別冊
文部省
東京大学宇宙航空研究所
研究（開発）の推移

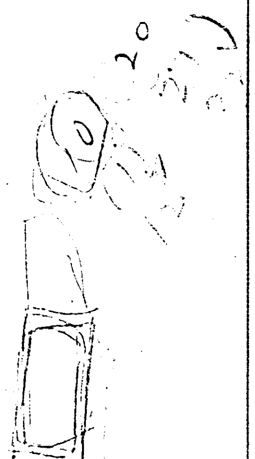
プロジェクト ＼ 年度 ＼ 経費	年度	年度	年度	46 年度	47 年度	48 年度	年度		最終目標
M 計画	M−4S			M−4S−3 第1号科学衛星	M−4S−4 第2号科学衛星				M−4S型ロケットによる第1.2号衛星打上げ
	M−4SC				M−3C−1				M−4SC型ロケットによる第3.4号衛星打上げ
	エンジン			M-10 M-11 M−12TVC	M−22TVC−1	M-20 21 M−22TVC−2 M−13TVC−1			M−4SC型ロケットの予備試験
	テストロケット			L−4SC−1	L−4SC−2	L−4SC−3			

昭和46年度における研究（開発）結果

プロジェクト	研究課題またはサブテーマ	単独または共同研究の別	試作品等			46年度の結果の概要および問題点
			名称	製作外注の別	進捗状況	
M計画	M-4S-3 （第1号科学衛星）	単			46.9.28 発射	ロケットは正常に飛しょうし、搭載した第1号科学衛星「しんせい」を軌道にのせ、電子温度プローブの不具合を除き、すべて正常に作動し、軌道上における観測を実施。 「しんせい」は現在も順調に周回し、科学観測を続けている。
	L-4SC-1	単			46.8.20 発射	第2段ロケットにTVC装置を搭載して、S1TVC装置の動作特性およびピッチプログラムによる特性の一部を求めることができたが、制御回路の一部、故障のため完全な結果は得られなかった。
	M-12-TVC	単			47.3.29 地上燃焼試験了	新推薬を用い、比例制御方式による推力方向制御装置を備えたMロケット第1段エンジンの地上燃焼試験で、所期の成果を収めた。

M-10— 故障
M-11— 地上テスト終了

昭和47年度における研究（開発）計画

プロジェクト	研究課題またはサブテーマ	単独または共同研究の別	試作品等	研究（開発計画）
M計画	M−4S−4 （第2号科学衛星） REXS	単		第2号科学衛星（REXS）をM−4S−4号機により、昭和47年度第1次実験において打上げ、プラズマ波、プラズマ密度、電子粒子線、電磁波、地磁気の科学観測を行なう計画である。
	L−4SC−2	単		ピッチプログラムによるS/TVC装置の制御特性およびロケットの燃焼中における飛しょう安定試験を行なうことを目的とし、昭和47年度第2次実験において打上げる計画である。
	M−3C−1	単		M−4SC−1号機の予備試験機で、第2段目にS/TVC装置を備えた3段式ロケットの開発研究を行なう計画である。
	M−22TVC−1	単		新推薬を用い、TVC装置を備えた第2段ロケットの地上燃焼試験で、M−3C−1およびM−4SC−1に用いる計画である。

