can learn to predict the effects—make weather forecasts days, weeks, and months in advance, and climate projections years or decades in advance. It's easy to see how these capabilities could be worth billions of dollars in agriculture and forestry, as well as tourism and leisure-time industries. We have already seen that many lives can be saved by predicting the path of a single hurricane. All mankind has a stake in these benefits from space, and we will look back 30 years from now and truly understand how crucial space activities of the 1980's and 1990's were.

As population and civilization grow, food, energy, water, and mineral resources become increasingly critical. Do we have enough? Where are they located? What alternatives do we have? Can we plan ahead and control the fluctuations? LANDSAT and weather satellites look down from orbit on most of the earth and routinely demonstrate the feasibility of using the vantage point of space to answer these and other questions.

In the long run, we will encounter shortages in certain nonrenewable resources; but there are many ways to expand our supplies. The techniques of substituting new materials (for example, aluminum for copper in electric cables), operating deep-shaft mines, and exploiting ocean-floor reserves are three important possibilities. Unfortunately, some of these approaches require more energy than we now consume in obtaining the same resources.

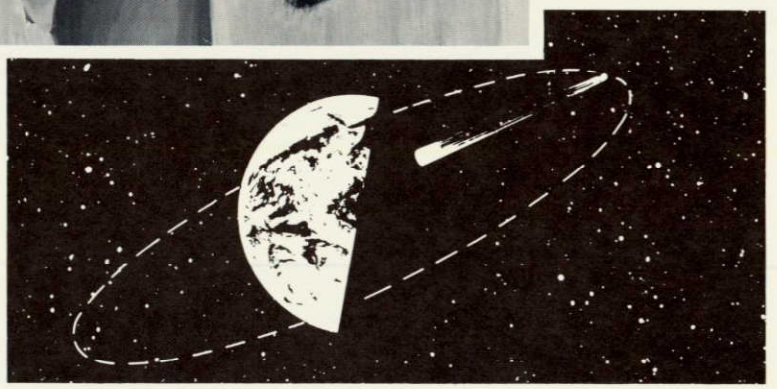
Prospecting the earth from space by *observation satellites* does not require so much energy as most other alternatives. From space, we can spot the delicate geological birthmarks that are likely spots for minerals and oil. Lineations, oil seeps, and other geological formations are often associated with commercially attractive mineral



deposits. Experiments carried out by the Skylab astronauts, the LANDSATs, and other space vehicles indicate that it is surprisingly easy to detect important geological formations from space. Fault lines, which sometimes stretch across hundreds of miles of the earth's surface, are especially apparent. Of course, space observations alone cannot prove the existence of economically recoverable oil and mineral resources. Ground truth data must supplement satellite-based observations before resources can be assessed and extracted.

LUNETTA – LIGHT FOR SAFETY AND PRODUCTIVITY

It is midnight. A nurse has completed her shift. She leaves the bright interior of the hospital and steps into the darkness. Her car is some distance away in a poorly lighted parking lot. She is apprehensive; statistics of violent crimes prove that she has good reason. Every urban police department knows that darkness invites crime, and often it is women or the elderly who experience these statistics first hand.

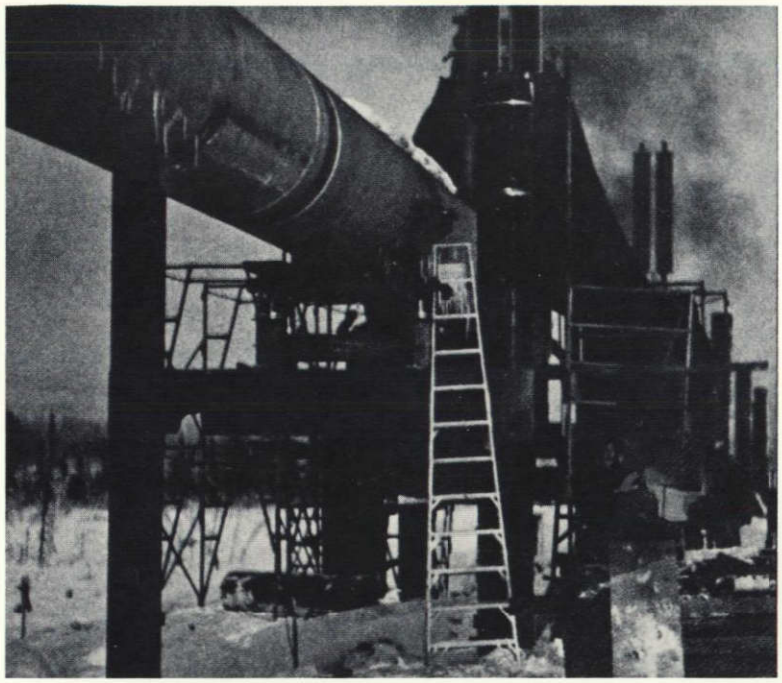


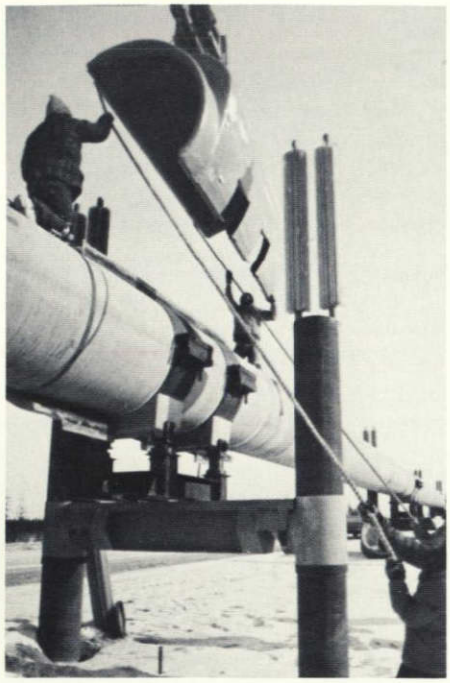
In a developing country, several farm communities face a loss of their crops. Precise, satellite-based weather forecasts predict the onset of heavy monsoon rains within a few days. The communities should work around the clock to harvest their crops. In mechanized farms, machines equipped with lights would operate 24 hours a day. But in poor countries, valuable time is lost because the farmers and their draft animals cannot see well enough to work in darkness.

