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Spinoff 1976: A Bicentennial Report

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A BICENTENNIAL REPORT

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the spinoff stimulus

Not only have men climbed the lunar craters. Not only have robot spaceships measured other planets. Most space benefits accrue directly to us on our own planet.

Today we educate the world via communications satellites. We prospect for oil with land-resource satellites. We keep the tundra frozen with spacecraft-derived heat pipes, making the Alaskan pipeline possible. Our damaged hearts are run by pacemakers, our ailments diagnosed by computer. Highways are grooved to prevent skidding. Bridges soon may be protected from corrosion. Better lubricants, more powerful solar cells, more efficiently designed railroad cars have been spun from space technology. Thousands of technical innovations are the payoff after 18 years in space.

Examples of how our national investment in space research and technology pays off will be described here, first as social, political, and economic stimuli and then in the exploration of space for its own purposes. The "research payoff" continues with current cases of space spinoffs that affect your job, your health, your mobility, your home, your environment, and your future.

Technology: currency of foreign affairs

Few human undertakings in the modern world are so important as the development of technology. And yet few subjects are so little understood. When you think of technology you think of machines. But it should be emphasized that technology, or the practical utilization of science, today is applied outside of industrial life too. Consider, as a start, how space technology has been spun off to improve our relationships with other countries.

Technology—of which the space program has become a leading generator—is now a currency of foreign affairs. It is a tool of advanced nations and a hope for underdeveloped ones. The National Aeronautics & Space Administration has helped at least 75 countries by exchanging technical information, launching their satellites, sharing communications and data derived from our own satellites, and conducting foreign experiments on our spacecraft.

Pace setters in a free society

A free society needs pace setters in multiple activities. The alternative is mediocrity. No other technological endeavor has set—and met—as high standards as are required in the space program. The term "zero defects" is an invention of space technology in which machines must function perfectly in the almost impossible environments of vacuum and temperature extremes.

And yet all that represents just some of the indirect benefits of space technology. Space has its own purposes, targets, and destiny. Space technology already is accomplishing things that cannot otherwise be done economically, or perhaps done at all. This is happening in satellite monitoring of the weather, global communications, navigation, oceanography, meteorology, geology, astronomy, and of course exploration of the solar system.

Dollar returns from our tax penny

If you ask the man in the street how much the space program costs the country, his guess is likely to be $20-billion a year. That's the figure he's heard and it sticks in his mind. That amount was the cost of *nine years* of the program to land men on the moon before the end of the decade of the sixties. As such, it was the primary cost of building our spaceport, tracking stations, and overall space capability.

It is a remarkable, often-overlooked fact that the pursuit of space goals generates innovations in virtually all fields of science and technology, and therefore helps stimulate progress in areas not even remotely connected to the original program. The use of the words "virtually all" is intentional. It is difficult to imagine a scientific discipline or area of technology that has not contributed to the space program—and vice versa.

Whatever stimulates massive scientific inquiry in all disciplines will benefit all science, for what science mostly needs is a focal point that can command the attention, respect, and dollars of the world. With 90% of all scientists ever born still alive and working today, with the rate of scientific and technological advancement accelerating now in geometric progression, the real world of solvable problems cries for a standard bearer, a stimulus, and a goal.

If you accept this broad view of spinoff, then the many benefits attributable to the space stimulus are difficult to measure in their entirety, so thoroughly have they pervaded our lives. Yet, so many benefits have accrued that even the direct generation of new products, processes, and whole new technologies and industries is impressive.

In attempting to quantify the benefits to the national economy from secondary applications of space technology, economists last year traced the spinoff of four broad NASA programs. They estimated that secondary benefits in these areas will return $7-billion to the economy in a 14- to 20-year period—more than twice NASA's current annual budget. Another recent study showed that each new dollar invested annually on space research and development would return $23 over a 10-year period (see "Your Job," below).

Spinoff really works—but not as an isolated phenomenon. The research payoff is a fact of modern American life, interwoven with the direct benefits of space and our entire technology. Because of spinoff, we can define space exploration as a self-funding pursuit of the unknown, the most potential-filled endeavor in history.

Some day, spinoff may acquire an even more expanded meaning. It may include new crops hybridized with plants native to other planets. Or even knowledge transferred by communicating with intelligent life in other solar systems.

Before discussing some of today's specific products that have been spun off from space technology, it may be of interest to describe just what we are spinning off *from*.

exploring the solar system

The exploration of the solar system began with observations from space of our own planet. It started 19 years ago shortly after Sputnik roared its way into the consciousness of people throughout the world. Since then thousands of satellites built by dozens of countries have been launched, with the U.S. maintaining space leadership by a wide margin.

It's not who's first that counts, as Columbus proved. It's who's first with a difference. The fact that Soviets were first with a satellite or that we landed men first on the moon is of little relative importance.

The difference is that we landed men six times, returning human observations that will keep scientists busy for years, and that our satellites now assist in solving a multitude of world problems. We have built a space capability and have begun the exploration of the solar system, opening a new era of civilization.

Servants in space

If outerspace exploration represents knowledge for tomorrow, the earth satellites are the workhorse machines of today. At the beginning of 1976 there was a swarm of about 750 satellites operating in earth orbit, 375 of them launched by the United States.

Among the many uses of these servants in space are weather forecasting, communications, scientific data gathering, solar observation, and prospecting and management of natural resources.

Good weather forecasting saves money. An accurate five-day forecast, which may be possible as satellite technology progresses, has been estimated to save up to $5.5-billion yearly in the U.S. alone, and as much as $15-billion for the entire world. The savings would be in agriculture, construction, transportation, recreation, and other industries.

Today's satellite system of weather watchers provides pictures of cloud cover over the globe both day and night. It contributes significantly to accuracy of one and two-day weather forecasts and increases man's ability to discover and track hurricanes, thus helping save lives and property.

The tropics are believed to be a key to earth's weather. Beginning in 1974, the United States and 69 other nations monitored virtually every known weather factor along a 20-million-square-mile rim of tropical land and sea around the world. Some 4,000 people using 41 ships, 40 buoys, 12 aircraft, five U.S. satellites, and one Soviet satellite probed from a mile below the sea surface to the top of the atmosphere. From stationary orbit, our synchronous weather satellites maintain a 24-hour watch on most of the Western Hemisphere, transmitting data to produce a picture every 30 minutes.

Improved communications through satellites have enabled ships and airplanes to find faster, safer routings around storms, ice, and other obstacles. Communications satellites have widened television coverage, extended education and medical care to remote regions, and even have reduced the cost of overseas phone calls.

The Intelsat, or International Telecommunications Satellite System, continues to grow in capability. This organization of 91 nations has brought the advantages of telecommunications to most of the world. The system today consists of more than 6,000 telephone circuits among 110 earth-station antennas located in 66 countries, and it is growing with new launches of improved satellites each year.

Larger applications technology satellites, powerful enough to broadcast directly from orbit into countless television sets, are being placed in geosynchronous orbit so that they'll hover, in effect, over a fixed spot on earth. The latest, the ATS-6, was launched in May 1974 and has performed flawlessly since. It has enabled physicians to conduct medical consultations in remote areas and brought high school and college courses to students in isolated Appalachian and Alaskan communities.

Dr. Wernher von Braun, president of the National Space Institute and vice president of Fairchild Industries Inc., which built the satellite, describes a typical scene. A seven-year old girl in a remote Alaskan village of 425 people had caught her hand in the wringer of an old-fashioned washing machine.

A doctor at a hospital in Tanana, several hundred miles distant, flipped a few switches and the badly frightened little girl appeared on the screen.

"Hold up your sore hand," the doctor said. "Now hold up your other hand and let me see if you can wiggle your thumbs."

Both could see each other. The isolated girl no longer was isolated. Not only could the doctor allay the girl's fear, but he could diagnose and treat her almost as well as if they were in the same room. He prescribed to the native nurse how to clean, bandage, and resplint the broken thumb.

Last May, a year after its launch, the 1.5-ton satellite was moved 8,000 miles to serve the people of

India. Here, where a great many of the half-billion population live in villages and rural areas and almost none has ever seen a TV set, educational and medical telecasting may be the only realistic answer to improving the lives of an eighth of the people on earth.

The Indian government now has begun using ATS-6 to beam instructional television programs to some 5,000 villages and cities in seven states. India views satellite education as the *only* means to break the back of its widespread illiteracy.

Our lunar legacy

Both satellites and men have special roles in exploring the other worlds of our solar system. Where it is feasible for man to go, it is difficult to conceive of an instrument more capable. The human body has been defined as "a 10-cycle closed-loop, sensing, computing, and performance system in a 0.1-ton chassis with a 0.1-horsepower motor." Only such "equipment" could grasp the significance—and the adventure—of the moon's many complex phenomena.

When Neil Armstrong and Buzz Aldrin landed in the Sea of Tranquility the morning of July 20, 1969, about 1.5-billion people—almost half the population of the earth—were able to watch it by satellite-relayed television. Never before (or since) had so many human minds been concentrated at the same time on one activity. Man's first expedition to another world had enormous psychological and philosophical impact. It was a symbol of both human aspirations and inter-dependency. When we see our planet televised from the moon, the fact that it is finite, beautiful, and a single object, instead of 145 distinct nations, becomes overpowering. It may be trite to say, but true, that if spaceship earth sinks we all sink with it.