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CONTRIBUTORS TO THIS ISSUE

KINGMAN BREWSTER, JR., President of Yale University; Professor of Law, Harvard University, 1953–61; co-author of "Law of International Transactions and Relations" and author of other works * * * *WILLY BRANDT*, Chancellor of the Federal Republic of Germany; Vice-Chancellor and Foreign Minister, 1966–69; Governing Mayor of West Berlin, 1957–66; author of "A Peace Policy for Europe" and other works * * * *MORRIS JANOWITZ*, Chairman, Department of Sociology, The University of Chicago; Fellow, Center for Advanced Study of the Behavioral Sciences, 1958–59; author of "Political Conflict: Essays in Political Sociology," "The Professional Soldier: A Social and Political Portrait" and other works * * * *ROBERT W. BARNETT*, Director of the Washington Center of The Asia Society; Deputy Assistant Secretary of State for East Asia and the Pacific, 1963–70; author of "Economic Shanghai: Hostage to Politics" * * * *LESLIE H. GELB*, Senior Fellow, The Brookings Institution; formerly Director and Deputy Assistant Secretary of Defense for Policy Planning and Arms Control, and Director of the Pentagon Papers project * * * *THOMAS L. HUGHES*, President of the Carnegie Endowment for International Peace; formerly Deputy Chief of Mission, American Embassy, London; Deputy Director and Director, Intelligence and Research, State Department, 1961–69 * * * *HERBERT SCOVILLE, JR.*, formerly Deputy Director for Research, Central Intelligence Agency; Assistant Director for Science and Technology, Arms Control and Disarmament Agency; author of "Missile Madness" and "Toward a Strategic Arms Limitation Agreement" * * * *WALTER F. HAHN*, senior member of the research staff of the Institute for Defense Analyses; co-editor of "American Strategy for the Nuclear Age" * * * *OSVALDO SUNKEL*, Professor of Economic Development and Senior Research Fellow of the Institute of International Studies at the University of Chile and Professor at the Catholic University; author of "Integración política y económica" and other works * * * *ROBERT JASTROW*, Director of the Institute for Space Studies, an office of NASA's Goddard Space Flight Center; Adjunct Professor of Geophysics and Chairman of the Graduate Program in Space Physics at Columbia University; author of "Red Giants and White Dwarfs: The Evolution of Stars, Planets and Life" and other works * * * *HOMER E. NEWELL*, Associate Administrator of the National Aeronautics and Space Administration; Associate Administrator for Space Science and Applications, 1963–67; author of "Express to the Stars" and other works * * * *HENRY S. BRADSHER*, Hong Kong correspondent of *The Evening Star*, Washington, D.C.; Bureau Chief for the Associated Press, Moscow, 1964–68, and New Delhi, 1962–64 * * * *EVGENY CHOSSUDOVSKY*, a Soviet citizen and senior U.N. official; Secretary of UNCTAD's Trade and Development Board; formerly Special Assistant to Professor Gunnar Myrdal, first Executive Secretary of the U.N. Economic Commission for Europe.

The articles in FOREIGN AFFAIRS *do not represent any consensus of beliefs. We do not expect that readers of the review will sympathize with all the sentiments they find there, for some of our writers will flatly disagree with others; but we hold that while keeping clear of mere vagaries* FOREIGN AFFAIRS *can do more to guide American public opinion by a broad hospitality to divergent ideas than it can by identifying itself with one school. It does not accept responsibility for the views expressed in any articles, signed or unsigned, which appear in its pages. What it does accept is the responsibility for giving them a chance to appear there.* The Editors.

THE SPACE PROGRAM AND THE NATIONAL INTEREST

By Robert Jastrow and Homer E. Newell

IN 1900 the population of scientists and engineers in the United States numbered one in 2,000. Today the ratio is one in 120 and the figure is still mounting. Current federal expenditures for research and development are $15.7 billion. During the postwar era these appropriations built the American research establishment to a level of strength beyond that of any other nation. Throughout the 1950s and most of the 1960s the build-up continued without opposition. Recently the taxpayer has begun to regard the House of Science with a degree of concern, because the costs of technological programs have become staggering in the last few years. Painful choices are being forced on the Congress. Shall program A or program B be funded? Each is so expensive that it seems impossible to fund both. Which will advance the national interest more? The general value of research is also being subjected to a closer examination. At what level of support does science make its maximum contribution to society? If the science we have purchased so far has been beneficial, will twice as much science be twice as beneficial?

The space program is a case in point. On January 5, President Nixon announced that "the United States should proceed with the development of an entirely new space transport system . . . the space shuttle which gives us routine access to space by sharply reducing costs in dollars." The decision to proceed with the shuttle was based in part on the dollars-and-cents savings it would yield, which are estimated to run to more than $12 billion in the first decade of shuttle operations against shuttle costs of $8 billion for development and hardware. But a bargain in bananas only represents a savings if the customer needs bananas. Why does America need a space program? Why does she need a man-in-space capability? What is the relation of space to the national interest?

To some, space is, or should be, pure science; to others, it is prestige and the American image; to still others, space means national security. Most often space is identified with science, but when a comparison is made with funding levels in other branches of scientific research, it becomes clear that support given to the

program involves other factors besides the public interest in pure science.