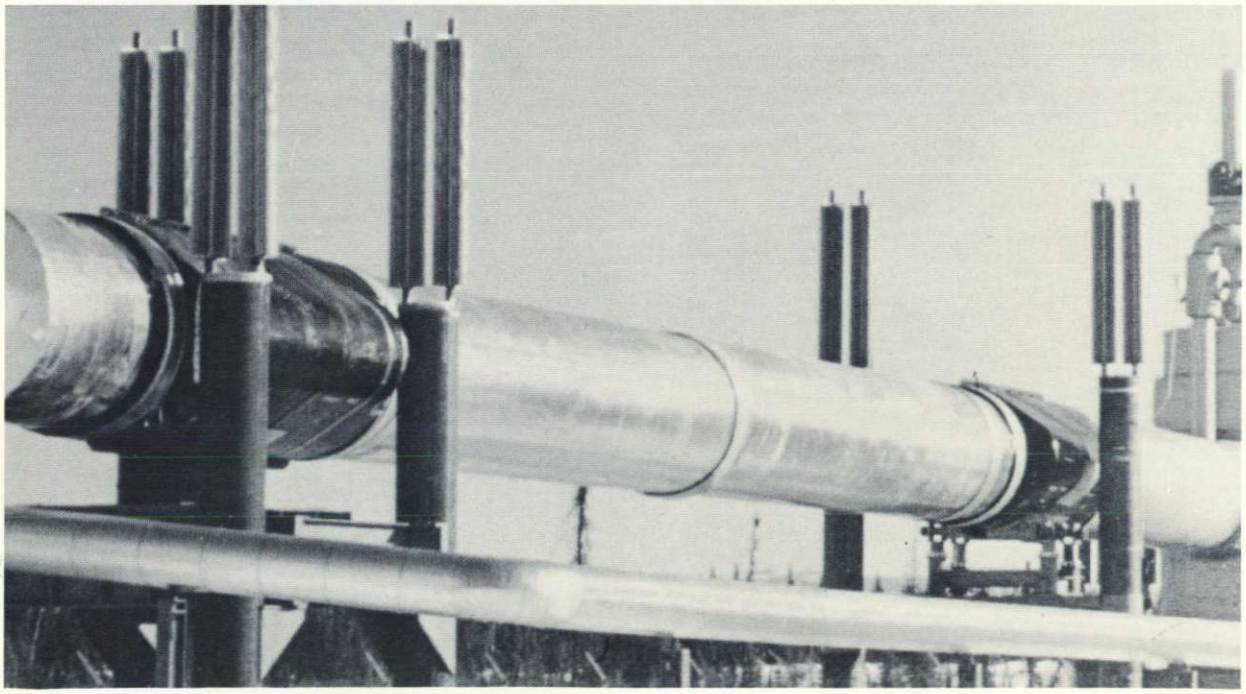
Civilization and productivity are linked to light. Today, mankind needs more outdoor lighting than ever before and consumes more energy generating it than all previous generations put together. For the foreseeable future, no letup in the rising demand for outdoor lighting is in sight. Urban growth and rural development all over the world add to the demand. Even for relatively well lighted cities, better lighting—especially area lighting—is highly desirable to improve public and traffic safety.

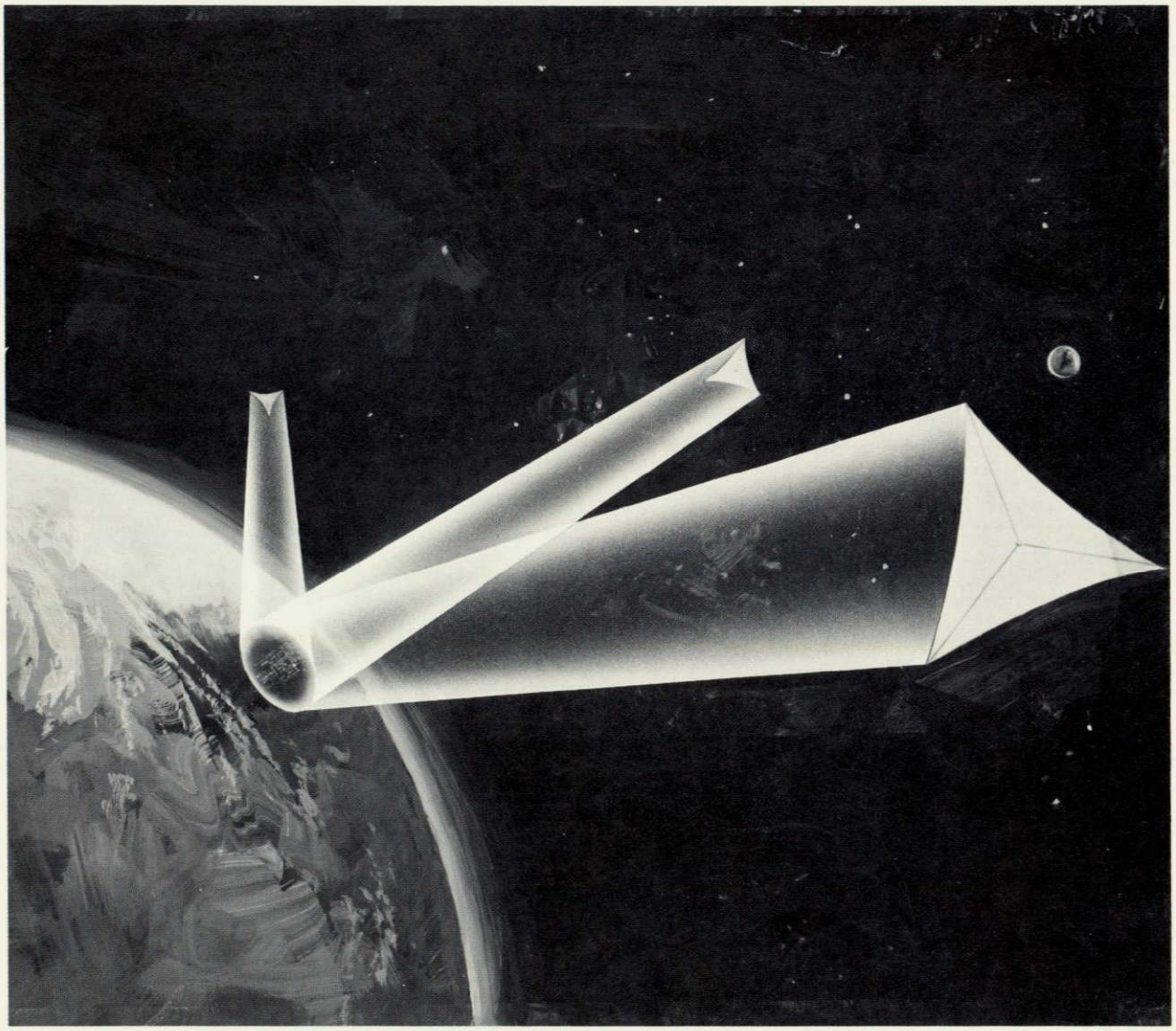
In the era of space industrialization, we can build a device called *Lunetta* to control the light we receive from carefully selected areas of the sky at night. Like the moon, Lunetta reflects sunlight and, therefore, is

environmentally benign. No cables have to be laid. No fuel has to be burnt to generate it. And it can be diverted to almost anywhere on earth during a power blackout or other emergency. Natural light from the sky reduces the burden on the local environment and removes itself without a trace when it is no longer needed. This is especially important when the search for raw materials leads industries farther and farther into remote areas. (The Alaskan pipeline is only one example.)