A second, even greater result of the expeditions to the moon was its prominent role in the beginning of a vast scientific awakening. Like all scientific endeavors, the practical benefit to us in our homes and lives will occur in the future. But we already have learned more about the moon and the origin and evolution of the earth through the six manned lunar missions than has been learned since the dawn of history. This abundance of scientific understanding, supplemented by robot probes to the planets, is rapidly advancing the earth sciences through a new field of comparative "planetology." With the world running out of oil and other minerals, the new knowledge couldn't come at a better time.

A third part of our lunar legacy reflects the primary intention of the Apollo flights. They were first steps, "travel engineering" missions, if you will, carried out to design and improve the equipment, to learn how to travel to the moon and back safely, to conduct what were essentially interplanetary expeditions—in short, to build a manned space capability.

To expect more than that psychological impact, more than that bountiful scientific harvest, and more than that engineering capability would be as though we lived at the end of the 15th Century and complained that Columbus failed to return sufficient quantities of gold from his first trips. No one dreamed of limiting future voyages then.

Shuttling to orbit

Following the lunar landings and using essentially the same hardware, the 100-ton Skylab space station was launched in 1973. Three missions that year and the next proved that man can live and work in space for prolonged periods. Last year, the joint U.S.-Soviet, Apollo-Soyuz linkup provided experience in docking with dissimilar equipment and languages and preparing for future space-rescue missions if needed.

These flights also saw the beginnings of men conducting experiments in space to develop manufacturing processes in weightlessness, observe the sun from space, and monitor earth resources. One day we will make electronic components, thin films, optical devices, and even pharmaceuticals in space. And space will be the *primary* location for astronomy.

But a better method will have to be devised than building multi-million-dollar ship-sized rockets and then throwing them away after one use. Few considerations kill an otherwise desirable plant site quicker than lack of suitable transportation.

The space shuttle will provide low-cost transportation to earth orbit. Now under construction to be operational in 1980, the shuttle will take off like a rocket and land like an airplane. It will be the major part of a reusable space transport system that will replace most current U.S. launch vehicles.

In addition to the shuttle, the system includes an upper stage or "spacetug" and a spacelab. The shuttle will enable a space crew to place, repair, and retrieve satellites, as well as carry the spacelab to orbit. The spacetug, a propulsion vehicle, will remain in space to move payloads, such as the spacelab, from one orbit to another. The spacelab will provide scientists the opportunity to accompany and conduct their experiments in space. With its capability to return payloads from space and to be used over and over again, the space shuttle system will make spaceflight more routine and considerably less costly.

Pioneering the planets by robot

For some time at least, manned flights will be confined to the earth-moon region of space. But our direct exploration of the solar system continues even so, using comparatively small robot flybys, orbiters, and soft-landers.

Following the Mariner mission to Venus and Mercury beginning in 1973, Pioneer 10 stretched mankind's influence through the asteroid belt and across the half-billion miles to the giant Jupiter, arriving late that year. In December 1974, Pioneer 11—renamed "Pioneer Saturn" after it flew within 26,000 miles of Jupiter and proceeded on to Saturn —will pass near or through the rings in 1979.

Meanwhile, Pioneer 10 headed on a course that will carry it completely out of the solar system, passing the orbit of Pluto in 1987. In 40,000 years it will have coasted to the distance of the nearest star, but in the direction of the constellation of Taurus, the Bull.

If it should encounter intelligent life in some other solar system, its final mission will be accomplished, some 40 centuries later. The little 570-lb spacecraft carries a gold-plated 6- by 9-in. message graphically and mathematically telling of man and from where he came.

Jupiter is so large and massive, containing two-thirds of the matter of the entire solar system except the sun, its gravity affects the orbits of the other planets. Jupiter, thus, is an important key to understanding the behavior of the smaller planets, including earth.

The Pioneers found that the magnetic field of Jupiter, unlike the earth's, may be created by several ring currents—like electric dynamos—deep within the planet. Earth and Jupiter are the only planets known to have substantial magnetic fields. Jupiter's field sometimes stretches across 9-million miles of space, only to shrink in volume by three-quarters or more of that distance.

Despite these unearthly fields, enormous pressures, and high temperatures, Jupiter has conditions that could be suitable to the evolution of life—but not on its surface. If life exists on Jupiter, it would have to swim in the atmosphere, much as life in our oceans. Jupiter may provide the same kind of primordial "soup," consisting of hydrogen, methane, ammonia, and water, in which life probably originated on earth.

If life does exist in the Jovian sky, or on any of the moons of Jupiter or Saturn, it will take at least a soft-lander to find it. Our quest for life on other planets shortly will use that approach—on Mars.

Next stop: Mars!

Visiting Mars on our country's 200th birthday is an appropriate achievement in the step-by-step exploration of the solar system, a fitting continuation of the pioneering spirit of '76.

In the year 1776, if a citizen of the new republic could be made to believe that this country would land a robot on Mars two centuries later, he would have assumed that the planet naturally would then become a territory of the United States.

The fact that we no longer take this selfish view, the fact that we seek cooperation with other countries in the peaceful development of space, and the fact that we perform our space feats openly on the world stage dramatize how our nation has matured over those 200 years.

Americans have taken many steps for mankind since 1776, but few as filled with excitement as the search for life on another planet scheduled to begin on Mars this summer. The surface exploration of Mars will yield new knowledge of the origin and evolution of our solar system, possible origins of life, and—again—new insights into the processes that have shaped the earth.

We used to think that of all the other planets in this solar system that Venus was the most like earth, even a sister planet. After all, the two planets are the closest in space and therefore the closest in distance from the sun. Both are almost exactly the same size, weight, and mass. Both possess heavy atmospheres. Lush tropical jungles and warm rivers awaited pre-1962 science-fiction characters on Venus.

But in that year the Mariner-2 flyby shattered hopes for a Venusian heaven. It discovered Venus was much more like hell: molten tin could flow in those rivers. Last October, the Russian Venus-9 soft-landed on the planet, erasing any doubt that the high temperatures existed not merely in the atmosphere but on the surface itself. The Russian lander measured the surface at 905 F. The atmospheric pressure was 90 times our own.

Mars, though, that little planet hardly bigger than the moon, that cold, apparently lifeless world orbiting so far from the sun, that cratered body with only a 67th the surface atmosphere of our planet—Mars turns out to be more like earth than any other planet in the solar system.

We now know that the surface temperature rises to at least a balmy 77 F on the equator shortly after midday. We know too that Mars' atmosphere and clouds contain a small amount of water vapor. While the polar ice caps are predominantly frozen carbon dioxide, the smaller caps left after this dry ice evaporates are water crystals.

What we do not know, and one reason the two four-ton Vikings have been sent to soft-land, is the nature of the water we see. Is it the last disappearing remnants of once-plentiful rivers and lakes? Or is Mars locked in an ice age that has frozen most of its water at the poles or beneath a layer of surface dust? Does water, even now, exist beneath the surface?

Martian water holds many clues to the planet's history. Assuming Martian life is dependent on water, as is life on earth, an understanding of the daily and seasonal appearance and disappearance of water is necessary to establish whether life could have existed on Mars.

Before Viking-1 lands on or about July 4, it will orbit the planet to pinpoint warm, wet places with thick soil layers. Viking-2 will arrive seven weeks later, well after the first spacecraft has had time to land and send back engineering data about the descent and arrival site. In this way, the trajectory of the second Viking could be changed to land elsewhere if desired.

Once the Vikings land on Mars—after years of work by thousands of scientists and engineers—a boom will be unfurled to dig up soil samples for incubation and analysis. Several experiments then will be conducted to detect the presence of living micro-organisms.

Comparing the earth

These are among 13 separate investigations of Martian conditions, including planetary structure, weather, chemistry, and biology that will be undertaken both in orbit and on the surface. We now have first-hand data on two bodies of the solar system—earth and the moon—and less-extensive but direct measurements of Venus, Mercury, and Jupiter. Knowing the makeup of Mars in detail will enable us to compare it with the moon, the other planets, and earth, yielding a far better insight into how planets evolve.

Mars has sand dunes, cloud formations leeward of some mountains, and similar earth-type phenomena. Martian weather may be a simple version of earth's. If so, the Viking weather station will help us learn how weather is formed on planets, including our own.

When you stop to think about it, you realize that biology is our only science, so far, without comparative reference. Until we find life on another planet—even microbes—we can have no comparative biology as we now have comparative geology, physics, chemistry, and the other sciences. If life does *not* exist on Mars, we at least will have a close-up comparison of a planet evolving in the absence of life, a new approach to understanding how the earth's teeming lifeforms have affected this planet.

But if life *does* exist on Mars—or on a Jovian moon, for instance—we will have much more than a new science. We will have proof at last of that elusive quest without human parallel: that life is not confined to this one planet alone.

your job

The relationship between building a space capability—even searching for life on another planet—and improving life on earth is closer than is generally realized. Of all the areas of U.S. society needing improvement in 1976, inflation and unemployment are among the most crucial.

We certainly are a nation of workers. Despite a comparatively high rate of unemployment, 93.2-million Americans are employed. Spaced only a mile apart, we'd reach the sun! Of the total 214-million Americans, 43.5% are working. That's almost half of all of us, children and retirees included, who have jobs.

The sheer numbers make us realize the awesome magnitude of job creation in a free-enterprise system, the delicate interplay of capital investment and technology, the necessity for job enrichment, and the rightfulness of government transferring tax-bought knowledge back to the people.

No one in government would argue that premise. How effective the space program is in creating and upgrading jobs and in reducing the hidden tax of inflation is the question.

Productivity reduces inflation

Economists don't often agree. But they are unanimous in believing that increased productivity constitutes a potent long-term solution to inflation. The forces causing inflation are neutralized both by getting more out of each unit of labor and by expanding the supply of goods and services. Higher outlays for space research and development have been shown to result in lower rates of inflation.