II

Initially, there was no doubt regarding the motivation for bringing the National Aeronautics and Space Administration (NASA) into being. The American space effort was conceived in a mood of national insecurity. It grew out of the paroxysm of humiliation and self-doubt experienced by the United States in the fall of 1957, when the first Sputnik went into successful orbit while shortly after, as the world watched, the first American Vanguard rocket collapsed on the pad in a sea of fire. Headlines shouted "Kaputnik" and "Flopnik." With the launching of Sputnik, the Soviet Union had entered a domain of the environment that seemed to be denied to the United States. In the years following, the Soviets rapidly expanded their control over the new region. Their efforts were climaxed in 1961 by the first orbital flight of a Russian cosmonaut. The position of the United States as a world power seemed threatened by this evidence of a major Soviet technical capability in being. World comment at the time suggested that on both sides of the Iron Curtain the two systems of government were being reëvaluated on the basis of the Soviet achievement.

NASA was two years old at the time of the Gagarin flight, and the space budget had reached the substantial level of $900 million. In retrospect, it is clear now that a billion-dollar budget was merely the entry fee into the race the Russians were running. On that budget, the United States was no longer falling behind the Russians, but neither was it catching up. An all-out effort was necessary, and the moon beckoned.

A landing on the moon seemed to have all the needed elements. It was a clearly defined goal and gripped the imagination; its achievement would recreate the image of U.S. technological leadership; it involved minimum danger of a military confrontation; and it would automatically give the United States a first-class man-in-space capability. At the same time, the lunar landing was so far beyond the abilities of either the United States or the Soviet Union in 1961 that the early lead taken by Russia in manned flight would not predetermine the outcome. The lunar landing project provided America with a chance to overtake the Soviet Union and brighten its tarnished image with a major first in space. All in all, a greatly strengthened man-in-space effort seemed the most efficient way of redressing the strategic imbalance created by Soviet mastery of the new technology.

These factors created Apollo. Its goal was not the landing on the moon per se, but the development of a U.S. capability to operate and maneuver in space with man, and to maintain our presence there in the face of vigorous activity on the part of another great power.

Throughout the 1960s the Soviet Union remained the main driving force behind NASA, but with the landing on the moon in 1969 the original Soviet threat seemed to fade. American interest diminished, and a phase-out of manned flight operations commenced. According to current congressional authorizations, the manned flight program comes to an end in 1973, after the second Skylab flight scheduled for that year.

The projected termination of manned flight in 1973 posed a major policy issue for the United States. A parallel can be drawn with the situation that faced the government in 1961. At that time, the United States was confronted with a major Soviet achievement—the first manned orbital flight—while its own program continued to lag far behind. In 1971 the United States was faced with the termination of its manned activities in space, while Russia gave every indication of driving ahead forcefully in this area. The Soviet Union launched twice as many satellites as the United States in 1971, put up the first space platform, and, while it suffered a serious reverse in the deaths of the Soyuz 11 cosmonauts, showed no signs of a slackening interest in manned space flight.

The presidential action must be viewed in this context. Concern with the general strategic posture of the United States would appear to have been the overriding consideration in the recent decision to proceed to the next stage in the development of manned space flight.

Once that decision was made, the space shuttle had to follow, for the shuttle represents the most economical means of continuing manned flight operations. It is a reusable rocket—in effect, a rocket-plane—which can be flown again and again, carrying scientists, engineers and satellites up into orbit and back down to a conventional jet landing—all at a substantial reduction in cost. The Saturn launches cost $55 million each, and the launch of the more advanced Titan 3C costs $24 million, whereas a shuttle

flight will cost $8 million and deliver considerably more payload for the money. It makes no sense to continue to rely on the rocket technology of the 1960s, when the experience gained in the Saturn-Apollo project and other U.S. space programs has shown the way to a much more efficient and lower-priced generation of space vehicles.

III

According to this analysis, a major force behind the space program as a whole is a concern for national security, and with the fact as well as the image of American technical and scientific strength vis-à-vis the Soviets. However, space is not the only government program important to the security and the technological strength of the United States. Can America afford the financial drain of matching the Soviet Union in every field of science and technology? Many Americans believe that this cannot be done without weakening other essential programs, such as urban reconstruction and education.

