The space effort: picking up where Apollo left off

The program to land a man on the Moon was the largest peacetime scientific mobilization in history. We need to revive that science driver to end the economic depression. Marsha Freeman reports.

As the United States and much of the world celebrate the 25th anniversary of the first lunar landing on July 20, the future of manned space exploration itself is in doubt. The global economic depression has forced a retrenchment in the American, European, and Russian space efforts, to the point where even programs that have been nearly completed, such as the Russian Mir 2 space station, or those that *should* have been completed, such as the U.S.-led international space station, face an uncertain future. What is needed to reverse the economic decline is a visionary space effort, with the goal of landing men on Mars in the second decade of the next century, to function as a science driver for the economies of the world.

President John F. Kennedy's program to land a man on the Moon and return him safely to Earth within the decade of the 1960s was unique in two ways. First, it was a crash program, not because, as is charged by austerity-mongers, it gave a "blank check" to the National Aeronautics and Space Administration (NASA) to accomplish the lunar landing, but because it set a timetable. In order to meet the goal, all of the necessary resources had to be mobilized, and because of the personal commitment of the President, they were. Today, goals are set but are *not* met, because the nation's goals are made secondary to the ill-informed decision that the resources do not exist to achieve them.

Second, it was the largest *peacetime* mobilization of scientists and engineers in history. As a great research and development effort, the Apollo program required the creation, design, fabrication, and testing of new technologies to take man into a totally new environment—space. Because it was a civilian program, it functioned as a "science driver" for the whole U.S. economy, putting new capabilities, such as computers, into widespread use in industry, agriculture, the medical sciences, and all facets of American life. Increases in productivity as a result of the capital investment in new technologies allowed even greater resources to be allocated for science and technology. In that way, it laid the economic basis for taking man even farther than the Moon.

It is often said that the trouble the space program finds itself in today is a function of the end of the Cold War; that the driving force of the Apollo program was beating the Russians to outer space, and that now that such competition is gone, no one can find a reason to spend the money on space exploration. While it is true that the "space race" from the late 1950s was predicated upon the development and deployment of military vehicles, such as the intercontinental ballistic missile (ICBM), to President Kennedy, the scientists and engineers, and the American public, the program to take man to the Moon was something much greater than an effort to gain political or military advantage in very turbulent times.

The Apollo program represented the commitment of a nation to accomplish a great task; one of historical dimension, that had challenged man from the time he looked up into the heavens. The idea that man and his machines could cross the void of space, in an environment that provided no air to breathe or life support of any kind, and land on another heavenly body, captured the imagination of everyone in the 1960s. It is estimated that approximately half of the world's population either watched on television or listened on the radio as Neil Armstrong announced that he was taking "one small step for a man; one giant leap for mankind," when he stepped onto the Moon on July 20, 1969.

The American people have never lost interest in the space program. Ten million people each year visit the National Air and Space Museum in Washington, D.C., making it the most popular museum in the country. When asked why they come

Within months of the Apollo 11 Moon landing, astronauts Neil Armstrong, Edwin "Buzz" Aldrin, and Michael Collins toured 24 countries as a Presidential Goodwill Tour to emphasize the willingness of the United States to share its space knowledge. Here the three astronauts are swarmed by crowds during a motorcade in Mexico City, a testimony to the global enthusiasm generated by their achievement.

there, most say because it makes them proud. The possibility that man will venture out again into space, to live and work on the Moon and to explore and colonize the planet Mars, stirs the imagination of every young child and every adult who has the hope that his children will participate in that mission.

But there is no way to reach these goals through tentative, incremental steps, hoping that they will someday make the leap to a manned mission to Mars. A crash program that sets the goals with a timetable is what is needed. While we have lost time during this past quarter-century when no visionary goals existed for the space program, we must set the long-range goals for the next decades, and shape a programmatic timetable of near-term milestones that enables us to meet those goals.

Turning economics on its head

There is a gross misunderstanding in Washington and throughout the West of the role that investment in space and related research and development plays in the economy. In general, the belief is that in times of budget deficits, worthwhile efforts such as space exploration have to be sacrificed because there is not enough money to pay for such "extras." In reality, *only* investment in these kinds of great projects, and the infrastructure that makes them possible (which includes education and medical care, as well as energy, water, and transport upgrades), has the potential to pull the economy out of the current depression.