An extensive study conducted last year by Chase Econometric Associates Inc., Bala Cynwyd, Pa., dramatically demonstrates the role of space technology in reducing inflation. Employing sophisticated models of the spreading effect of several hundred industrial projects, Chase found that high-technology endeavors, of which the space program is clearly the largest, result in significant rates of social return out of all proportion to their cost.

The study showed that a $1-billion annual increase in space research and development programs, if begun this year, would have the following results 10 years hence:

1. The gross national product, at bare minimum, would be $23-billion higher by 1985 (in today's dollars). That is an annual return on investment over the 10-year period of more than 40%.

2. The 1985 inflation rate would fall by a full 2%.

3. The unemployment rate would be reduced by some 400,000 jobs. In addition, the size of the labor force would rise by 1.1-million new jobs. (The difference is caused by the increase in demand reducing the amount of hidden unemployment as more workers join the labor force.)

The reason the Chase model projects the space payoff so high is that the research investment spreads to other industries as well. Achieving higher industrial output and lower inflation is inevitable, according to Chase, due to the growth of labor productivity.

Productivity growth means that less labor is needed per unit of output. As less labor is required, costs decline. As costs decline, prices decrease and consumers' real income rises, which then leads to greater purchases of goods and services and improved mass production which lowers unit costs still further. The size of the labor force then can increase through greater job opportunities spread across many industries, old and new.

These economic spinoffs don't occur immediately, however. They begin to become significant after about five years. Our growth in output per man hour actually has fallen behind that of other industrial nations due to a slowdown in the last 25 years of U.S. investment in new technology. A revitalized space investment is part of a larger emphasis on industrial growth that must be made if the U.S. is to retain its narrowing technological leadership.

Space-spawned industries

Some 30,000 people in 47 states will be at work on the space shuttle by June—in addition to those employed directly by NASA. The number is expected to increase to a maximum of 50,000 sometime next year.

Yet direct jobs are only a small part of the job-making and inflation-reducing payoff of space research. Spending on space must be distinguished from investing in space. A society can spend on pyramids just to make jobs. But investing in space creates whole new industries.

The computer business is probably the greatest non-aerospace spinoff of space technology. Every major computer system in the world is made in America, but without the forcing function of NASA's stringent requirements, these computers would not be available today. U.S. exports of computers increased 1400% in the first decade of the space age.

Industry officials forecast a million computers operating by 1980, versus a current population of 175,000. That's a growth rate of 40% a year—about twice that of the past decade. Even more important, the growth of computers magnifies increased productivity throughout the world in all industries that use computers—and that means virtually all industries.

There are other space-related industries too. High space standards advanced the state of vacuum technology so far that processing of high-purity materials, coatings, and especially semiconductors now is done routinely in vacuum. The cryogenics, or ultralow-temperature, industry erupted as a direct result of liquid gases needed for rocket propulsion and life support in space. Today hospitals and steel mills are among dozens of beneficiaries throughout the nation that routinely store and use liquid oxygen, nitrogen, helium, and other frozen gases.

Even the pipeline business has benefited from new aerospace technology, combining two techniques in a novel way. One is the space method of winding glass thread to make lightweight, strong rocket casings. The method has been applied to manufacturing lighter-weight pipe, making it possible to utilize the emerging technology of laying entire pipelines by helicopter, especially in remote areas.

Last year, economists at Mathematica Inc., Princeton, N.J., isolated four mature examples of spinoffs and estimated their return to the economy. Benefits from these four areas were projected conservatively to add up to $7-billion by the early 1980s. These are not models, but actual thriving industries spun off from the space program:

1. *Integrated circuits.* Developed for satellites, communications, and other space uses, and now used in TV sets, automobiles, and hundreds of industrial and household products, the improved technology will return an estimated $5,090,000,000 from 1963 to 1982.

2. *Gas turbines.* Initially developed for jet-engine aircraft, but widely spun off to electric-power generation plants, these turbines will effect fuel-cost savings of an estimated $111,000,000 between 1969 and 1982.

3. *A structural-analysis computer program.* Developed originally to help design more efficient space vehicles, the NASA program today is used to design railroad tracks and cars, automobiles, bridges, skyscrapers, and many other structures. It is expected to return $701,000,000 in cost savings from 1971 to 1984. Use of the program yields about a 60% improvement in predicting the behavior of stressed parts and a two-thirds cut in calculation time.

4. *Insulation for cryogenic uses* (explained above). The probable estimate of benefits is $1,054,000,000 between 1960 and 1983.

While these industries were deliberately selected because they are large and because NASA's involvement was significant, remember that their $7-billion return represents *just four examples* of spinoff.

Of course it takes time for new developments to mature into new or expanded industries. Increases in industrial productivity that affect your job begin with isolated bits of technology. Some of these new space spinoffs that may have that potential are described next.

Management by computer

Management techniques, basic to a nation's productivity, have been significantly advanced in the U.S. by the space input. Computer-based management systems borrowed from the space program help us plan and control thousands of actions required in complex industrial projects.

It is doubtful whether the mammoth nine-year man-to-moon project could have been coordinated effectively without the program evaluation and review technique. Originally devised by the Navy to facilitate construction of the Polaris submarine, the technique, as modified by NASA and offered to industry as a computer program, now is applicable to all kinds of large construction and other projects requiring complex scheduling. Before usage of the program became widespread in industry, scheduling could be agonizing.

"It's like childbirth! That's the best way I can describe what we go through to create project networks for proposals and programs," according to one contractor. Another: "I don't know which is worse—reproducing acres of network diagrams for everybody's mutual bewilderment, or spending countless hours specifying special diagrams for the draftsmen to draw up."

But then a company in California combined the NASA computer program with another to generate graphic output automatically. The result: no more pains of childbirth! The output provides automatic, precise, easy-to-read networks. Management can use the method to depict costs, manpower needs, and other information. It is an accurate and fast way of scheduling modifications in nationwide branch offices, modeling accounts receivable, and of planning other corporate activities.

One of the most complex computer systems in the world is the automatic checkout equipment devised for the manned missions to the moon. It was built to integrate the extensive Apollo spacecraft procedures from manufacture to launch.

The system has been spun off to retail-store and bank transaction systems, as well as to control electric power transmission grids, thereby reducing the likelihood of power blackouts. Those automatic machines you see in banks today that spit out money when you insert your credit card are examples of the spinoff. So are the computerized machines in car rental agencies and airline ticket offices.

Better paint for bridges

An improved zinc-rich coating that protects against salt spray was devised by space researchers and then found to be an ideal paint for bridges. Tests on the Golden Gate are under way this year to determine the life of the paint on coastal bridges where salt corrosion is a major problem.

When you add up all the bridges over salt water, offshore drilling rigs, ships, utility pipelines, and other candidates for the improved corrosion-resistant paint, you have a huge, $2-billion, annual market.

Another example of increased productivity through space spinoff is a process for manufacturing metallic filters from spun fibers used in rockets. Today the filters are used in chemical processing, making photographic films, and in underwater filtering on offshore drilling rigs.

NASA's need for reliable ultrasonic devices to inspect welds on rocket casings has been spun off into a variety of devices. One is a group of unique rail cars that drive slowly over some 160,000 miles of track in the U.S., Australia, Europe, and Mexico checking old track welds for deterioration. The cars find improper welds not readily seen in X-rays, and save countless hours in the search.

The "clean rooms" devised for handling semiconductor and other miniature assemblies also have been spun off from the space program to the food-processing industry. Marked savings in previously rejected packaged foods have resulted.

Bigger plows and faster mail

You may have noticed that farmers pull bigger plows today. The reason is both because their tractors are more powerful and because their plows and other implements don't break as easily when hitting rocks in the field.

NASA fracture-toughness tests originally devised to check spacecraft structures helped bring about these improvements. Electric utilities and nuclear pressure-vessel manufacturers also use these tests now to inspect for flaws in an attempt to avoid devastating brittle fractures.

Even the Post Office is automating its parcel-sorting equipment as a result of a space spinoff. Techniques worked out for the automatic checkout and launching of spacecraft now help make it possible for a postal worker to key zip codes into a computer. The computer then controls the discharge of the parcels at very high speed. So far, the computers are at work in post offices in California, Illinois, New York, and North Carolina.

your health

NASA's role in major areas of human concern is nowhere more evident than in its myriad contributions to health. Space medicine together with innovations in remote acquisition, monitoring, and interpretation of physiological processes during flight have generated technology for improving both the quality and quantity of health care.

The problem even in this advanced country is staggering. Seven of 10 Americans visit their physicians at least once a year; one of 10 is hospitalized. The cost of the country's health services is some $83-billion, roughly 7.6% of the nation's gross national product.

Pacemakers that can be charged

Probably the best-known space spinoff to your health is the cardiac pacemaker, an outgrowth of miniaturized solid-state circuitry developed for spacecraft. When the natural heartbeat becomes irregular because of heart disease, the electronic pacemaker delivers small, regular electric shocks to pace the heart. About 30,000 pacemakers are implanted each year in the United States and a like amount in the rest of the world.

Until recently, pacemakers lasted only about 22 months, after which time their battery power is depleted, necessitating surgery to remove and implant a new device. Repeated surgery can be traumatic. It's also expensive, typically costing more than $2,000 for each operation.

A new pacemaker developed by industrial researchers with an assist from NASA is rechargeable through the skin by inductance. Once a week the patient simply puts on a charger vest for an hour to recharge his pacemaker. Since recharging can be done frequently, only one cell is required and the size of the pacemaker has been reduced to half the thickness. Now they weigh only 2 oz.