The question is one of values and priorities. From this point of view, is space a good place for the United States to put its money? What is the dollar return from the space program, relative to the potential return from the same amount of money invested in another sector of American society?

This question opens up an important avenue for discussion. Starting with the development of the Early Bird communications satellite in 1965, space technology has entered into the mainstream of the American economy with surprising rapidity. Today many observers predict that the U.S. investment in space will be repaid many times over. The list of promising space applications includes better weather forecasts, prospecting for minerals from space, better communications, satellites that monitor the atmosphere and lakes and rivers of the United States for pollution and are the only economically feasible means of doing so, and satellites that guide ships and planes to their destinations and provide traffic control over crowded air terminals.

IV

Better weather forecasting could yield several billion dollars a year as a result of increased productivity, mainly in the agricultural, transport and construction industries. Weather forecasting depends on the measurement of such atmospheric properties as pressure, temperature and the strength and direction of the winds throughout a large region. Currently this information is usually obtained by launching into the atmosphere small balloons containing weather instruments plus a radio to transmit results of the measurements to weather stations on the ground. In the future satellites will join the balloon network and expand weather coverage to a global scale.

At this point the reader may well register doubt. How can a satellite hurtling through space far above the atmosphere carry out measurements of such properties of the atmosphere as pressures and winds? Isn't it necessary to do the equivalent of raising a wet finger in the air itself to secure that information? Can the data really be acquired from a distance?

The answer depends on a little-known instrument called an infrared radiometer which is becoming a standard item of equipment on weather satellites. It is a well-known fact that satellites carry cameras to photograph the weather and provide early warnings of hurricanes and other disturbances. Less well known is the fact that the latest satellites also carry a delicate instrument which measures the intensity of the feeble emanation of heat which radiates to space from earth and its atmosphere. The sensitivity of these instruments is such that they could detect the heat from a flatiron at a distance of one mile. The heat radiated to space from the earth contains many different wavelengths, and each wavelength originates at different depths in the atmosphere as well as on the ground. By spreading out the measured radiation into its component wavelengths, the scientist on the ground is able, with the aid of a computer, to calculate the temperature of the air on the ground and at every level in the atmosphere.

Once the pattern of temperature variations is known over the entire globe, the scientist is in a position, again with the aid of a computer, to calculate the winds and the weather. The connection between temperature and winds is not obvious and requires some explanation. If the temperature of the ground were uniform all over the earth, there would be no winds and no weather. Winds arise because the sun's rays do not heat the ground uniformly. For example, the equator receives more sunlight than the poles. Where the ground is warmest, the air expands, rises and flows away. In this way temperature differences create winds. The actual situation in nature is considerably more complicated than this simple description suggests, but the basic theory is accurate. If the temperature pattern is known, the weather can be predicted.

In principle, the method can be applied without the aid of satellites. However, it would be prohibitively expensive to measure the temperature of the entire globe by ordinary methods. At present, extensive areas of the world are not covered by weather observations. Even in the United States the coverage is spotty, with only 70 balloon-launching stations for the collection of weather information. Large areas of the weather map are almost blank, including the polar regions and the oceans.

Unfortunately, much of the weather that blesses or afflicts the United States often originates in one of these blank regions on the weather map. The weather experienced by the West Coast generally comes from the Pacific Ocean, while the weather over the Midwest and the East Coast usually has originated some days earlier in central or western Canada. This fact prevents the meteorologist from making useful forecasts more than a day or so in advance, and even the one-day forecasts leave much to be desired.

Observations of the weather in the oceans and sparsely inhabited land areas surrounding the United States, impossible before the advent of weather satellites, should lead to a quantum jump in the accuracy and range of weather forecasts. Large savings through improved weather forecasting can be expected in the weather-sensitive sectors of the U.S. economy, because the volume of business in these industries is substantial. In agriculture, transportation, construction and roadbuilding, for example, the total annual volume in 1970 was about $270 billion, and estimated losses due to weather were in the neighborhood of $13 billion. A relatively modest reduction of 20 percent in these losses would correspond to a $2.6 billion savings. These circumstances lie behind the estimate of important gains to the U.S. economy from this single application of space technology.