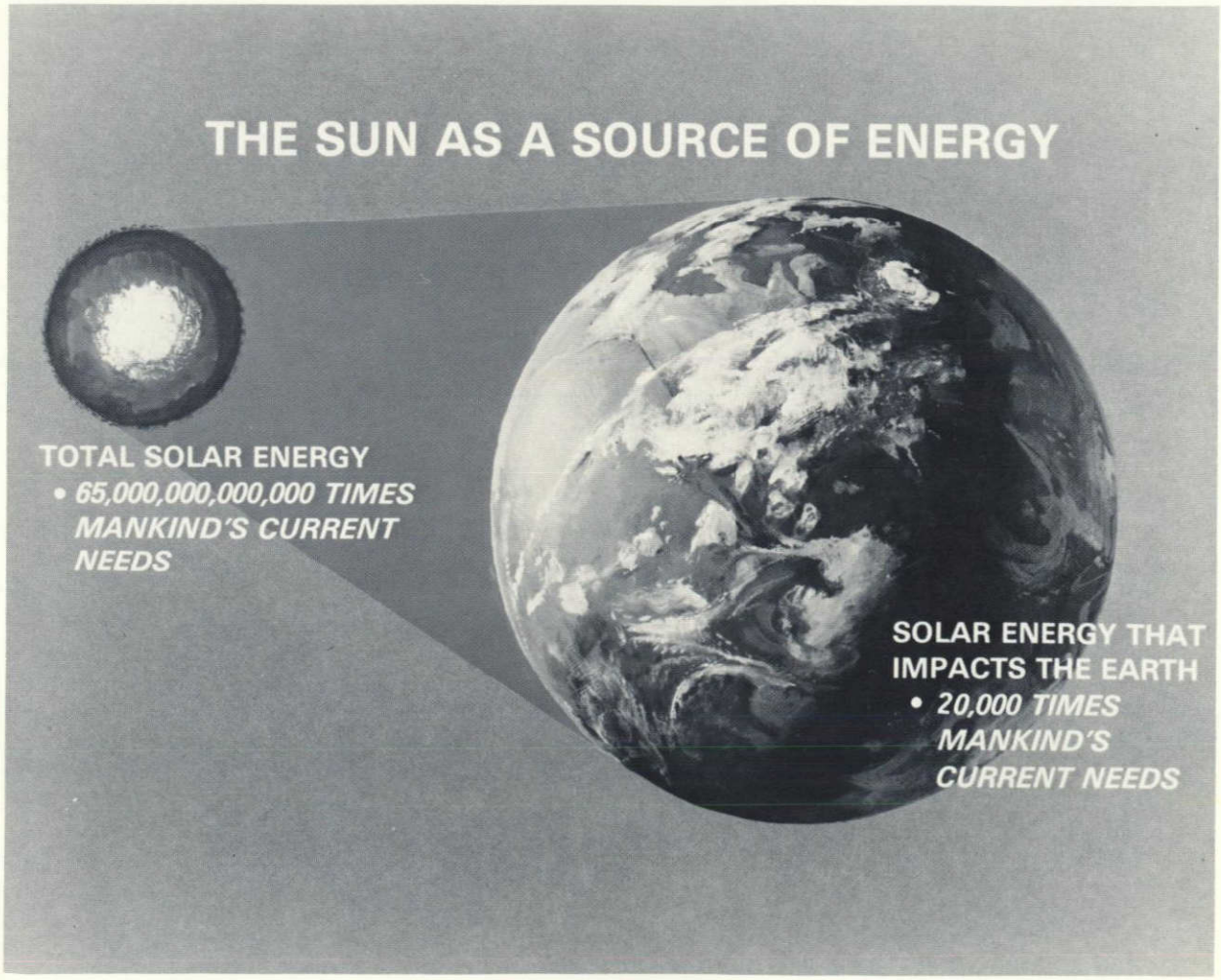
Typically, the light would illuminate an area to the level of a residential pedestrian pathway, corresponding to about 200 to 300 full moons. Unlike our moon, Lunetta is not a big disc—a searchlight in the sky sending down a brilliant shaft of light. The light would originate from several small reflectors, spraying the urban area with gentle light from several directions to avoid harsh glare and deep shadows. There could be as many as 15 objects in the sky, each brighter than the planet Venus but of starlike appearance. Unlike the moon, Lunetta's light would not brighten the atmosphere outside of the small area being illuminated. Hence, Lunetta would not interfere with astronomical observations.