Another advantage of the new device is that it is immune to electrical interference such as microwave ovens or automobile ignitions that sometimes stop conventional pacemakers. The development is evolving. Current research is aimed at further reducing the size and increasing its reliability.

But even better pacemakers can not prevent cardiovascular disease, the number-one killer in the U.S. that accounts for more than a million deaths a year. Many of these deaths could be prevented if firemen and other rescue workers had better training and better technology that, in effect, would deliver the facilities of a hospital to the scene of the heart attack.

NASA now has spun off its Skylab telemetry to a "Telecare" emergency system. Telecare contains in one package all the instruments that a doctor or paramedic could reasonably want in a cardiopulmonary emergency. It contains a respiratory resuscitation system, a 15-minute oxygen supply derived from a chlorate candle that *releases* oxygen when burned (also a space development), an electrocardiogram display and telemetry system, a defibrillator for external heart stimulation, and a blood-pressure measuring system similar to that developed for Skylab that works even when there is high background noise.

Telecare units now are being used in ambulances in Houston, Cleveland, and other cities, as well as in a demonstration remote-care program in the 4,300-square mile Papago reservation in southwest Arizona where 10,000 Indians live.

The cardio-emergency alert

Telecare also is an important ingredient in a new NASA-assisted cardio-alert program in Cleveland. Here, firemen trained as paramedics telemeter a heart-attack victim's data to the Fairview General Hospital's Kemper coronary unit. Listen:

PM: (paramedic): *Kemper, This is Squad Two . . . We're at the victim's side. A 62-year old woman. We have no respirations yet.*

KU (Kemper coronary unit): *Did you institute CPR?*

PM: *Yes. We're starting right now.* (CPR is cardiopulmonary resuscitation, or artificial breathing and blood circulation.)

KU: *Is there a pulse?*

PM: *Negative.*

KU: *Continue CPR. Do you think someone can start an IV of 5% dextrose and water?*

PM: *Five percent. Okay.* (An IV, or intravenous infusion, must be set up as fast as possible. If the heart isn't pumping blood to fill the veins, they'll collapse, making it difficult to medicate the patient.)

KU: *Are you hooking the patient up to the monitor?*

PM: *We're beginning.*

KU: Is she responding at all?

PM: Wait a moment..No. No pulse.

KU: *Try a precordial thump* (a blow to the chest). *How long has she been unresponsive? Can you hook her up to the monitor yet?*

Within one minute, the paramedics begin transmitting the electrocardiogram, which is printed out and taped at the hospital. In the scene described, adapted from the Fairview General Hospital publication, the paramedic-trained firemen shock the heart electrically into a more normal pattern. They also administer drugs, have the hospital notify the patient's doctor and retrieve her records, and of course rush her to the hospital.

She lives. So do almost all such victims in the area of the cardio-alert. The Cleveland program, in which 21 firemen have graduated as paramedics, is a pilot project that may be extended to communities elsewhere.

Electrodes for cardiograms

Another cardiac spinoff derives from biomedical electrodes that transmit electrical signals from astronauts' bodies. At the onset of manned spaceflight, it was discovered that existing electrodes were not acceptable since they must be comfortable over great lengths of time and extremely sensitive to pick up the heart's weak electrical signals. Since then, biomedical electrodes have been under intensive development all during the space program. They are used in electrocardiogram and other hospital instrumentation throughout the country, especially with patients requiring constant and long-term care.

NASA's developments of spacecraft transducers, or devices used to convert energy from one form to another, now have been transferred to detect arteriosclerosis, or hardening of the arteries. The usual test involves inserting a hollow needle into an artery and directly measuring the arterial pulse. It's time-consuming and painful.

The space spinoff determines the flexibility of arteries externally. The device uses a pressure-sensitive transistor that converts arterial pulses into electrical signals. When amplified they can be recorded on a standard electrocardiograph.

Sound waves instead of X-rays

A portable "echo-cardioscope" has been adapted for man on earth from monitoring heart functions of astronauts. It too replaces the need for inserting tubes in blood vessels (through which X-ray motion pictures are taken). The echo device forms images of internal organs using high-frequency sound—in somewhat the same way that underwater objects are detected from submarines using sonar.

Other ultrasonic imaging equipment also has been transferred from space use to avoid reliance on potentially harmful X-rays. A new system is capable of resolving body-tissue images that are comparable with the quality of those from X-rays. The first clinical trials are underway this year in detecting breast cancers.

But until ultrasonics replaces X-rays for that purpose, still another space development is helping physicians reduce the quantity of X-ray exposures. Typically, doctors take more than one picture to expose an X-ray film properly. Now, solar cells that convert sunlight to electricity on space satellites can make a single exposure suffice.

Since solar cells are sensitive to X-rays as well as light, a sensor made from such a cell is placed directly beneath the X-ray film and determines exactly when the film is exposed to optimum density. Not only was the X-ray hazard reduced significantly in a trial project at a Pasadena hospital, but the number of patient examinations was doubled. The sensors are expecially useful in breast radiography. Since the breast is transparent to X-rays, very low-energy X-rays must be used, requiring exacting exposures.

Space research has been transferred to cancer therapy too. White blood cells and bone marrow—often destroyed along with cancerous cells in leukemia treatment—now can be stored for future use, just as blood plasma is kept in blood banks.

Previous attempts to freeze disease-fighting blood cells and bone marrow either destroyed the cells by rupture when cooled too fast or by dehydration when too slow. A special circuit developed for precise temperature control of scientific instruments aboard the Mars-bound Vikings has been adapted to a new freezing unit using liquid nitrogen. An evaluation unit, which can freeze white blood cells in an hour, was delivered last year to the National Cancer Institute.

Remember the suits the lunar astronauts wore between splash down and their quarantine on the recovery ship? Designed to protect the environment from unknown microorganisms, similar suits now protect immune-deficient children and patients suffering from leukemia, burns, or other maladies where infection can kill. The suits make it possible for such patients to leave their isolation rooms for up to several hours.

Medicine by Mars probe

A whole new line of medical instruments that measures the ventilation of the lungs to help treat diseases such as emphysema has been spun off from an analyzer that detects the composition of the atmosphere from satellites.

This year, a modification of the device allows a single nurse to monitor up to 15 patients by watching a television screen. A "spinback" of the instrument will help determine whether life is present on Mars if the Vikings land successfully.

The Viking mission has contributed to the mundane problem of decontaminating hospital oxygen systems in another development. The unlikely relationship goes like this: technology developed to sterilize the Vikings utilizes a dry-heat technique ideal for sterilizing ventilators and other oxygen equipment.

The apparatus typically is contaminated from previous patient use. Chemical disinfectants remove most of the microorganisms. But the few that are left multiply rapidly in the humid oxygen. A NASA laboratory helped re-design one manufacturer's equipment using space-type plastics and new methods of sealing compartments.

The food protectors

American health also is safeguarded by food-protection techniques transferred from the space program. For instance, "clean rooms," the sealed, slightly pressurized chambers originally used in the electronics industry to eliminate dust from tiny space components, now are being utilized by food processors.

NASA's experience in producing spacecraft food even has been adapted to meal packages that don't require refrigeration. The packaged food is meant for handicapped and elderly live-alones who often suffer from malnutrition.

And a frozen-food indicator will warn grocers if those frozen mushrooms just arrived have ever been thawed and refrozen. The unique tag turns bright red if the food, with which it is packaged, is ever defrosted.

It was discovered in the development of a battery system for operation in balloons at high-altitude temperature extremes. Almost by accident, frozen salt crystals used in the battery were found to turn red on thawing and stay that way even if refrozen. The crystals also can be frozen with blood plasma or other medical supplies to warn against inadvertent thawing during transport.

Weighing babies in incubators

In other new developments, premature babies can be weighed inside their incubators as a result of a NASA-sponsored summer institute in biomedical engineering. A weight-alleviation device, enabling a stroke or other paralysis victim to re-learn muscular coordination, is being adapted from the suspension device that helped astronauts simulate the one-sixth gravity of the moon before the Apollo landings. Techniques developed for space telemetry have evolved into a complete motion-analysis laboratory in California to analyze the walking patterns of crippled children. An electro-optical instrument developed originally to measure the visual performance of pilots has been spun off to test your vision and print out the proper prescription for glasses automatically. And a "feeling meter" initially invented to determine whether prolonged weightlessness in space could cause neurological damage now helps neurologists assess sensory perception.

your mobility

Your mobility has grown dramatically over the years. Distance in 1976, means little to Americans who annually fly more than 100-billion passenger miles and drive an average of 10,000 miles a year. To increase that mobility, highways and streets have been added at the rate of 200 miles a day during the past two decades.

But freedom of mobility has been costly in accidental deaths and injuries, particularly from automobile traffic. Some 45,000 fatalities and 4.8-million injuries occur each year. The economic loss due to highway accidents is approximately $19-billion.

NASA, in a sense, is primarily in the transportation field through its development of advanced aircraft and spacecraft. Much of its work in surmounting technological difficulties, though, is applicable to highway and railway traffic as well as to aircraft.

Auto traffic safety and efficiency

For instance, the Apollo programs to analyze trajectories and landing locations on the moon have contributed to the nation's first fully computerized automobile traffic-control system. The prototype system, uniquely named SAFER, for Systematic Aid to Flow on Existing Roadways, has been installed by an aerospace company in a nine-square-mile area in Los Angeles county, where it controls about 200,000 vehicles daily at 112 intersections.

