RETURNS TO EARTH

by Alex Roland

The dreamers who first launched man into space were not much concerned about what he would do when he got there. When the question was put, many of them simply referred to Columbus's discovery of the New World, as if the analogy were exact and the implications self-evident. Others dusted off the apocryphal story about Ben Franklin at the first balloon flight in Paris in 1783. "But what good is it?," someone asked the American minister. "What good is a newborn baby?," Franklin replied.

The space age began, with Sputnik 1, in 1957. One is tempted to ask, "What good is a 23-year-old?" What return have the American people realized on the $73 billion they have spent on the civilian space program since 1957? In space, man has flown 12 times faster than he ever did before, has walked on the moon, and has landed expensive instruments on Mars. The space program has led to dramatic advances in virtually every branch of science and technology; it has spurred several new industries and created, in the process, hundreds of thousands of jobs. But it has not, so far, revolutionized our lives. As of this moment, in terms of its effects on the mass of mankind, the exploration of space lags somewhat behind the development of crop rotation, or the discovery of vaccination.

Let's look at some specifics.

Space science, which is simply traditional science conducted in a new laboratory, has produced results that may one day prove to be the most far-reaching harvest of our space activity. But that time has not yet come. When Homer Newell, formerly associate administrator of the National Aeronautics and Space Administation (NASA), and for many years director of the agency's space science program, recently surveyed the first 20 years of space research, he found it had produced "no change in fundamental physical concepts and laws."* Some old notions, such as that of a cold and static moon, had been discarded. Some new ones, such as the existence of a neutron star, had been

*Homer E. Newell, *Beyond the Atmosphere: Early Years of Space Science* (NASA SP 4211), Washington, 1980.

proposed. But all either flowed from, or might have been predicted by, earthbound science.

The first big space discovery had led many scientists to expect something more. With data from the first American satellite, the 14-kg. Explorer 1, launched in 1958, University of Iowa physicist James Van Allen discovered a radiation belt enveloping the Earth. From this quick discovery flowed an intense campaign of research that not only confirmed the existence of the Van Allen belt but even charted its shape and dimensions.

Poking through the Atmosphere

The Earth's magnetic belt, we have learned, extends out to 10 Earth radii in the direction of the sun, and much farther than that away from the sun. (The drag of the solar wind pulls the "magnetosphere" in the antisolar direction, much as water in a moving stream trails a wake behind obstacles in its path.) This magnetosphere captures or deflects protons and helium nuclei from the sun with consequences we are just beginning to understand: the creation of auroras and magnetic storms, for example. Research in this field has now churned out more information than our theories can absorb.

Virtually every scientific field can boast some comparable eye-opener as a product of space research. In astronomy, the discovery of x-ray emissions from celestial bodies, denied to man until he could poke his instruments through the atmosphere, has led to the tentative identification of "black holes"—the cores of collapsed stars so dense that not even light can escape their gravitational pulls.

Satellite geodesy has provided the most accurate picture yet of a slightly pear-shaped Earth and its ellipsoidal (not round) equator, and has allowed geologists to measure continental drift to an accuracy of inches per year. Comparative planetology has emerged as a distinct field allowing scientists, for the first time, to test hypotheses about the Earth against the evidence from a larger sample of planets. The study of Venus's atmosphere, for example, led to concern over the increasing Freon levels in our own atmosphere.

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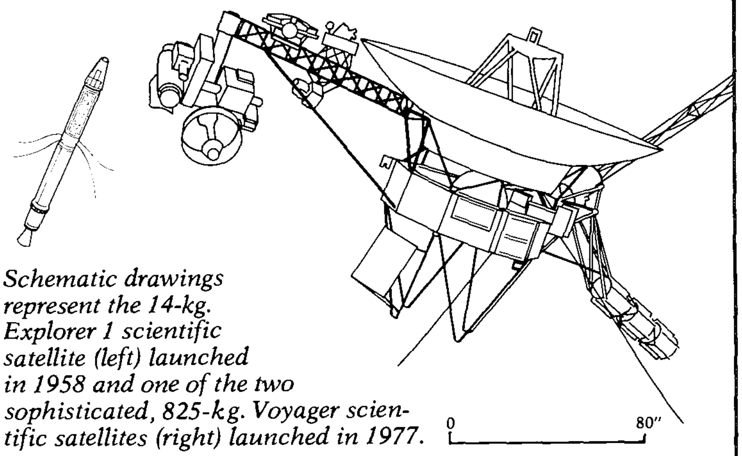
FLYING LABORATORIES



Schematic drawings represent the 14-kg. Explorer 1 scientific satellite (left) launched in 1958 and one of the two sophisticated, 825-kg. Voyager scientific satellites (right) launched in 1977.

Source: National Aeronautics and Space Administration.