The usual approach in formulating the federal budget is to start with what are called the nondiscretionary programs, such as payments for unemployment, health care, welfare, social security, and veterans benefits, which are commitments the government has made by law. Vital programs deemed to be in the national interest, such as military spending, are added in. And then there is the more than $200 billion annual U.S. federal debt payment.

What is "left over" can be budgeted for discretionary spending, within which is included the funding for the space program and other science and technology activities.

As the real, physical economy has progessively collapsed and tax revenues from corporate and individual income have contracted, "social safety net" spending has climbed against falling tax revenues: not only do the indigent and unemployed have to be cared for, but so also do the increasing number of working poor who qualify for food stamps and other income supplements.

There is no magic involved in understanding the causes of the current budget deficit.

Aside from timid initiatives from the White House to increase employment opportunities and investment in industry, construction, and other productive sectors, the approach is a "slash and burn" budget-cutting one, and the discretionary programs, such as NASA, are the first ones on the chopping block. This approach is supported by both Republican "fiscal conservatives," and self-described "austerity Democrats."

Cutting the budget will *never* lead to economic prosperity. Quite the opposite. As investments in infrastructure, education, scientific research, and scientifically vectored great projects are sacrificed, and the decreasing wealth of the physical economy is siphoned off to feed spiraling speculation and derivatives, the faster the economy spins downward.

One important exception to this upside-down idea that a nation in economic crisis cannot afford to maintain a scientific capability has been in the former Soviet Union. On Sept. 2, 1991, one month after the attempted coup against Mikhail Gorbachov, Academy of Sciences Vice President Yevgeny P. Velikhov made an impassioned plea before the Extraordinary U.S.S.R. Congress of People's Deputies that they "not break things so violently that the pieces cannot be put back together again." After enumerating the serious problems facing the economy he asked: "What distinguishes Third World countries from those in the First World?

"In the main," he asserted, "Third World countries have resources, they have a work force, too, but they do not have science or expertise. . . . If we destroy science we shall never rebuild it. . . . Then we will have no future." Over three decades, Velikhov has held leading positions in the Soviet Union's, and now Russia's, programs in thermonuclear fusion research, magnetohydrodynamics energy technology, the applications of lasers in industry, and the conversion of military assets to civilian use, and he has a broad understanding of the role of science and technology in an economy. Other spokesmen of the Russian scientific community have suggested that some fraction of the foreign aid that is given from the United States go directly into the space program.

It is past time to insist that the limiting factor in what is accomplished in space exploration should not be funding, but the time that is needed to rebuild the infrastructure—the scientific and engineering manpower, the laboratories and R&D facilities, the high-technology factories and skilled work force—needed to meet our goals. The Apollo program is the paradigm of how a science driver creates the basis for economic growth.

The economics of space exploration

The investment that the United States made in the Apollo program, primarily between 1961 and 1968, created the economic growth enjoyed through the following decades. The Apollo expenditure, approximately $20 billion over that period, is less on an annual basis today than the American public spends on pizza, much less video games and entertainment.

Direct federal dollars used by the space agency during Apollo created 20,000 new government jobs in government-funded facilities, including NASA research laboratories, and also paid the salaries of nearly 400,000 highly skilled manufacturing workers who were building the rockets and space vehicles in the burgeoning aerospace industry.

But in order for there to be a permanent impact on the economy, such government-funded activity must create investment, jobs, and new technologies in the private sector. A study on this subject published by *EIR* in 1986 yielded an interesting result: It was not simply government tax dollars that created the 1960s economic growth. Private corporations began expanding existing facilities and ordering new machine tools *using their own financial resources* after President Kennedy announced the Apollo program, but *before* government contracts had wended their way through the economy. In 1963, there was a net addition of 124,000 metal-working machine tools in industry. In 1958, there had been a net loss of 211,000. Throughout the decade of the 1960s, heavy industry in the United States virtually "rebuilt" itself.