In operation, information on existing traffic conditions is collected and fed to a computer, which then calculates the best traffic-light sequence to match the traffic flow. Motorists creeping ahead in rush-hour traffic find the system relieves congestion far better than the usual predetermined red-green light pattern. During tests, mobility was improved 15%, saving motorists a considerable amount in gas consumption and auto maintenance due to engine idling. Of course it also reduces auto-exhaust pollution for the same reason. These systems now are being installed in Baltimore, Md., and Overland Park, Kan., and are planned for other cities.

A different way to increase automotive efficiency—and save considerable amounts of fuel in the process—is to eliminate air friction on cars and, especially, on square-shaped trucks. Streamlining trucks obviously would improve their aerodynamics, but truck lines need "cubic" vehicles so they can be packed with square boxes.

NASA engineers have found that air-drag reductions of 24% can be achieved simply by adding wind deflectors at the top of the truck between cab and trailer. In tests, the method has saved about 10% of fuel consumed.

On automobiles, adding a plate extending a few inches below the front bumper and a small spoiler on the back of the trunk results in about a 5% fuel savings.

Safer winter tires are another automotive transfer from space. If all goes as planned, the one-ton Viking lander will parachute to Mars this summer supported by just three straps of a remarkable new fiber. The fiber, five times stronger than steel, now is being used as the cords in the new tires.

The rubber of these tires, which do not use highway-destroying studs, is the same as that used on the tires of the "Rickshaw" used by astronauts Alan Shepard and Stuart Roosa to transport equipment on the lunar surface. Conventional tires lose their pliability below freezing. The new ones provide traction even in the coldest weather. After all, they remained pliable on the moon in temperatures as low as 195 degrees below zero!

Smoother riding on highways and railways soon may occur through adaptations of gyro-stabilized spacecraft guidance systems. A new instrument is being devised to measure bumps, curves, and grades. Highways and railways thus can be shaped more precisely for better and safer riding, as well as making them easier to maintain.

Other new automobile improvements from space include better brakes lined with a new high-temperature space material; hybrid circuitry for more accurate digital clocks and radios that use 20% less electricity; and truly bright searchlights and flashlights for emergency use. The intense searchlight, which can operate from the cigaret-lighter receptacle of your car, was spun off from the xenon arc lights developed for the space program to simulate the sun. The million candlepower searchlight is about 50 times brighter than your car's high-beam headlights, yet weighs only 7 lbs. A smaller unit in the shape of a flashlight produces 20,000 candlepower, or about nine times as much light as an ordinary two-cell flashlight.

Safer driving (and airplane landings) are resulting from aircraft runway research. NASA has conducted an extensive testing program on cutting grooves in runways to eliminate airplane skidding during rainy weather. Now sawed into highways, the grooves reduce tire hydroplaning, a phenomenon created by a thin layer of water on highways that causes tires to slip. New uses studied by NASA include pedestrian walks, playgrounds, sanitary concrete slabs in cattle ranches and dairy farms, loading docks, ramps, warehouse floors—anywhere that men, animals, or machines can slip on wet surfaces.

Driver aid to the handicapped

The lunar rover driven by Apollo astronauts on the moon also suggested a spinoff to enable severely handicapped people to drive an automobile. A quadriplegic impressed by the lunar rover's almost automatic controls was invited to try to drive the rover at Johnson Space Center. He did. He started, stopped, turned, backed, and even parked.

Thereafter, NASA and the Veterans Administration's Prosthetics Center began a long-range program to develop lunar rover-type controls for handicapped drivers.

Out of this work a design concept emerged that would integrate the control device of the lunar rover into a passenger vehicle. Field testing is proceeding now to determine whether the severely handicapped can drive such vehicles in traffic.

Mass—and individual—transit

Your mobility also may be extended through a variety of rapid-transit systems being explored now by aerospace companies seeking to utilize space-earned knowledge. Aerospace technologies in flight safety, reliability, and complex control designs are being adapted to mass-transportation systems. NASA contractors have built two high-speed gas-turbine powered trains for service between New York and Boston, and are designing a transit system for Columbia, Md., a "planned city."

A NASA program to develop a series of small, driverless electric vehicles is underway in Pasadena. Proximity sensors, optical filtering, and other space-developed methods are incorporated into a six-passenger experimental tram that automatically follows a thread-like cable on the roadway surface. The tram isn't supposed to replace urban rail or bus service, but rather will support these systems by providing inexpensive short-run feeder service to conventional stations.

The low-speed tram is started and stopped at will by the passengers themselves. Proximity sensors halt the car when anything comes in its path. It is steered by automatic circuits and a hydraulic servo system.

The first 'A' in NASA

In aircraft developments, NASA is providing the technical leadership for short-takeoff-and-landing aircraft, which ultimately offers a solution to the 300% growth in intercity air traffic expected 10 years hence. NASA's $100-million program, begun in 1971, will provide the technical base to build practical short-takeoff airplanes. Small airports then could be shoehorned into cities and surrounding suburbs, thereby making existing jet terminals adequate for some time to come.

Advanced airplane engines of the 1980s will utilize a significant breakthrough in ball-bearings designed by NASA. They will last 20 times longer than the highest-quality bearings now in use. Airplane-fuel consumption can be lowered at least 20% through the use of hydrogen-enrichment methods now under study at several NASA facilities. The research aims at improving general-aviation engines both to save fuel and reduce emissions. And helicopters will require less maintenance as a result of space-transferred high-speed carbon seals that last four times longer than conventional seals.

Internal navigation systems used by Apollo spacecraft have been spun off for commercial aircraft early in the space age. In more than 12-million hours in flight, the systems have proved to be 99.5% accurate. Today these navigation systems are flown in about 500 commercial aircraft. They are invulnerable to weather and are not dependent on radio, radar, or celestial navigation.

Rescue at sea

While all of these advances improve your mobility when you *plan* to go somewhere, one of the early successes of transferring space technology was the development of a life raft. The original life raft, utilizing a radar-reflective material, was designed by NASA in 1959 to assure that astronauts could be found if their returning spacecrafts were off course.

After reading about the radar-reflective idea in a 1964 *NASA Tech Brief*, several companies attempted to design a commercial version. But it wasn't until a scientist named Robert Perchard acquired an exclusive license from NASA and developed an improved raft that it entered widespread use. Perchard had a personal reason. His son, a Coast Guard pilot, had crashed in Alaskan seas. Conventional radar searching had failed to locate his life raft until he had died of exposure.

Perchard's new design incorporated a radar-reflective canopy colored speckled orange for easier sighting. He made dozens of other improvements too, in both rafts and life preservers. A man floating with a life preserver utilizing the radar-reflective material can be sighted from an altitude of 6,000 feet. Today the rafts and life preservers are carried by the world's navies, merchant marines, and pleasure aircraft and boats.

Last year, an airplane manufacturer began another phase in the evolution of this spinoff, the development of a life raft that can be deployed quickly from a downed helicopter. Most ditched helicopters sink immediately, rolling inverted, with water rushing in through cockpit windows.

The evolution of the radar-reflective life raft is repeated in kind with most spinoffs. Technology often progresses by the centimeter. But it never ends.

your home

Your home is a prime beneficiary of space technology. New building materials, better use of existing fuels as well as solar energy, fire-prevention techniques and tools, and a variety of household products all have been spun off from our national investment in space.

Builders and manufacturers of homes and housing equipment constantly strive for new methods and materials to survive in the highly competitive marketplace. Probably the most significant opportunity for change in houses over the next few decades will be in energy management. Our homes consume about 20% of the energy used in the United States each year—an amount almost equal to all imported crude oil.

Why not *show* builders, manufacturers, and homeowners how space spinoffs relate to home improvements? A dramatic way to do that would be to construct an actual house utilizing as many of the new developments as possible.

Planning for such a house has been under way for some time, and NASA will build a demonstration house during this bicentennial year at its Langley Research Center near Hampton, Va.

Now: the 'Tech House'

The demonstration house is called TECH, standing for The Energy Conservation House. Unlike past "houses of tomorrow," Tech House emphasizes cost effectiveness. It is not only a compilation of space spinoffs. Rather, Tech House integrates technical developments expected to be commercially available by 1981.

The 1,500-sq-ft building contains a living room, kitchen-dining room, three bedrooms, two bathrooms, laundry, garage, and an outdoor living area. Tech House will be tested by being occupied by a family for at least a year. Afterwards, it will be opened to the public.

NASA established some stringent criteria for inclusion of new developments in the house. For instance, initial costs of improvements must be repayable to a buyer through energy or other savings effected by the improvements themselves over the life of an assumed 20-year mortgage.

Tech House maximizes energy savings. Heating is provided by solar collectors and a nighttime radiator system using a heat pump. The house even partially reclaims waste water. Wall, roof, floor, and window sections, as well as home appliances, were studied to determine which components provide the greatest net savings.

Many of the energy-reduction advantages of Tech House are made simply through good design. For instance, the long axis of the rectangular house is oriented east-west with large south-facing glass areas. The garage is positioned to protect the house from the north wind. Two interior fireplaces, added for aesthetic reasons, are provided with glass doors to reduce heat loss through chimney flues. Doors between sleeping and living areas furnish better zone-temperature control.

Even the landscaping is designed in accordance with a new concept called "solarchitecture" that contributes to the house's energy conservation.

While good design can go far in making improvements, space spinoffs are the essence of Tech House. Space materials are being used as part of "thermal shutters" to reduce heat loss through windows. Space-developed fire-retardant materials for curtains and carpets also are used, as are superinsulation, solid-state appliance controls, and low-noise flow valves for air-supply ducts. An integrated burglar-alarm system is independent of the house's electrical system.