What all of this adds up to, however, is not entirely clear. Certainly there has been a vast enrichment of our knowledge; we have added, incrementally, to what we already knew. Some of those new increments have been sizeable. Yet, as Homer Newell pointed out, the basic theoretical framework of modern science has not been altered dramatically. So far, the space program has produced no Copernicus, no Newton, no Einstein.

Few, of course, ever claimed that it would. The United States went into space, initially, for political reasons, not purely scientific ones. At the same time, implicit in the statements of NASA administrators before Congress, and of Congressmen before their constituents, has been the expectation that the technological payoff from space exploration would be enormous; in return for a hefty NASA appropriation, the country as whole would receive, to put it bluntly, a sizeable kickback. Instead of a handful of Einsteins, we would produce Edisons aplenty.

That expectation, I believe, has been more or less fulfilled, even if, in many cases, the new technology has simply enabled us to do better (or faster, or cheaper) something we were already doing pretty well.

Communications satellites, which primarily handle telephone traffic, are a case in point. Their advantages over traditional means of communication are obvious. Overland and undersea cables, known as landlines, must follow the contours of the Earth; they suffer severe restrictions on the volume of traffic they may carry. Station-to-station radio and television transmissions are limited to line of sight and are at the mercy of atmospheric conditions. But three communications satellites in "stationary" orbit 22,300 miles above the equator—actually, they revolve around the Earth at the same rate the Earth rotates—can blanket the entire planet, except for the most remote polar regions, with virtually instantaneous communications of every kind.

Finding Tuna

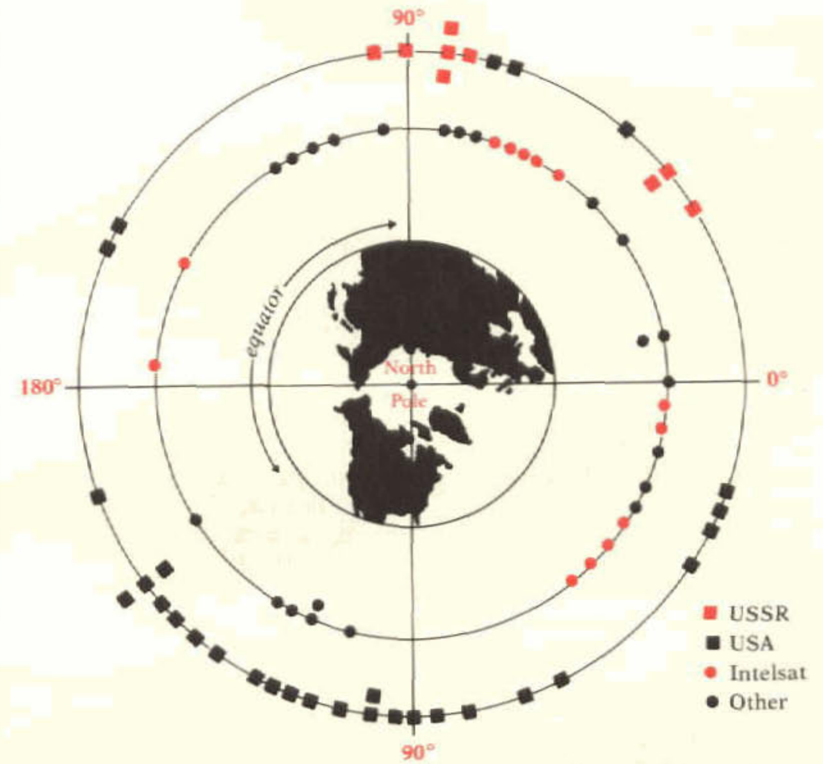
Of all the promises of the early space era, the communications satellite is the most fully realized because it is the most fully commercialized. The Communications Satellite Act of 1962 opened the door to private exploitation of a technology developed largely at public expense. In 1963, private stockholders and companies like AT&T, ITT, and GTE banded together to form Comsat, the Communications Satellite Corporation. Next year followed Intelsat, the International Telecommunications Satellite Organization, in which Comsat is a major partner and the management services contractor. Intelsat has grown from 19 to 104 members, with some 300 antennae at more than 200 ground stations around the world. Apart from such cooperative ventures, private firms and foreign governments have commissioned satellite launches by NASA. Between 1975 and 1979, the United States launched 39 communications satellites.

Intelsat's fourth generation satellites are now on station over the Atlantic, Pacific, and Indian Oceans. Each has a capacity of 12,000 telephone circuits at a cost of $800 per circuit per year, compared with Intelsat 1's 240 circuits at $32,500 each per year. Ground stations with five-meter antennae now cost less than $100,000. The prospects of satellite communication are now so alluring that overcrowding in geosynchronous orbit is becoming a real problem.

No other commercial exploitation of space flight can compare with communications satellites. Weather satellites, for example, have had a comparable if less dramatic public impact, but they remain in the hands of government. The United States launched 13 weather satellites between 1975 and 1979. Those equipped with automatic picture transmission send their images routinely to more than 800 users in every country in the world. Anyone can receive the pictures simply by investing the $15,000 or so needed for ground equipment, be it Eastern Airlines or station WFLA-TV, Tampa.