It was the optimism generated by the President's initiative that drove the economic activity, not government contracts as such. This *expectation* that the Space Age would bring with it a revolution in all facets of economic life was expressed in a 1962 book by the editors of *Fortune* magazine when they described the relationship of the emerging space program to the aerospace industry as "hitching the economy to the infinite."

The challenge of *manned* space travel through the Apollo program revolutionized technologies in energy production, electronics and computer control, medical techniques, and materials. The robotic spacecraft programs, which were the necessary precursors to sending men into space, contributed to this cornucopia. The overall impact of these programs on the economy was described in a study released by Chase Econometrics in 1976 that estimated that for every $1 spent in the space program, $14 were returned to the economy in new jobs, factories, technologies, products, and other economic activity.

Launching hardware into space required that it be as light and compact as possible. Heavy and bulky first-generation computers and electronic devices based on the use of vacuum tubes, had to be replaced by superior technology. Space assets, even unmanned, would be too expensive to lose to failures and malfunctions. Hence, standards of production to meet more stringent specifications were needed, surpassing anything required by even the military. The inability to meet this challenge could mean that spacecraft worth hundreds of millions of dollars, representing years of work, could fail on their way to Venus or Mars. One of the differences between the U.S. and Soviet economic systems was the ability of this technology to be transferred to the economy.

For example: In 1964, to ensure that the standards would be met, NASA established a reliability program for microelectronic products, which were subsequently adopted by the Department of Defense and the microelectronics industry as a whole. The production of components in accordance with NASA standards reduced the percentage of spoiled parts and increased production yields by about 20%, making the infant U.S. electronics industry the leader in the world market.

Nastran, a computer software package developed for analyzing the behavior of elastic structures under the wide range of conditions that spacecraft would be subjected to in space, was released for public use in November 1970. It had been developed at NASA's Goddard Space Flight Center between 1965 and 1970 at a cost of $3 million—an investment no individual firm could afford—and has been used in aircraft and automobile production, bridge construction, and power-plant modeling studies.

To ensure the production integrity of spacecraft components before they were launched into space, NASA researchers developed extraordinarily precise, non-destructive testing techniques. Ultrasonic testing technology developed by NASA at a cost of $2 million turned into an industry with annual sales of $50 million by 1980. It was adapted for use for quality control in the production of steel rails, aircraft, nuclear reactors, and automobiles.

The multiplexer circuit developed for the Marshall Space Center for use in the Saturn V rocket to go to the Moon was installed in most U.S. textile weaving mills between 1968 and 1971, yielding productivity increases of 2-3%. There are thousands more similar examples.

Improving the human condition

When the time approached that *man* would venture into space, the space agency and the doctors working in the program had a new host of challenges. Monitoring the health and bodily functions of astronauts over long distances required the development of the kinds of technologies that have become an everyday part of intensive care units in today's hospitals.

The microminiaturization revolution for space applications created medical applications for treating diseases using tiny systems that could be implanted. The treatment of diabetics using an implantable insulin pump was one such spin-off, which, it is estimated, could cut the $20 billion per year in medical costs to treat this disease in half, by greatly reducing the complications and illnesses through a precise regulation of insulin dosage.

The first implantable devices were heart pacemakers, which have evolved as space systems improved. The first pacemaker of the late 1950s failed within less than 12 hours after implantation. The first spacecraft, launched in the 1950s, had useful lives of only a few weeks. The development of rechargeable lithium batteries has extended the lives of both from days to years. The need for spacecraft to contain control systems that allow them to respond to radio commands from controllers on Earth led to the development of pacemakers today that respond to signals from a physician's console that controls the stimulation pulse rate to the heart, for adjustment and regulation.

In addition to the medical devices that have been developed, largely by researchers directly involved in the space program by applying the advances in new materials and microminiaturization, some systems developed for space have found direct application in treating disease.