Wires, flat and thin

NASA's flat electrical wire originally designed for spacecraft also is being incorporated into Tech House through special baseboards. Both baseboard flat wires for homes and under-the-carpet wires for offices now are being tested.

Substantial savings are expected to result because of reduced installation time.

Another housing development to which space technology has contributed is the unique geodesic dome originally designed by noted architect R. Buckminister Fuller. NASA supplied a grant to Fuller and his co-workers to develop the domes into future space structures. Today, larger geodesic domes are enclosing living areas, swimming pools, tennis courts, greenhouses, and commercial work areas. Nine of these structures can be seen at the Kennedy Space Center where they are to house the U.S. Bicentennial Science & Technology Exposition.

Some of the wall panels made for prefab houses also are a space spinoff. They resulted from high-performance plastics developed for rocket casings and liquid-hydrogen containers, and now save more than 15% in the cost of conventional prefab panels.

Better firefighting equipment

Should your home ever burn, firemen might use axes to provide ventilation. But axes are slow. Now small amounts of a special explosive can literally cut a hole instead of blasting a part of the structure apart as with ordinary explosives. The unique cutting charge was derived from the explosive used to separate stages of the Gemini launch vehicle.

Firemen now are being equipped with lightweight air tanks pressurized about twice as high as previous tanks. The new tanks, harnesses, regulators, and face masks with a wider field of view all were based on spacesuit technology. Firefighters also will have better short-range radios based on a NASA patent for weather-balloon communications.

Safer natural gas and solar heat

Not only building materials, but better fuel-handling, less waste, and new sources of power, are being derived from space practices. For instance, after the 1973 disaster on Staten Island that killed 40 workers repairing a liquid natural-gas storage tank, New York City requested NASA's help. The space agency has been at the forefront of handling liquid gases used as rocket fuels. NASA engineers have completed a prototype risk-management technique for use by the New York Fire Department in reviewing construction of liquefied natural gas tanks and equipment.

When gas or other fuel is burned in homes, much of it often is wasted through insufficient insulation. Such waste has been discovered selectively—and homeowners in several communities invited to see the results—by use of an aerial survey technique developed with NASA support. A thermal infrared scanner was flown over rooftops in Nebraska and South Dakota last year by a midwestern utility company. Temperatures of the roofs of buildings were recorded as "thermograms," in which warm roofs appear in light tones and cool roofs in dark ones.

Even the waste heat escaping through chimneys can be reclaimed. Heat-pipe technology devised for cooling electronic systems aboard spacecraft has been transferred to commercial equipment. The heat pipes extend into a chimney flue and redirect the otherwise wasted heat back into the building. Manufacturers of these highly efficient heat-transfer devices have found they increase heating efficiency in homes by about 10%.

NASA also is experimenting with solar collectors for heating homes. About half of the total heat demand of several multi-dwelling homes in Greenbelt, Md., is expected to be furnished by solar collectors installed this year on their roofs.

Private homeowners also have adapted NASA solar technology for their own use. One installed a corrugated thermal absorber he read about in a NASA publication to heat his swimming pool, estimating a utility savings of $400 annually.

A NASA scientist has determined that "black chrome," once used for plating cameras and decorating objects, is about 20% more efficient than commercially available coatings for solar collectors. While today's coatings make it possible for collectors to heat water to about 200 degrees, black chrome can raise it to well above the boiling point. The higher heat makes air conditioners significantly more efficient.

Products for your home

In addition to new building materials and fire-safety techniques, space research has contributed to the development of many products used in your home. For instance, the life of electric-motor brushes in vacuum cleaners, electric shavers, cameras, and many other products has been extended substantially with new space lubricants. These thin-fluid or dry lubricants were developed first for bearings and motors that had to work in the vacuum of space aboard orbiting satellite observatories.

Quartz-crystal clocks and watches that have an accuracy of a minute a year also came from space technology. They were developed for the Apollo moon missions, in which accurate timing was critical.

And, for the home hobbyist, a small 7-lb welding torch has been spun off from the space-developed chlorate candles that uniquely generate oxygen while burning.

your environment

The population and technological explosions that have occurred so drastically since the nation began 200 years ago have modified your environment in the extreme. You live mostly in a world of metal and concrete instead of forests and streams. Made to go five miles an hour, you go five hundred. Built to eat when hungry, now you're governed by the clock.

Of themselves, these changes are neither bad nor good. It is what we make of them, how successful we are in adapting our environment to our goals—and in adapting ourselves to our environment—that we create better or worse conditions for human life. The realization that our environment is threatened, that our natural resources are finite need not be cause for despair. Conversely, they teach us an appreciation of human ecology, the interdependence between man and his surroundings.

Spinoffs from space technology are helping to improve that ecology. They locate and protect our natural resources, warn of storms and fires, detect and improve the quality of the air and water, and even contribute to our recreational pursuits.

The water and food watch

Among the myriad purposes of our Landsats, or land-surveying satellites for locating earth resources, is the monitoring of fresh-water supplies. Hydrologists analyzing Landsat data have found that man currently extracts fresh water from only about a hundredth of one per cent of the total global supply.

Satellites are promoting better utilization by observing large areas on a repetitive basis. For example, satellite pictures of snow accumulation and possible locations of subsurface water supplies in relation to cities, irrigated areas, and industrial developments make future planning more accurate and economical.

There is 20 times as much underground water in the United States as in lakes and rivers. Florida alone has more subterranean fresh water than exists in the Great Lakes!

Satellite water-volume measurements in Florida now calculate how much water is present in previously unmeasurable places such as swamps, and help decide whether to release water from one area to another. The satellites measure rainfall over remote areas. They determine the size and number of thousands of temporary small lakes in the southwest U.S. They immediately spot new water bodies, such as Lake Anna Reservoir in Virginia. They accurately map wetlands and drainage patterns in inland states. Even glacier ice—containing nearly 80% of the world's fresh water—is monitored by satellites for possible future use.

Crop identification now is performed routinely by satellite, utilizing NASA's computer-processing capabilities to make much more accurate forecasts of harvests. Precise estimates become more and more vital as the world's food demand rises.

By necessity, the satellite food watch also becomes a watch for the conditions in which destructive insects breed. Among the most damaging of agricultural insects is the screwworm. A satellite-sensing mission now is underway to eradicate screwworms in Mexico, as has been largely done in this country.

The screwworm is a grub that destroys cattle, poultry, and wildlife in warm regions. Eggs laid in open sores and navels of new-born animals hatch and grow to a length of a half-inch by eating living flesh.

At one time screwworms infested the U.S. from Florida to California and as far north as Nebraska. They have been kept in check in the last two decades by dropping billions of sterile flies to mate with females in the infested regions, thereby eliminating offspring. A 300-mile buffer zone along the Mexican border has helped protect the U.S.—although a reinfestation in parts of Texas in 1972 caused $10-million damage to livestock.

The two-country cooperative effort began last year in a 50- by 100-mile area in central Mexico. It is the forerunner of a much larger program to eradicate the insect throughout all Mexico, maintaining a new buffer zone across the narrow isthmus near the Mexican-Guatemalan border.

Without satellites, 260 additional weather communications links would have to be constructed to yield accurate environmental data. Continuous, detailed reports on soil temperature, moisture, and vegetation coverage are required to determine the insect's breeding patterns so sterile male flies can be distributed effectively.

Similar technology may help extend the sterile-fly technique to other insects, such as the tsetse fly in Africa. The disease-carrying tsetse is so great a danger that thousands of square miles of Africa today are unfit for human or animal habitation.

Forest fires and floods

Among the most dramatic applications of space technology to your environment is the improved ability to detect possible disasters such as forest fires, tornados, and floods. Forest rangers say that knowing where fires may occur and how they might act is almost as important as quenching them.

NASA sensors originally developed to detect fires on airplanes and spacecraft have been teamed with a satellite relay station and computers to provide a fire-index monitor for forests. The sensors check air temperature, relative humidity, and the flammability of forest-floor litter, in an experimental program in California.

The measurements are converted and beamed to satellites to avoid interference by mountains. There they are coordinated with area-wide photographs. The combined data then are beamed to a NASA facility in northern California where they are processed by computer and sent to the forest ranger stations.

The data measurements are consistent and accurate—so much so they are being used now by the weather service in Sacramento for long-range regional forecasts. Data now are collected throughout the year instead of just during the "fire season," which improves forecasting. Integration of a fully automatic data-processing system now underway will serve as a prototype for a network of 23 automatic unmanned remote stations scheduled for mid-1977.

Another kind of space technology has been in use for more than a year by the U.S. Forest Service to help with its huge job of surveying our vast forest resources. It is a "pole of light" that enables surveyors to take a bearing on a point they can't see.

The surveying tool, a spinoff of laser technology developed for space communications, is carried into the woods and erected over an otherwise-unseen marker. It sends a narrow beam of light vertically into the sky. The beam thus literally becomes a pole of light that can be used as a target for one or more receivers placed at great distances from the laser. The technique eliminates the need for machetes or bulldozers to carve a straight sighting path through jungles or forests.

The weather watchers

Forest protection is a vital but small part of the earth-watch by satellite and other space technologies. A larger part of it is weather forecasting. The 36-hour predictions of today are as accurate as the 12-hour forecasts issued 10 years ago—correct 82% of the time.

Even better forecasts should ensue as a result of the three meteorological satellites now in fixed orbits 22,300 miles above the equator. Number one in the series, launched in 1974, provided the first almost-continuous day-night coverage of a major hurricane and later was moved in time to observe last spring's tornado season in the midwestern and eastern U.S. The last of the three satellites was launched last fall.