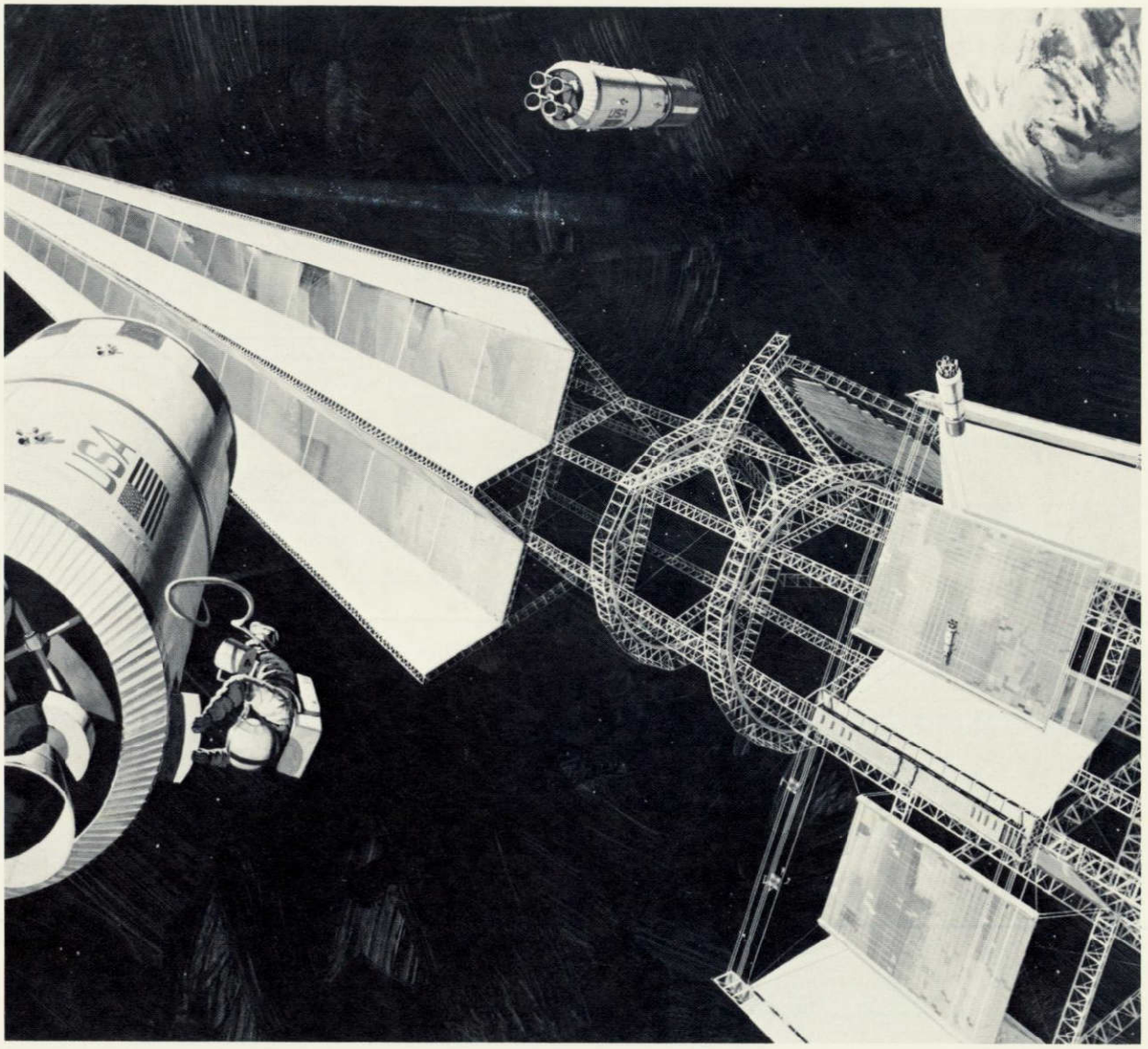
On cloudy nights, the light would be diffused as if it were passing through frosted glass. Clouds would, of course, weaken the light; but that effect would be taken into account in sizing the system. Most of the time, clouds are patchy so that only a few of the reflectors would be obscured and the overall illumination would still be effective.

One of the nicest features of Lunetta is the way it relates to your pocketbook. For 200 moons (at clear sky) of Lunetta light, the cost would be less than that of present outdoor lighting systems (for the light of approximately one full moon averaged over an urban area).

ENERGY – A NEW AGE OF ABUNDANCE

Space abounds with energy. Originating in stars, specifically in our sun, it is transmitted over great distances the only way it can be transmitted in space—by electromagnetic radiation. We are presently consuming solar energy stored chemically in the earth over the past 700 million years. Although the amount of energy needed on earth is huge by our standards, it is minuscule in terms of the sun's daily energy expenditure, of which our planet intercepts only a tiny portion. If we can plug ourselves into this connection, a new age of energy abundance will be ours. That much is clear. The big questions are how and for how much. Several options are available.





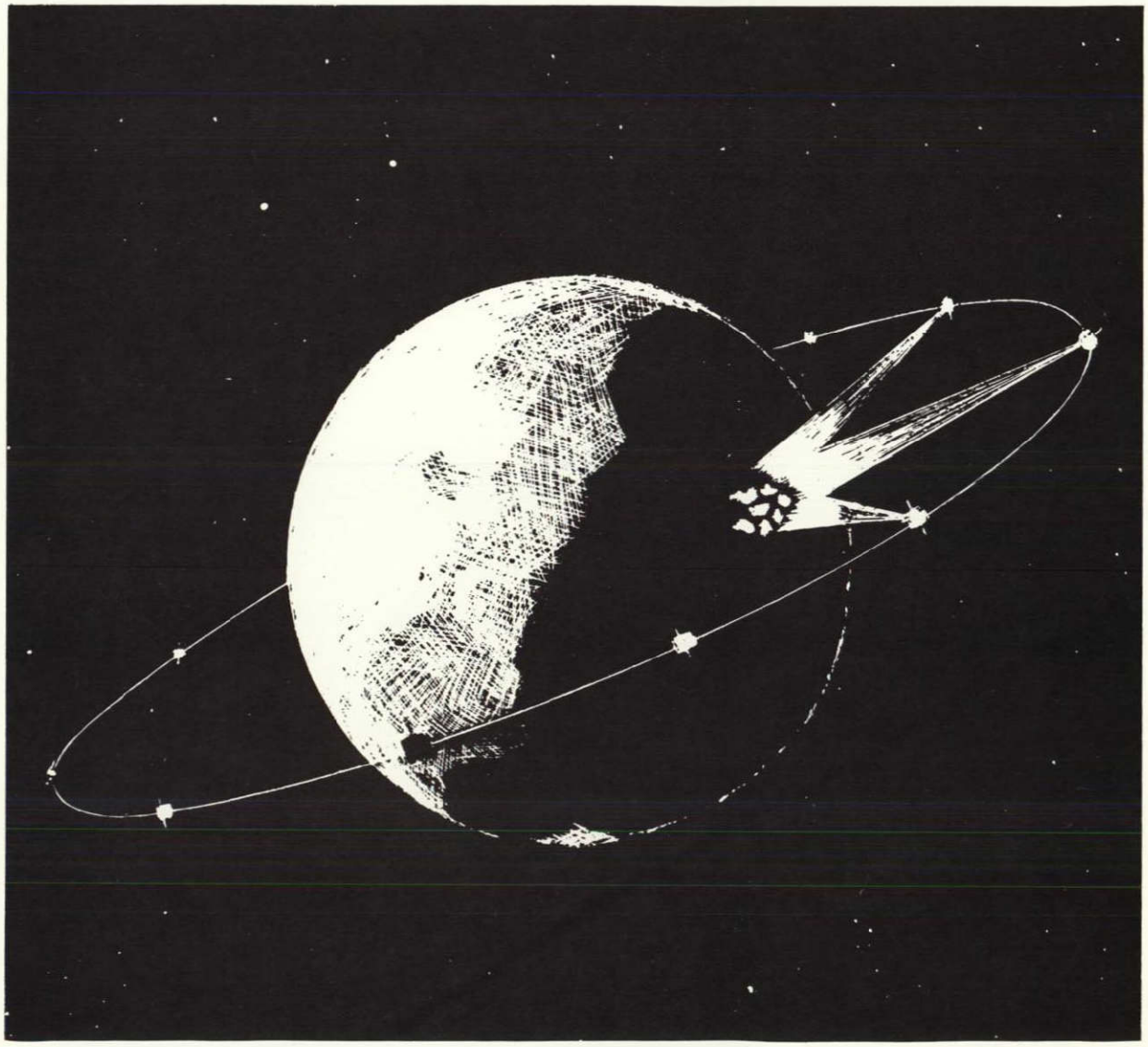
In one technique, we would generate electricity in space by means of solar cells and send it to earth in microwave beams. Located in a stationary orbit 22,000 miles above earth, such a power plant would typically be 20 square miles in size. It would continuously generate electric power, which would be converted into microwave energy. The microwave energy would be channeled into a giant antenna that would beam the energy to the surface of the earth in a controlled manner.