Weather respects neither geography nor political bounda-

SATELLITES IN GEOSYNCHRONOUS ORBIT



Source: National Aeronautics and Space Administration.

This chart shows communications satellites that were in operation as of November 1979. Geosynchronous orbit is nearly saturated because most communications satellites need a 2° arc to themselves (to avoid interference) and all of them must be "parked" at a height of 22,300 miles—the altitude at which an object in orbit revolves at the same rate as the Earth.

ries. It moves in the closed vessel of our atmosphere and changes on a global scale. Only by studying it on the same scale can we hope to raise weather prediction from a game of chance to a precise science. Weather satellites hold out that promise—although it remains mostly unfulfilled. While the accuracy of short-range (one-to-two-day) forecasting has improved by 20 to 30 percentage points since the introduction of weather satellites, long-range forecasting has progressed more slowly.

More tangible, if more disparate, results have been achieved with earth-resources satellites. A whole array of "remote-sensing" techniques, from visual and near-infrared photography to radar, heat detectors, and magnetometers, have been applied to studying the Earth from space. Some of these techniques have been borrowed and adapted from the military, some from exploration of the moon and planets, some developed especially for this purpose. Together they amount to a remarkably flexible and adaptive tool, limited more by the questions it is not asked than by the answers it cannot give.

The earth-resources satellites now in orbit have applications that range from forecasting wheat crops in the USSR to measuring pollution in the Chesapeake Bay. Landsat can identify faults and fractures in the Earth's crust that are often associated with mineral and oil deposits. The Geostationary Orbiting Environment Satellite, among other capabilities, helps West Coast fishermen pinpoint concentrations of tuna and salmon. Stereosat, which will be in orbit by the mid-1980s if funding disputes are resolved, is designed to transmit 3-D pictures of objects as small as 10 meters in diameter, a degree of resolution surpassed only by military reconnaissance satellites.

Perhaps the greatest limitation on earth-resources satellites is a bureaucratic one: No single agency is responsible for collecting and disseminating remote-sensing data. There is currently talk in Congress about setting up a semipublic entity, much like Comsat, to handle the millions of satellite pictures relayed to Earth every year. That probably won't happen for at least a decade. Until then, the National Oceanic and Atmospheric Administration, which was set up for an entirely different purpose, will fill the gap as best it can.

Mylar and Medimax

Another dimension of space activity that has altered our lives in ways too disparate to comprehend is its technological legacy. To be sure, historically, most high-tech enterprises, from the transatlantic cable to the wartime Manhattan Project, have yielded "spin-offs"—advances applicable to completely different endeavors. But NASA seems to have produced more than its share. In part, this is because space flight was so unprecedented a venture, one that involved everything from testing for life on Mars to learning how to stop and restart engines in a vacuum.

Spinning off technology was also a matter of deliberate policy. Under the National Aeronautics and Space Act of 1958, NASA was ordered to "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." NASA took the mandate seriously, setting up a Technology Transfer Program to bring businesses and arcane technologies together.

Teflon, a solid, chemically inert polymer that became famous during the 1960s as a nonstick coating for cookware, is not a product of space research, but the popular notion that it is reflects a willingness on the part of the public to believe that almost everything new *in* the space age is *of* the space age. Yet, for countless products and techniques, the belief is no myth.

The solar panels that now provide auxiliary power and heating for many homes and businesses reached their present stage of efficiency largely because they were needed to power spacecraft. Weight limitations on spacecraft also helped spur the electronics industry into the microminiaturization that led to digital watches and pocket calculators. The estimated 30 million Americans with hypertension can now have their blood pressure tested on the Medimax-30, a coin-operated machine produced by Advanced Life Sciences, Inc., and derived from the equipment developed to monitor astronauts in space. Thanks to the space program, we now have Mylar "tanning mats" and, just in time, new machines for detecting skin cancer.

Thus, the legacy of the first two decades of space flight has been both substantial and diffuse, even if it has not transformed our lives. To date, the space age has had a less profound impact than the atomic age that preceded it. If tomorrow a green elephant steps in front of the Viking lander on Mars, or if orbiting solar installations take up some of the energy burden of the 21st century, then perhaps the present era may one day be viewed as "revolutionary."

So far, however, the space program's *chief* legacy has been an intangible and symbolic one. The effect is subtle, perhaps imperceptible to those first touched by it. Arthur Schlesinger, Jr., has written that "the landing on the moon is the most exciting event of our age, [one that] will be remembered long after everything else about the 20th century is forgotten." More important than the fact of the landing itself was the opportunity to look—like a painter stepping away from his canvas—at our fragile, blue "Spaceship Earth," suspended alone and beautiful in a dark and indifferent universe. It was—and is—a sight worth thinking about.