V

Multibillion-dollar annual returns to the American economy from weather satellites may be matched by the yield from satellites employed in prospecting for valuable mineral deposits. The prospector and his burro are essential in the search for mineral deposits, but aircraft play an important supporting role, and so should satellite reconnaissance in years to come. In some cases geological faults—cracks in the earth's crust which are likely to be associated with ore deposits—can be seen in photographs taken from orbit. In other cases the presence of a buried ore deposit is signaled by a particular type of rock on the surface. Experience shows that an ore deposit is often surrounded by a special kind of rock, known as the "host rock" for that type of ore. Since different kinds of rock reflect sunlight in different ways, wide-area photographs of the region taken from a satellite can reveal the telltale host rock that indicates an ore deposit.

The stakes are high in this game. One estimate places the yield from potential satellite discoveries of mineral deposits in the United States at $2 billion a year in royalties alone. The total value of mineral deposits discovered each year by ordinary prospecting on the ground in the United States, Canada and Mexico amounts to roughly $10 billion. It is possible that several times this sum could be the global yield from major improvements in mineral prospecting. Here we reach the neighborhood of tens of billions of dollars in direct economic benefits from a single application of satellites. These gains would dwarf the investment in the underlying space technology.

Mining activities in northern Canada illustrate the economics of satellite prospecting versus ground prospecting. A single rock outcropping near Kitt Creek in Ontario led to the discovery of the famous Timmons deposit, one of the world's largest bodies of copper, zinc, gold and silver. This single find is estimated to have a value in the neighborhood of $10 billion. The find was made by a lucky fluke when a prospector stumbled across a small outcrop of ore that give him a clue to the massive treasure-lode lying beneath the surface. Geologists believe that many deposits as rich as the Timmons find may exist in the area because it belongs to one of a number of belts of green schist—a type of rock deposit frequently associated with rich ore. The total area of the belts in this region is roughly 100,000 square miles. The terrain is too rough for jeeps or burros. Recovery of its mineral wealth requires systematic exploration of the entire region on foot, by prospectors stopping every hundred yards to collect soil samples for laboratory analysis. Tens of millions of dollars would be required to complete a survey of this one region. A complete exploration on foot is a workable approach in principle, but forbidding in practice because of the prohibitive cost.

The same analysis applies *a fortiori* to the still more difficult terrains of Brazil, equatorial Africa and Southeast Asia, in which a heavy cover of trees and vegetation makes ground exploration exceedingly difficult and expensive. The available evidence suggests the presence of large deposits of mineral wealth in these regions. Again it seems incredible that a satellite hurtling through space hundreds of miles above the surface of the earth should be able to detect mineral deposits concealed by a heavy tree-cover. But an example will indicate how this might work. Research has shown that trees growing in metal-rich soil absorb the metallic elements of the soil into the structure of their cells. As a consequence, the tree leaves reflect sunlight differently from leaves on the same type of tree growing nearby in ordinary, metal-poor soil. The rest of the story is clear: Measure the intensity of reflected sunlight over a continental expanse of forested regions by means of instruments mounted in a satellite, and look for the critical patterns that betray the presence of mineral deposits.

As a test of this method, measurements have been made at tree-top level at a site near Copper Creek, Arizona. They show large differences in the reflected sunlight from two neighboring trees, one located in soil with a high abundance of copper and molybdenum, and the other growing nearby in ordinary soil. The tree growing in the metal-rich soil reflects twice as much yellow light as the tree growing in ordinary soil, but half as much blue light. This combination is an unmistakable sign of the presence of the metals. Such measurements obtained from a satellite can be used to guide the prospector to the mineral wealth of millions of square miles, with a great saving in time and money.

Aircraft can make the same measurement and are used for this purpose in surveys of small areas. Satellites acquire their unique value when a continent-sized area is to be surveyed. It is, of course, in these large-scale surveys that the greatest gains can be realized. The direct operating cost of an aircraft survey of the interesting areas of the earth, which total approximately 100 million square miles, would be about $300 million. The same survey could be carried out by a single satellite costing no more than $30 million. Additional savings result from the fact that each satellite photograph or radiation-scan covers thousands of square miles, revealing significant large-scale variations with unnecessary details suppressed. For many surveys the satellite detail is adequate, and consequently data-processing costs are far less than would be the case with the superfluous detail furnished by aircraft surveys.