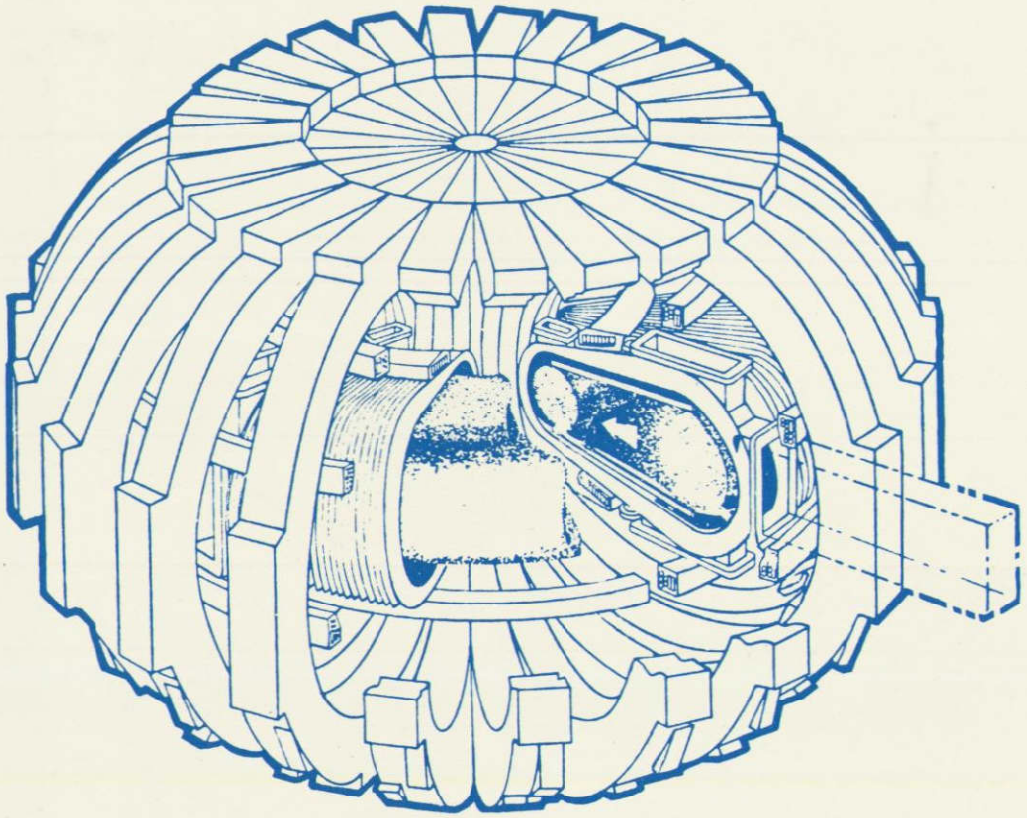
On earth, a huge receiver would absorb the energy and convert it back to electricity—a pollution-free, nonradioactive, cool, electromagnetic power station, generating 5 million kilowatts day and night. In the first two decades of the twenty-first century, the systems in stationary orbit could contribute as much as 25 percent of our national electrical need.

An attractive alternative is *Powersoletta*, which would beam solar energy directly from space to solar power stations on earth. One problem with conventional solar power stations on earth is that in many countries there is not enough sunshine to make large-scale electric power generation worthwhile. By "helping" the sun with a set of large reflectors more powerful than Lunetta, the ground station could be supplied 24 hours a day with solar energy almost equal in intensity to the sun's light.

The Powersoletta reflectors would be aimed at banks of solar cells on the ground. This extra energy would not be harmful but would illuminate the area to daylight brightness. Thus, with Powersoletta, energy would be transmitted to earth in the form of reflected natural sunlight.

One set of reflectors could serve several ground stations around the earth, thereby reducing the cost of domestic power and, at the same time, making this country an energy exporter. Countries or regions lacking abundant solar energy for power generation could be serviced by the late 1990's at a higher energy input into the ground station than could be obtained even in the Sahara Desert.





FUSION REACTOR

A third technology used in producing energy in space is nuclear fusion. A strong effort is presently under way in the United States, the Soviet Union, Japan, and Western Europe to develop commercial fusion power on earth. The first goal—generating more energy output from the fusion reaction than is spent to initiate the reaction and sustain it—may be reached in the early 1980's.

But a considerable number of difficult engineering problems will remain. The most severe problems are due to the fact that the plasma is a copious source of very high energy neutrons. The neutrons brutalize the wall material and cause it to contaminate the vacuum between the wall and the plasma, which in turn creates other problems. Moving the walls farther away from the intense neutron source can reduce these problems, but it is difficult to do on earth because a high vacuum must be maintained in the enlarged reactor. In space, very high vacuum is available in large volumes. There, the proper conditions prevail to alleviate the material problems and arrive at a stable magnetic confinement of the plasma.

A fusion power plant in space could serve many purposes because space industrial processes are energy-intensive. It could also power industries on earth. And a fusion power station would be considerably smaller than a power station that uses solar energy.

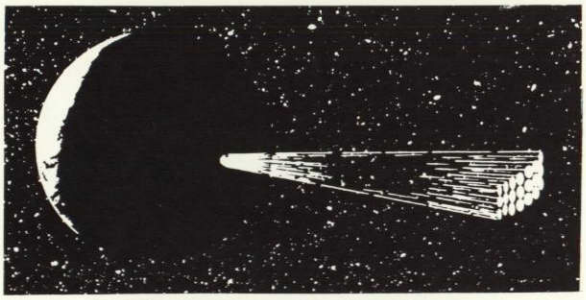
If we decide to put solar power and fusion to work on earth and in space, a new age of energy abundance will be ours. And with energy abundance, many of our other scarcities—materials, food, and jobs—will also be alleviated.

FOOD, CLIMATE, AND SCARCITY

In spring of 1977, a few cold nights destroyed much of Florida's citrus and other crops. The loss ran into the hundreds of millions of dollars, some 15,000 jobs were lost, and the price of produce inched up another notch. In 1976, night frosts destroyed much of Brazil's coffee crop; and Americans watched the price of coffee triple.