NASA is working not only to observe and investigate tornado phenomena, but also to develop tornado-resistant building designs. Similarly, the space agency's computer technology and satellite pictures are mapping areas flooded by the Mississippi River, helping states assess damage and plan disaster relief.

After the 1973 Mississippi flood, which resulted in extensive damage and loss of life, Mississippi and Louisiana officials received special training by NASA in remote-image analysis. In coming years some 20,000 communities will need detailed surveys not only to control floods but to determine what insurance rates should be set for various flood areas. NASA is helping with the mammoth task, utilizing its technologies in surveying, hydraulic analysis, mapmaking, computer software, and digitization procedures.

Another vital resource—urban land—is no less a candidate for ecological study by space technology. Techniques developed for analyzing data from the moon and planets will help suggest better uses for specific areas of land later this year in Los Angeles and Tacoma, Wash. Experimental programs begun there incorporate maps, satellite photos, and other land data into routine city and county census records. Urban planners can query their data bases and display numerical values for each of their city's blocks and streets on a TV screen.

The system is being developed in such a way that it can be used in some 200 large U.S. cities that use computerized census files. These cities then will be able to make more intelligent rezoning and other urban-planning decisions.

The freon threat

Space techniques also contribute to controlling air pollution over cities and in the upper atmosphere. NASA recently developed an extremely sensitive spectrometer to determine whether gases released from aerosol spray cans are disrupting the earth's protective ozone layer. Flying the instrument at various levels in and above the atmosphere, scientists found hydrogen chloride—produced by the breakdown of aerosol gas molecules in the stratosphere—is distributed in a layer starting at nine miles and reaching a maximum concentration of almost one part per billion at about 12 miles.

The results don't necessarily implicate the use of freons, since hydrogen chloride is released naturally from the oceans and volcanoes. But the level is relatively high now and must be monitored to detect any future buildup.

Freon itself doesn't harm the ozone layer, but when it reaches an altitude of about 25 miles, the sun's ultraviolet rays trigger the release of chlorine from freon. The chlorine breaks down the ozone. Millions of tons of freon are produced annually, but it takes about 10 years for freon to drift up to the level where it dissociates. Thus measurements at all levels of the upper atmosphere are needed. The high-altitude research also is important in determining the pollution effect of supersonic jet airplanes flying in the stratosphere. Later this year the Orbiting Astronomical Observatory-3 will be used to add to the body of information gathered from aircraft and sounding rockets.

Similar instruments are being used by NASA to measure air pollutants emitted from airports, coal-fired power stations, city incinerators, and automobiles.

In one spinoff, a NASA instrument developed to detect effluent produced by solid-rocket fuel is being used to measure harmful gases released from burning waste oil in the Gulf of Mexico.

In another, computer programs devised to perform thermodynamic analyses of rocket combustion have been transferred to predict where oxides of nitrogen will be formed in municipal combustion chambers. For instance, the Los Angeles water and power department had spent $6.5-million constructing a new plant when a building permit was denied because of anticipated emissions of nitrogen oxides. Use of the NASA programs reduced the emissions sufficiently to comply with the new law. The additional pollution-control equipment will cost $2-million compared to the total plant cost of $68-million.

Not only are ideas and products being spun off. So is used equipment. One space contractor has adapted the facilities it built to test the lunar-module rocket engines into a facility for removing sulfur from coal economically. The company's plant south of Los Angeles includes test stands, fabrication shops, computerized monitoring equipment, and a complete chemical laboratory. A half-ton per hour pilot plant is being built there to treat the coal. It will occupy the lunar-module engine test stand.

But because high-sulfur coal will have to be burned for some time, NASA also is working to measure smoke-stack emissions. A program to detect sulfur-dioxide effluents at a distance is under way. Ultraviolet video tubes and telephoto lenses measure the otherwise-invisible emissions. The television technique was spun off from its first purpose—to identify hydrogen leakage and prevent fires in tanks where space rocket fuel is stored.

Cleaner sewage: accidental and otherwise

Accidental inventions, proof of theories, or interesting items of information often are found while looking for something else. Horace Walpole's fairytale about Ceylon, "The Three Princes of Serendip" (as Ceylon used to be called), whose heroes made such discoveries routinely, injected the word "serendipity" into our language. Serendippers, or finders of things unsought, also operate in the realm of space technology, at least once in awhile.

One significant example is the million-gallon-a-day sewage treatment process that originated when a NASA chemical engineer was testing materials in search of a lightweight rocket-engine insulator. He built a pyrolysis unit for manufacturing activated carbon. As a result, he later discovered that sewage solids made an excellent raw material that proved to be a good agent for further sewage treatment!

The work led to the construction of a new kind of sewage plant. Expected to begin operating later this year at Huntington Beach, south of Los Angeles, the plant converts solid sewage to activated carbon. The carbon then treats incoming wastewater.

This sewage plant—which incidentally is a large-scale pilot operation for even bigger ones to come—not only makes activated carbon out of the solids by high-temperature heating, but recycles the newly made carbon back with new sewage solids, where it is reactivated. A small amount of ash is all that remains at the end of the process. Contrast that to most municipal sewage plants in the U.S. today, which discharge about 40% of their solid wastes into the nation's rivers and offshore waters. The new NASA innovation is a solid breakthrough in more ways than one!

In another kind of water pollution, hot water discharged from power plants into rivers, lakes, and oceans often is suspected of increasing algae growth, which depletes dissolved oxygen in the water and kills fish. On the other hand, clean hot water from power plants has been shown to promote fish growth.

Obviously, better tracking of hot water streams, or "plumes," is needed to foster a better understanding of the effect of heated water on marine life and to decide where to locate future power plants.

NASA's work with sonar systems and advanced electronics to find space payloads landing in water will be spun off this year to tracking underwater thermal plumes. A miniature sonic transmitter will be modified to determine both temperature and depth. The device thus will become a wireless "bathythermograph," or instrument to measure the temperature of various water depths.

The unmodified sonar beacons also might be used to track wastes dumped in our oceans. For instance, garbage from nearly a *tenth of the U.S. population* now is barged and dumped in an area within about 25 miles of New York Harbor. Sludge is formed, but effluent from it drifts along the bottom, creating a potential health hazard. The NASA sonar beacons allowed to drift just above the seabed could monitor the direction and spread of the sludge to determine whether or where to allow future dumpings.

Predicting the 'red tide'

A space-assisted attempt to identify the onset of "red tide" also will get under way this year. The red tide consists of ocean-borne algae that leave tons of dead fish rotting on beaches. In Florida alone, a red-tide invasion has cost as much as $20-million in lost tourist business in a single season. The algae also concentrate a poison in shellfish.

NASA is working on an early-warning system that will include aircraft flying at various altitudes, on-site sampling of oceanic waters from research ships, and a scanner to be flown on the Nimbus-G pollution-sensing satellite scheduled for launch in 1978. The scanner is a spinoff from Apollo use where it enabled astronauts to determine prevalent chemicals in ocean landing areas. The space agency also is developing a submersible instrument to measure water clarity and an underwater meter to determine how daylight scatters in water—both as part of the warning system.

Environment for recreation

Your environment is—and should remain—of recreational quality. Space spinoffs not only are serving to improve and protect the land, air, and water, but have resulted directly in recreational devices. New products for outdoor sports, concerts, and even a cross between a movie and an amusement-park ride are among current items.

For instance, the aluminized plastic devised originally to keep cryogenic fluids cold now has spun off into extremely lightweight sportsman's blankets and jackets, sleeping bags, and ski parkas. Spacesuit technology has resulted in electrically heated gloves and skiboots that are rechargeable. Composite materials used in many space structures have been adapted for lighter, more efficient golf clubs and casting rods. An anti-fog compound formulated to keep spacecraft windows clear during launch now is used on diving masks, ski goggles, and snowmobile windshields.

A new silicone plastic foam that takes the shape of impressed objects but returns to its original shape even after a 90% compression has been transferred from better airplane seats to the liners of football and other sports helmets. Used as a gymnasium pad, the foam material is said to absorb all the energy of an adult falling 10 feet.

Even those hang gliders colorfully winging their way along beaches and sand dunes are a spinoff from space. They were designed first to recover spacecraft.

Safer pleasure boats have resulted from a material devised to protect fuel tanks on spacecraft and airplanes. The material, applied as either a coating or a tape, protects fuel hoses for inboard motorboats. In case of fire, the coating swells to as much as 200 times its original thickness and releases gases and water that help quench the fire.

Outdoor concerts now can utilize collapsable, reusable 100-ft towers to hold spotlights and speakers. The lightweight towers are a spinoff from the large radio telescope antennas used aboard orbiting satellite observatories.

And your indoor recreational environment has undergone a beautiful change in a performing arts hall in Akron that uses movable ceilings to accommodate audiences as small as 900 or as large as 3,000. One of the most attractive theater-concert halls in the world, the building employs a computer-controlled acoustic ceiling for sound-tuning the various activities conducted inside.

The movable ceiling functions with the help of a simple tool devised to equalize tensions in 150 supporting cables. The tool originally was developed to measure and adjust the cables of the elevators used at Cape Kennedy for lifting heavy spacecraft.

Finally, a new recreational device billed as a "total sensory experience" resulted from information furnished by a NASA industrial applications center. The entertainment product, called "Showride," consists of a 12-person cabin that can simulate any kind of room, a wide movie screen, and a four-track audio system. The cabin is moved smoothly or suddenly in synchronization with the motion picture.