Apart from costs, satellites are superior to aircraft because of the large area covered in each photograph or scan. Such an area is typically several thousand square miles. Airplanes usually cover no more than 100 square miles per photograph. Because many photos are needed to survey a large area, aircraft require the better part of a day to cover the equivalent of one satellite photograph. Consequently, different regions are photographed at different times of the day, and under different lighting conditions. If the area is large, and the survey lasts many days, the condition of the ground will vary from day to day because of local rain or snow. The intensity of the light reflected from the ground depends on these lighting conditions and ground conditions to a very great extent. The critical changes in intensity from place to place, which would indicate the presence of mineral deposits, are apt to be masked by the changes that occur from hour to hour and day to day during the course of an extended aircraft survey. Such difficulties do not arise in satellite prospecting.

The ability of the satellite to photograph large areas quickly and repeatedly makes it a very promising tool in the survey of other natural resources, such as crops, timberland, water and snow cover, which frequently vary day by day and from season to season. Crops offer a particularly interesting example because of the large losses experienced each year as a result of plant diseases. Infrared photographs taken from satellites can reveal plant diseases before they can be detected by the farmer on the ground, because a diseased plant or tree radiates a different level of heat to space, just as a feverish person experiences a change in body temperature. An estimated $840 million annually can be saved in the United States through the use of satellites for the detection of plant diseases, according to an IBM report.

VI

Communications satellites offer another fruitful field for the space program. Communications was the first area to be invaded by the new technology, and, together with weather forecasting, it constitutes one of the two areas in which satellites have already become an operational reality. The dollars-and-cents return to the economy from communications satellites is difficult to measure, but most experts agree that the gains promise to be enormous, because improvements in communications exert an upward leverage on the entire gross national product (GNP) by accelerating the tempo of business life. The only question is, what will be the amount of the increase in productivity? Will it be as small as one percent? Translated into dollars in the GNP, that would mean a gain of $10 billion annually. The indirect financial gains from improved communications may exceed all other returns from space.

The relationship between efficient communications and satellites can be clearly seen in the recent history of transatlantic telephone charges. The table below shows the monthly rates for a leased telephone circuit between New York and Paris during the period 1959 to 1971. The rates remained unchanged for a number of years, but in 1966—immediately after the first communications satellite went into operation—monthly charges dropped sharply and have continued to drop since that time.

NEW YORK TO PARIS TELEPHONE RATES: 1959–1971

Year	*Dollars per Month*
1959 through 1965	$10,000
1966	8,000
1967	6,500
1968	6,000
1969	6,000
1970	4,750
1971	4,625

Although expanded cable service also contributes to the reduction in transatlantic phone rates, the coincidence of the sharp decrease with the onset of satellite operations is striking.

Arthur C. Clarke, who invented the concept of the communications satellite in 1945, has maintained a high reputation as a seer of technological developments and their impact on mankind. His judgment probably can be relied upon when he predicts: "What we are building now is the nervous system of mankind. . . . The communications network, of which the satellites will be modal points, will enable the consciousness of our grandchildren to flicker like lightning back and forth across the face of this planet."

VII

The three cases of weather forecasting, mineral resources and communications illustrate the economic value of space. The space shuttle enters the picture at this point because it affords the most economical means of realizing the benefits of the space program in the economic sphere. The shuttle moves back and forth between the earth and space environments. It carries a dual propulsion system—rocket engines and liquid hydrogen fuel for space flight; jet engines, kerosene and wings for the return to earth. Space shuttles can carry passengers and freight into orbit and down again at a cost per pound far below today's cost for a satellite launching or a manned space flight mission. The cargo bay, probably about 15 ft. x 60 ft. in dimension, will accommodate satellites and space platforms weighing up to 65,000 pounds and will provide a low-cost method for placing commercial or scientific satellites in orbit. NASA estimates that in the first decade of shuttle operations $5 billion will be saved in launch costs through its use.

Additional savings are expected to result from the reduced cost of the satellites themselves. The cargo bay of the shuttle offers a considerably gentler and less rigorous environment for delicate scientific instruments than today's conventional launch rockets. Much of the cost of building a rugged design into the satellite can be bypassed as a consequence.