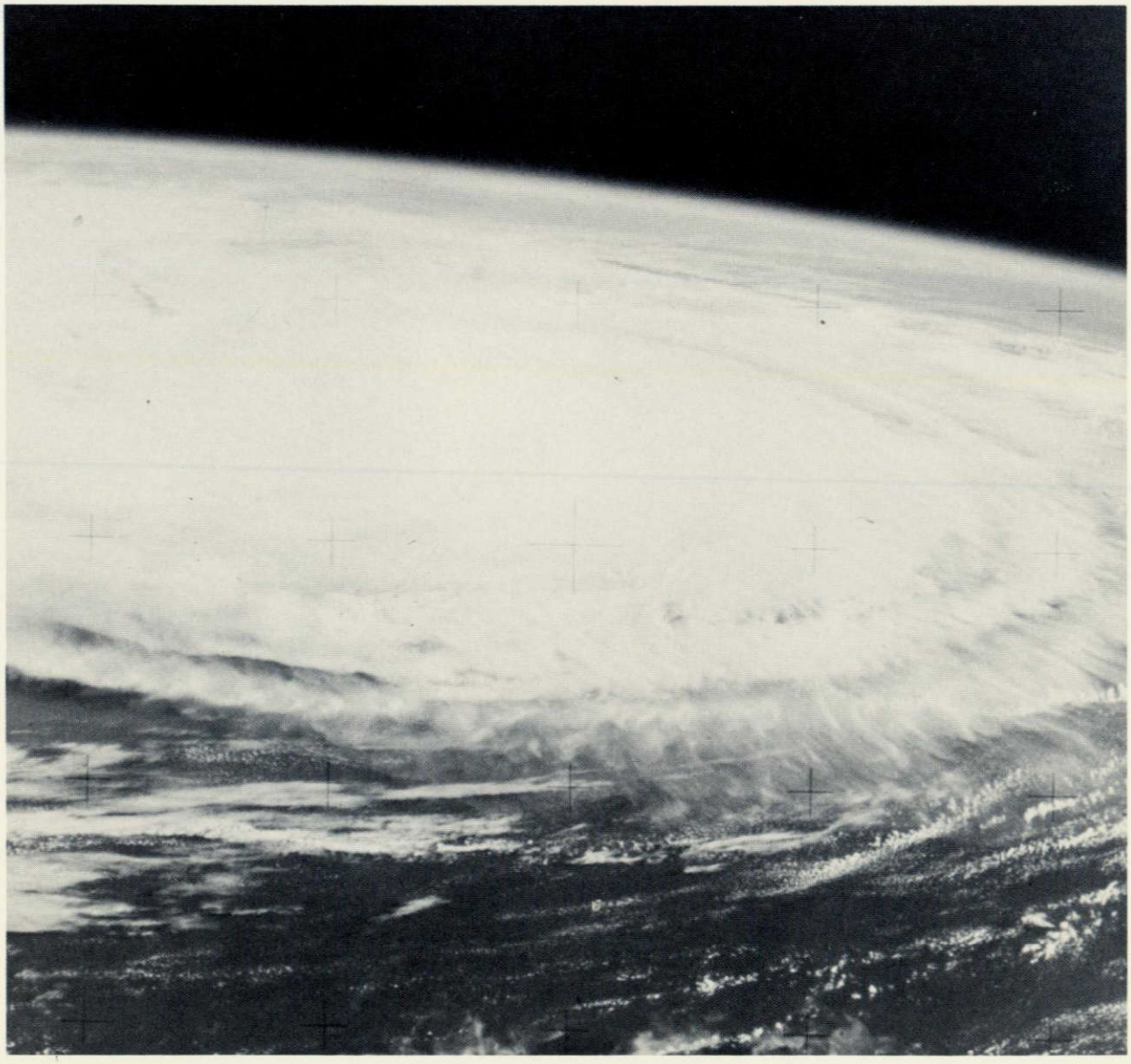
Cold nights are usually very clear, especially in southern latitudes. The clear sky allows warmth to radiate into space. This, however, means the "space connection" is open: energy can be radiated in as well as out. Reflectors, the same ones used for Powersoletta, could be assigned to a threatened area to prevent the local temperature from dropping below the critical level. This method is much cleaner and more effective than smudge pots. Of course, it would be light most of the time for a few days; but millions of people live with the midnight sun every year and rather enjoy it. At any rate, it would be for only a few days and is a small price to pay to avoid major economic damage.

Obviously, when these reflectors are used to prevent night-frost damage, they would alter the climate, but only locally and only in the desired way. The world climate would be unaffected. The reflectors would beam down the power of the sun, but they would cover only 0.000025 percent of the earth's area. The energy input does not compare with the sun's; it barely approaches the energy input for the area when there is no night frost.



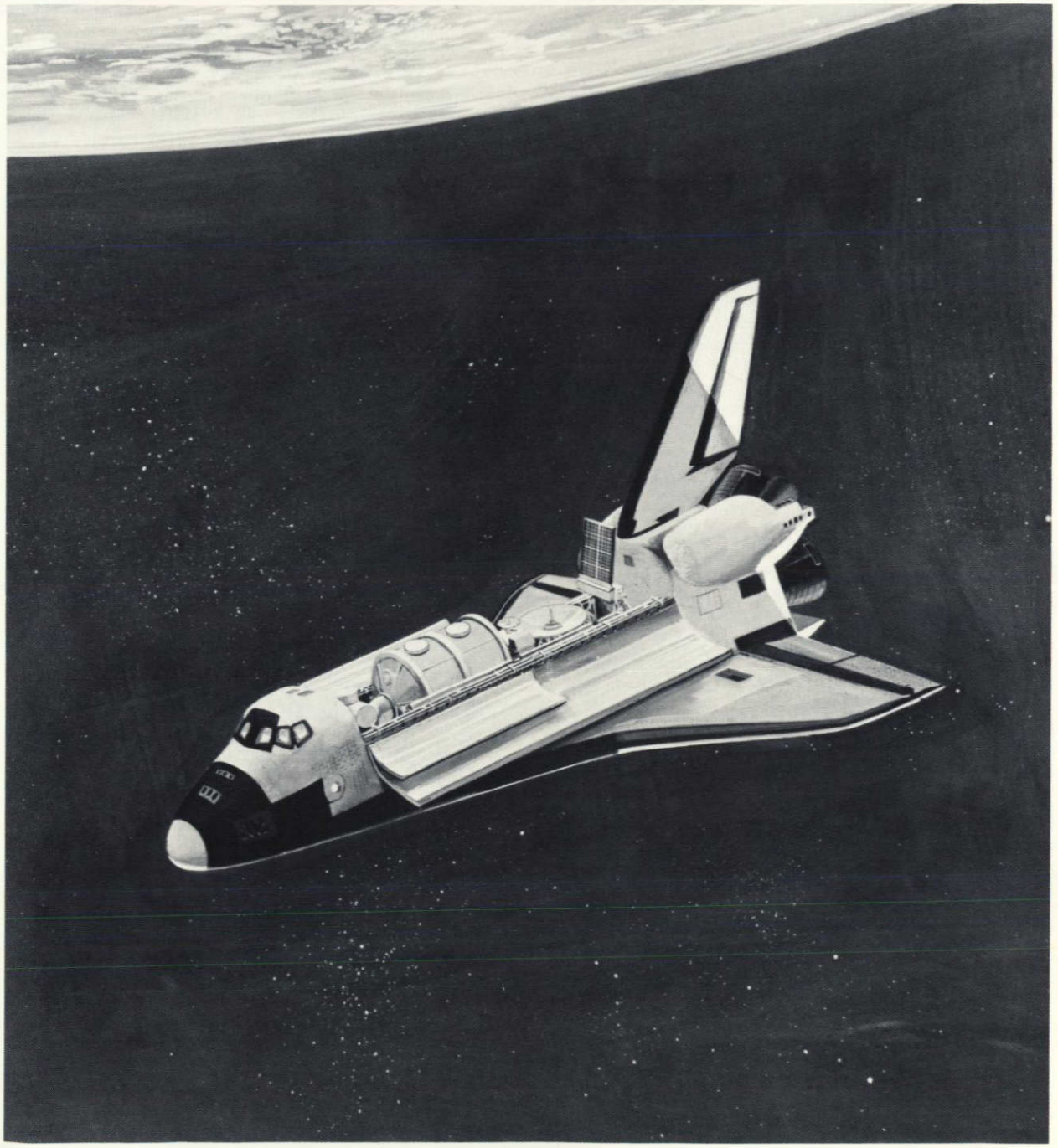
The earth's climate involves very complex processes, which we are only beginning to understand. The *Solar-Terrestrial Observatory*, considered by NASA for the second half of the 1980's, will observe both earth and sun simultaneously to increase our knowledge of climatic processes and their effects on the weather. This observatory will also increase our insight into the possibilities of safely modifying other local climatic conditions—rainfall, for example.