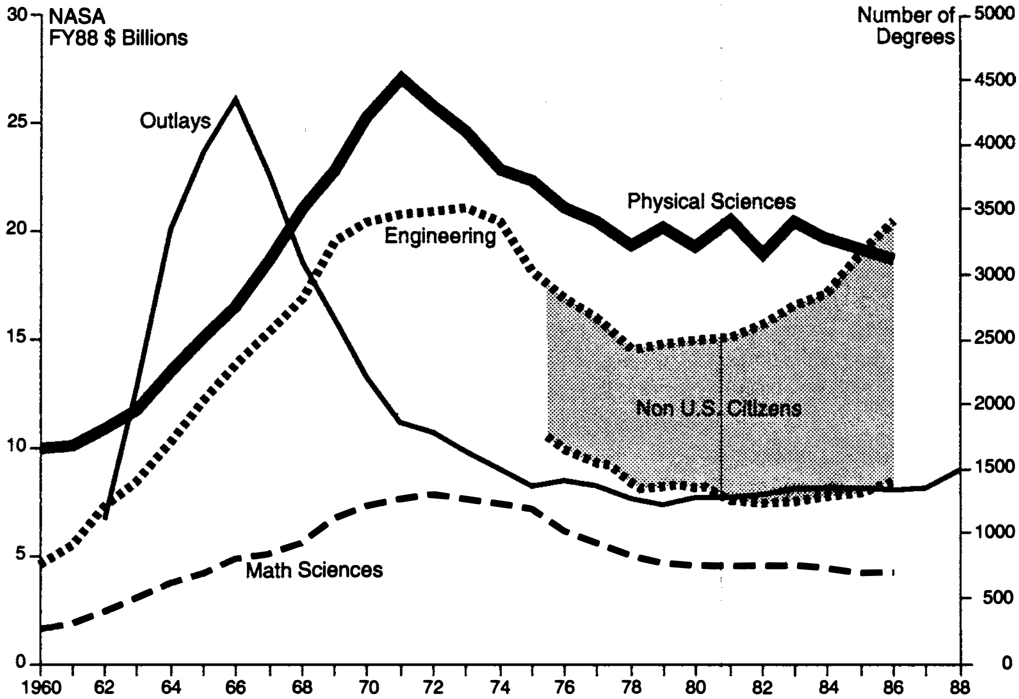
On May 23, 1994, NASA and the Multiple Sclerosis Association of America announced a collaborative program to continue to advance the state of the art in "cool suit" technology, originally developed for lunar astronauts' space

NASA space suit technology is applied here to protect patients from immunological compromise, yet allow them a degree of freedom. In case of leukemia, organ transplant, burns, radiation injuries, and immunodeficiency, infection is frequently life-threatening. Isolation techniques first developed for the space program have vastly improved the prognosis of these patients.

FIGURE 1
NASA budget outlays and science and engineering doctorates, 1960-88
(billions $)

The number of U.S. citizens earning graduate degrees in the physical sciences, engineering, and math has closely followed the funding for the space program. Recent educational "reforms" have only accelerated the decline in science literacy.

Source: NASA.



suits, to treat the disabling symptoms of multiple sclerosis (MS). It was found 30 years ago that lowering the core body temperature of MS patients 1°F relieved some of the symptoms of this disabling neurological disease.

Patients find that after 30-40 minutes of wearing a cooling cap and torso vest adapted from astronaut space suits, they have improved mobility, reduced fatigue, improved vision and cognitive abilities, and decreased psychological depression. This relief can last up to four hours after a cooling session, and cumulative improvements in functioning have been observed.

In anticipation of the availability of longer periods of weightlessness for research purposes aboard the space station, new equipment is being developed to study human biological processes in space, which have already been applied to the treatment of disease, years before the space station will fly.

But the real promise of space for improvements in human health is in the fundamental understanding of biological processes, to help *prevent* as well as treat disease. Just as space-based astronomy has opened a new window on the universe to help scientists understand the fundamental laws by going outside the barriers of Earth's atmosphere, the environment of Earth orbit provides a new window on biology, by removing one of the basic factors of life on Earth—gravity—to be able to observe its effect on the human biology.

Many of the changes that healthy astronauts experience in their adaptation to the weightless environment, such as loss of bone calcium and diminished effectiveness of their immune system, mimic the signs and symptoms caused by diseases such as osteoporosis and AIDS. Joint programs by NASA and the National Institutes of Health are being developed to extend the use of this unique space environment to try to discover the fundamental biological mechanisms that produce such disease effects, to aid scientists in their search for the causes, treatments, and cures.