A space transport system based on the shuttle also provides a means for repairing satellites in orbit, thus increasing their lifetimes, again at large savings. The new commercial satellites are expensive, and becoming more so as their capabilities expand. The first communications satellite placed in operation over the Atlantic—the Early Bird—contained 240 voice circuits and cost $8.2 million. The recently launched Intelsat IV supplies up to 9,000 circuits and costs $26 million. The advanced communications satellites proposed for a U.S. domestic system will cost about $50 million each. It seems extravagant to contemplate throwing away one of these expensive devices after a failure, when it can be brought back to earth in the cargo bay of the shuttle for overhaul, or even repaired in orbit by a technical team transported to the scene. Round-trip airfare for the overhaul is estimated to be about $8 million, but for this price the crew can salvage a $50 million satellite. The total savings resulting from the repair operations, plus the reduction in the cost of the satellites, is estimated to be $7 billion.

Some 20 U.S. satellites, each worth $30 to $50 million, will probably be in orbit in the 1980s, and each will play a critical role in some sector of American business and personal life. The list will probably include eight to ten Comsats dedicated to domestic and international uses, four or more satellites dedicated to worldwide marine and air navigation and traffic control, two or more satellites devoted to surveillance of the earth's face for mineral resources, water, timber resources, forest and grazing lands, fishing, farmlands, and the monitoring of air and water pollution, and several satellites devoted to astronomy, geophysics, and other branches of pure science. Experience will tell whether to divide these functions among numerous separate satellites as they are today, or to combine them in a smaller number of large electronic complexes. In either case, a low-cost space transport system will be required to maintain and repair these satellites in orbit.

Replacement costs are not the only problem in satellite maintenance. When a space platform is responsible for air traffic control or for the communications traffic of a continent, it will not be possible to permit one of these critically important devices to go out of service for a day, an hour, or even a minute because a transistor has malfunctioned. If air traffic control over Kennedy, O'Hare and other major airports depends on satellites hovering overhead, interruption of service would require reverting for a time to the less efficient modes of control which even today are becoming inadequate, and which in tomorrow's world would be extremely expensive. In the 1980s it is likely that the U.S. satellite network will be constructed on the principle of a 100-percent guarantee of uninterrupted service.

Continuity of service could be ensured without manned flights by building spare circuits into each satellite, ready to take over when a failure occurs. The backup equipment might consist of duplicate electronics for all the parts of the satellite or it could consist of one or more duplicate satellites launched with the main satellite and available for service at any time. But when circuit A became defective and circuit B took over, it would still be necessary to repair circuit A promptly; otherwise the failure of the satellite would only be postponed. Of course, a three-fold or four-fold redundancy could be built-in, but that soon becomes a very expensive way of obtaining protection from interruption in service. The space shuttle system is likely to prove the cheapest way of keeping critical satellites in continuous operation.

Financial returns are not the principal criterion for judging the usefulness of the shuttle, for its prime importance lies in the fact that space is an arena in which several nations are, or soon will be, engaged. The United States must maintain a presence in that arena through a manned flight program to preserve its position as a world power. But the extensive use of space is becoming an economic necessity for every technologically advanced nation. The United States probably could not maintain a competitive position with other major powers in international commerce unless it made full use of the most advanced technologies available, including those of space—commerce-oriented satellites and the economics of the shuttle—in the conduct of its domestic and foreign affairs.

VIII

Some students of the space program have expressed the view that its impact will be felt in other respects than the cost-accounting of economic productivity versus technological investment. There has been much discussion of the influence of space exploration on the mind and spirit of man, as an extension of the revolution in thought that was initiated by Copernicus and continued by Newton and Darwin. A study of the history and pre-history of man suggests that the human drive is expressed through just such tentative movements out of the world of tried experience into a new world of untested promise.

Sputnik and the moon landing signaled the opening of a new frontier across which man can now travel into the endless reaches of outer space. The new frontier of space will not be closed quickly, for astronomical knowledge shows that billions of stars, some undoubtedly accompanied by earthlike planets, surround us in the galaxy. Space exploration has brought home to more people than ever before the reality of this vast complex of stars and planets. "Out there" is really there, a place that one can get to. Never again can we make the mistake of identifying our speck of planetary matter as the universe.