The processes that create our weather and climate conditions may have "trigger points"—points at which small changes in temperature, pressure, or humidity could precipitate large modifications. Once these processes are better understood, *Soletta* reflectors might be used as trigger mechanisms to modify undesirable climatic conditions, such as the severe American winter of 1977 or the terrible drought in the sub-Saharan belt several years earlier. If we were to achieve this level of control, it would surely be one of the greatest achievements of space industrialization to benefit all life on earth.



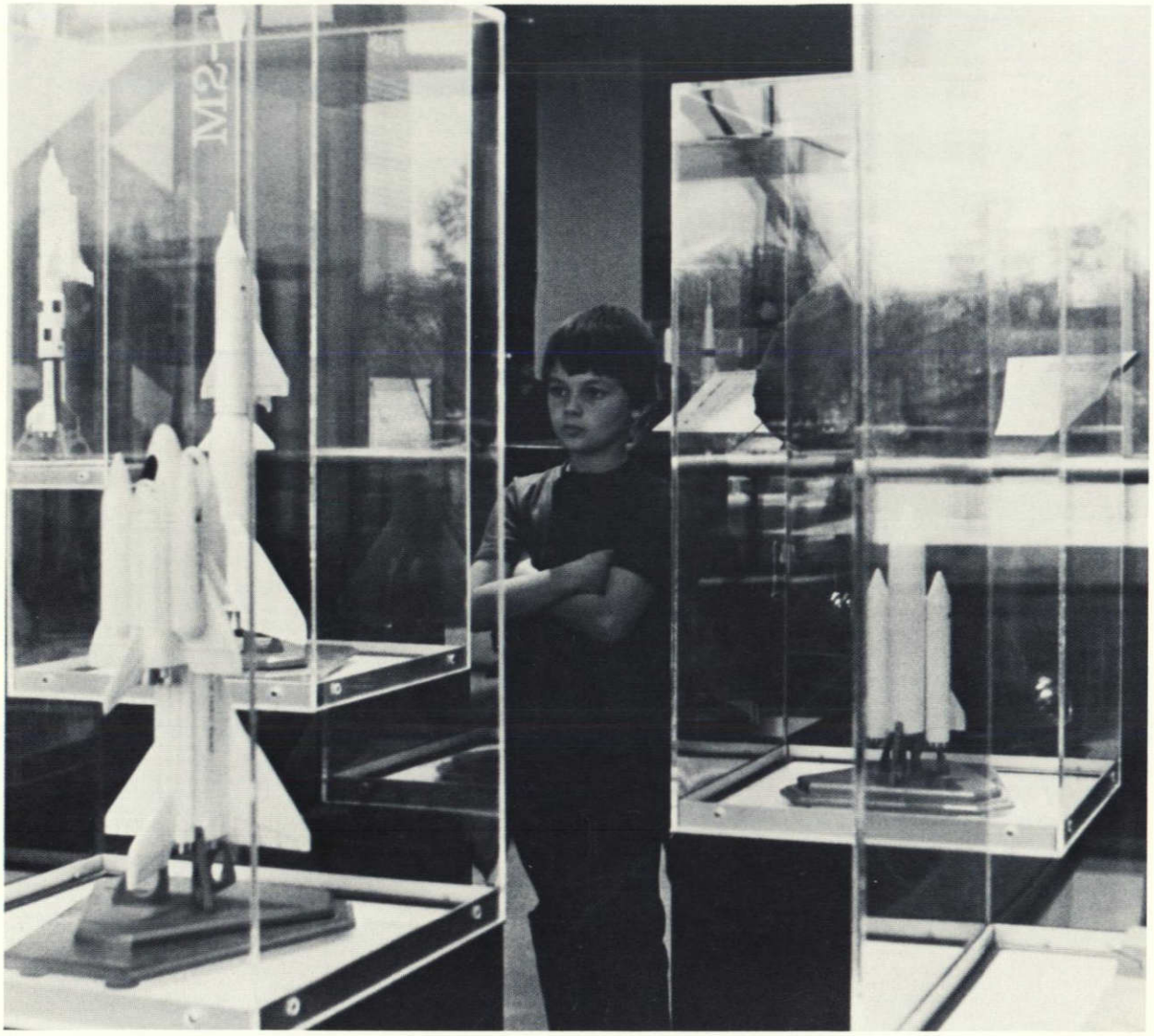
SPACE AS A PERSONAL EXPERIENCE

The Space Shuttle will allow scientists and technicians without special flight training to go into orbit and conduct routine scientific investigations. As space industrialization progresses, more space jobs will be created, not for only a few months but for many years. Medical treatment centers and even recreational facilities will be needed in space. Once they are available, visitors from earth will also begin to benefit from their use.