Your world in a box is fun—for amusement parks. With population pressures increasing and with Americans expected to work fewer hours as our next century unfolds, new recreational pursuits both inside and outdoors doubtless will emerge. In any event, a cleaner, less-cluttered world will be essential to your recreational and mental well being. Space technology will continue to contribute to improving your environment.

your future

One observation can be made of all the developments so far related: we live in an age of great change, of cultural revolution, and fortunately so. As Emerson asked, "If there is any period one would desire to be born in, is it not the Age of Revolution, when the old and the new stand side by side and admit of being compared?"

Compare them. The Wright brothers made the first successful powered flight in 1903, within the lifetimes of many people alive today. Sixty-six years later we landed men on the moon. Now we fly unmanned ships a half-billion miles to Jupiter.

The first 200 years of our nation may well prove to have been the hardest. When you realize how far we have come in understanding the universe and in using it to improve our lives in such a brief time span, you realize how much further we can go in the next 200—further, perhaps, in human relations as well as in technology. The two fields are closer than previously realized.

For instance, who would have thought just a few years ago that the Soviet Union in 1976 would be planning a ground station to receive data from our Landsat earth-resource satellites? Or that U.S. experiments would be flown on board a Soviet spacecraft? These are just two examples of hundreds of areas of recent cooperative programs in space between the U.S. and *most of the other nations of the earth.*

In a sense, *all* of the case histories of space benefits related in this report—and literally thousands more—will affect our lives to an increasing extent in the future. So will trips to the planets and, ultimately, to other solar systems. But what of the near term? How will spinoff affect your life in the next few years?

The coming age of solar power

Chief among these relatively near-future space benefits are energy developments, and chief among those is the direct reduction of sunlight to electricity. While the national debate proceeds to determine which sources of power shall have priority, the fact that solar-power conversion works *now* means that it will play a role as an energy source. Only the extent of solar-energy usage is undecided today.

NASA has gone to great lengths—literally into space!—to improve the performance of light-to-electricity, or "photovoltaic," cells. These devices, so far quite expensive for large energy outputs, are used routinely to power equipment aboard spacecraft. While they work on the surface of the earth too, they are more effective in space where they are free of clouds and nighttime conditions.

An exciting idea is to build large power satellites in orbit. There the cells would be more than three times as effective as the same cells placed on earth. Their energy would be beamed in the form of microwaves to large antennas positioned anywhere on earth.

A more efficient photovoltaic cell is being perfected at NASA's Jet Propulsion Laboratory. The cell is made from a compound called gallium arsenide with an extremely thin, nearly transparent gold film on its surface. In addition to greater efficiency, the solar cell resists radiation better than former cells, making it suitable for long life either on earth or in space.

While more standard research proceeds on increasing photocell efficiencies, NASA also is investigating other theoretical approaches to converting sunlight to electricity. One recent study funded by the space agency at a university seeks to determine the theoretical feasibility of a solar-conversion technique patterned after insect antennas.

Light received by our eyes is converted to electrical impulses by the retina. Insects communicate not only by receiving light rays, in the infrared as well as the visible spectrum, but they do so selectively—that is, by actually tuning their antennas to the proper frequency. Learning how they do this could prove valuable in developing lightwave energy-conversion devices of the future.

Related to the development of solar energy is the age-old windmill. Like photocells, wind generators are a clean-energy replacement for fossil or nuclear power. They can be used in areas where winds are abundant and steady.

NASA has spun off its expertise in aerodynamics, generators, and computer technology to design a modern 100-kilowatt windmill under sponsorship of the Energy Research & Development Administration. It was built late last year at the NASA Plum Brook test area near Sandusky, O. Electricity produced is sufficient to power 25 single-family houses. It is supplied through existing utility lines. The experimental system consists of a 125-ft rotor blade, a large tower, and transmission equipment.

In future models, NASA plans to utilize tiny semiconductor computers developed for spacecraft to adjust the blades automatically in response to wind changes. Such tests must precede development of truly big wind machines capable of producing millions of watts. If the output of the new NASA windmill could be increased tenfold by more efficient designs and larger rotors, about a half-million windmills—according to one estimate—could generate all the electrical energy now consumed in the United States.

In addition to supplementing conventional utility systems, windmills are ideal for remote locations. The main problem here is storing power during comparative calms. Thus NASA is studying the storage of wind energy by containing it in flywheels, by compressing air to drive air turbines, by separating water into oxygen and hydrogen, and by improving battery systems.

Coal, oil, and minerals from space

Conventional energy improvements also are being spun off from space technology. NASA and the U.S. Department of the Interior are working together to develop improved coal and coal-mining methods to be demonstrated in the mid-1980s. The coal research will draw on aerospace technology in such fields as automation, remote control, and combustion.

And when the oil finally begins to flow southward from Alaska's rich new fields, space technology will be largely responsible. A revolutionary heat pipe developed to cool electronic equipment on spacecraft has been transferred to the arctic environment where it is being used to keep the ground frozen along the 800-mile pipeline from the North Slope to the southern port of Valdez. The permafrost must be kept frozen along the entire route to avoid frost-heaving, which can tear apart a pipeline and spew oil over the landscape.

The exploration for even newer supplies of petroleum will proceed more efficiently by using a variety of remote-sensing satellites and space-instrument spinoffs.

One of the latter is a neutron-monitoring device developed to analyze chemicals on the moon. Now it is helping locate oil and other needed minerals on earth by bombarding search areas with neutrons. (The bombardment is of such low intensity that there is no residual activity after detection.)

The instrument, together with a data-acquisition system, can indicate what geographical areas show the most promise. Detailed core samples then can be taken in these locations to reveal oil, coal, or ore deposits.

Another instrument, initially devised to investigate small changes in the atomic composition of spacecraft metals that could cause structural failure, has been adapted into a gravity-meter. The density of hydrocarbon-bearing rock produces gravity anomalies slightly different from other soil. Thus the supersensitive gravity-meter may be able to reveal mineral and oil deposits from the air.

Diagnosing defects before birth

Sometimes the link between space technology and private use is anything but obvious. For example, the computer-image processing systems now used routinely by the space agency to enhance satellite photos have been adapted for genetics research. Geneticists are beginning to use the technique to identify missing chromosomes for diagnosing inherited diseases before birth. Such analyses could help reduce severe human afflictions such as mongolism in the near future.

NASA's new automated procedure starts with blood samples to produce microscope slides containing cells with visible chromosomes. The slides are searched by a computer-controlled microscope that finds the cells and feeds their images into the computer. There the individual chromosomes are isolated, measured, grouped by type, and arranged in the standard geneticist's format.

Diagnosing genetic errors by inserting a small needle probe into the abdominal wall of the mother also can be done now. The probe carries light through tiny fiber-optic tubes to the interior of the uterus, and returns an image to a television camera. The light source is a scaled-down version of the huge xenon arcs used in space simulators. It is ideal for this work because of its high brightness and concentrated beam. Research is proceeding currently to reduce the size of the optical system without loss of image quality.

Of less profound importance, another advance of personal interest soon may be available due to a space technique for coating lenses. If you've ever been bothered by glasses that slip off your nose or have dropped a pair, you may have considered plastic lenses that are lightweight and don't shatter. The trouble, of course, is that they scratch easily. The scratches scatter the light, reducing light transmission. The new space method results in an anti-reflection coating that reduces scattering, and could be used to coat plastic eyeglasses and many other lenses.

In designing unmanned spacecraft to explore the planets, NASA has gained a unique capability now being transferred to the planning of health-care needs. A computer model that integrates demographic, health, and other data already is being used experimentally in Los Angeles. The data can project rational requirements for hospital beds and medical specialists.

Among spinoffs in other areas that will affect your near-term future should be included the coming era of automated banking and ticketing described under "Your Job" in the context of increasing productivity. Tellerless banking machines, already in the lobbies of many banks and other buildings for use after closing, will coincide with the expected explosion of credit transactions in the near future. Ultimately, over the long term, currency could become obsolete.

Many of the other products and techniques reported in this publication will come into use in the near future, since all of them are current or ongoing projects. Automobiles with better gas mileage and less air drag, architectural improvements such as geodesic domes and the Tech House, better use of urban land as a result of marrying computerized demographic data with maps, longer weather forecasts, fewer forest fires, new recreational pursuits—all of these spinoffs soon will begin to affect your future. Perhaps later some of the products you use routinely even will be manufactured in the null gravity and vacuum of space itself—the ultimate spinoff.

Our irreversible commitment

Ours is a progressively technical civilization. Our national commitment to technology for improving our lives is irreversible; thus, technical goals must be questioned carefully more than ever before. Understanding this technical world is a challenge for all of us, not just for scientists and engineers.

In addition to formalized education, several nonprofit organizations exist today to fill the educational void that exists between specific areas of technology and the public. In the space field, for instance, there are the American Institute of Aeronautics & Astronautics, the American Astronautical Society, and the National Aeronautic Association. These are primarily organizations for aerospace technologies or educators.

A new organization was launched last summer for laymen, called the National Space Institute. Among its current projects is the awarding of a "Space Product" seal of approval to manufacturers of the kind of spinoffs described here—thereby enabling consumers to identify a product derived from space technology. The purpose of the institute is to offer a forum for the discussion of national space goals.

It is important that the public have a voice in the direction of civilization's vast new frontier. It is important that people from all walks of life partake in both the realities of space today and the dreams of tomorrow. Dreams of a better life built America, and they will build the frontier of space.

There are whole new worlds out there, and whole new worlds of thoughts. Where have we come from? Where are we going? The answers lie in the dark reaches beyond this planet.

Or in the brightness of another sun.

Neil P. Ruzic, National Space Institute