Because of the advantages of weightlessness, severe burn cases, ulcer sufferers, and victims of disabling heart attacks should have an unusually high survival rate in orbital hospitals. Burn victims can be suspended without agonizing skin-to-bed contact, external pressures on ulcers can be largely eliminated, and victims of heart attacks can be soothed into a super-calm state in the low-stress environment.

And there's another possibility. As the costs come down, the excitement of experiencing space first hand will be within reach. We may choose to venture out into space ourselves!

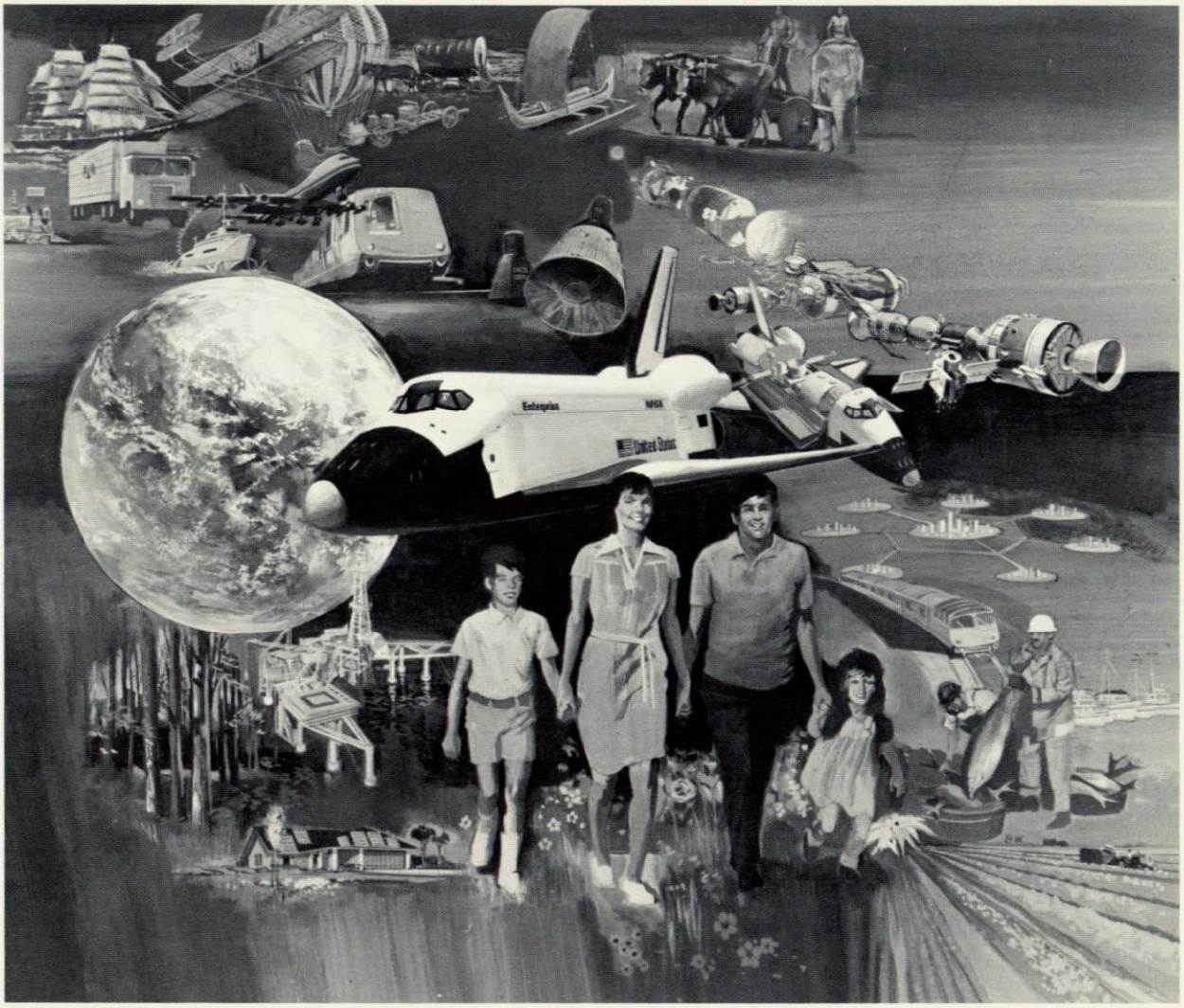


THE OPEN-WORLD CONCEPT

In the past few years, the prophets of doom have arrived at some unusually depressing assessments of the future. Population growth, pollution, and rising energy and raw material demands are, of course, cause for concern. But our studies (and others) indicate that most of these predictions are grossly exaggerated. There is a healthier alternative to conceding that we must halt industrial and economic growth to avoid the ultimate catastrophe. That alternative is to open our world and create a new base for growth. Only through growth—only through the continued generation of wealth—can we overcome the problems that face us. Stagnation and the administration of scarcity as a way of life are not acceptable answers.

The prophets of doom have always been among us to circulate their defeatist forecasts. But their pessimistic prognosis underestimates man's intelligence and creativity, and the enormous powers of his technology. Space is important in making our rich assets work for us in the future. Space offers breakthroughs in education, health, energy, and manufacturing, as well as the understanding, prediction, and control of our weather and climate. Space can also help us in the necessary stewardship of the resources we already have. It is the epitome of our technology.

With the advent of the Space Shuttle, we are approaching a new era of growth in space whose dividends can be applied specifically to the current and universal needs of mankind around the globe.



The pioneering spirit—a spirit of optimism and determination—underlies our country's greatness. We must continue in that spirit, looking not toward the west but toward the sky. We need space to develop our planet safely. We also need the space frontier to expand our productivity and broaden our options for survival and growth.

The opportunities in space are as limitless as space itself.

GLOSSARY

biosphere:	the life-containing area of the earth.
cost-effective:	economical in terms of the tangible benefits produced by money spent.
enzyme:	cell-produced proteins that trigger reactions and processes in living or nonliving organisms.
exoponics:	growth of food plants outside of the earth's environment.
extraterrestrial:	originating or existing outside the earth.
float zone:	a melted section of a solid substance (typically a melted area moving down a solid rod), typically held in place by surface tension.
ground truth data:	physical ground data used to calibrate and identify the output of remote sensors.
hard vacuum:	an extremely high vacuum (usually beyond 10^{-9} millimeters of mercury).
heat sink:	a place or device for the absorption or dissipation of unwanted heat.
lineations:	the arrangement of markings or features on the earth's surface.
teleoperations:	remote electronic control of electromechanical systems.
urokinase:	an enzyme found in human urine that is used to dissolve blood clots in the body.
zero g:	the absence or apparent absence of a gravitational field.