The direct application of space technology *from space* has provided weather forecasting techniques that save millions of dollars in damage to homes and property each year. Landsat and other Earth remote sensing systems have given farmers the tools to evaluate the health of their crops and the inventory of water resources, and have provided the technology for global assessments of resources. Communication satellites have provided not only instantaneous connections between all peoples of the world, but also the ability to be a "teacher in the sky" to isolated communities in Third World nations where there is no other access to education.

One immeasurable impact of the Apollo program on the economy, and perhaps the most important, was the inspiration of young people to dedicate their lives to careers in science and engineering. As **Figure 1** shows, in the past 30 years, the number of American students pursuing studies in the natural sciences and mathematics rose dramatically in response to the Apollo initiative. This scientific cadre, like those trained under Adm. Hyman Rickover for the nuclear Navy, became a pool of talent in the space program and throughout industry, in all of the widely varied fields that the space program touches upon.

Does it not put the ferocious debates in the Congress over spending $ 14 billion per year on space programs in the proper perspective to remember the leverage of this small investment in the economic and physical health of the world's peoples?

The challenge of Mars

Mankind has visited the Moon, but we have not yet begun to take advantage of its unique properties and resources. On that airless world should be placed a new generation of telescopes to peer out into the universe without the interference of an atmosphere or the electromagnetically noisy environment of Earth.

Lunar oxygen and other raw materials can be exploited for use in space. Because the Moon has an effective gravitational force only one-seventh that of Earth, materials that are needed for more distant destinations in space that can be supplied from lunar manufacture are more economical than those launched from the surface of the Earth. In the future, unique lunar resources, such as the rare isotope helium-3, which can be used as fuel in nuclear fusion reactors, may be economical to mine on the Moon and transport back to Earth.

Data sent back recently from the Clementine spacecraft suggests there may be water ice on the lunar poles. This could obviate the need to transport water for a lunar colony from Earth, which would otherwise involve a substantial cost. To establish human civilization on the Moon, the costs of creating an artificial life-sustaining environment must be reduced. This requirement will lead to new advances in closed-cycle life support systems where the precious water, air, and other resources needed by plants and people will be recycled rather than discarded. Such life support techniques, which will make it possible to live on the Moon, will also make it possible to develop the most hostile environments on Earth, such as the deserts.

For lunar cities and large-scale industrial production, more advanced, high-density, compact nuclear energy sources will be developed. The two-week lunar night, and the need for highly concentrated energy will limit the use of solar energy. Such next-generation nuclear fission technologies, using advanced fuel designs, direct conversion to electricity without steam turbines, and new materials for higher temperatures, will push forward the commercial development of the second-generation nuclear reactors now stalled by the Department of Energy.

The Moon, relatively nearby, will function as a test-bed for many of the new technologies that will be required for mankind's next destination, Mars. Unlike the Moon, the red planet had a geologically active past which produced the largest volcano in the solar system, a canyon that stretches 3,000 miles, and intriguing networks of channels that were clearly produced by rivers. The tenuous Martian atmosphere is a starting point for eventually terraforming the planet, and provides a "mineable" source for carbon dioxide and other consumables.

While we will not be able to definitively answer the question of whether there has ever been, or whether there is life on Mars until we get there, we can plan now to *bring* life there in the future.

Because Mars is tens of millions of miles from Earth even at its closest point, as opposed to the quarter of a million miles to the Moon, manned missions to Mars will require quantum jumps in propulsion technology to get there and life support systems that are highly reliable and entirely self-sufficient, because resupply from Earth will be difficult as well as uneconomical.

Thermonuclear fusion energy, produced from the fusing of light elements in the same way the stars create their energy, will be the propulsion of choice for manned Mars missions. While chemical propulsion technologies similar to today's Space Shuttle would involve travel times of nine months or so, and fission propulsion could shorten that by a couple of months, fusion has the potential to reduce the travel time to Mars to a matter of weeks. This is important for two reasons.

First, the radiation environment of space makes it advantageous to get wherever you are going as quickly as possible. Second, prolonged weightlessness has already been demonstrated to have serious debilitating effects on humans. A crew which arrives at Mars having suffered bone decalcification, shrinkage of heart muscle, and loss of muscle tone will be less able to start its exploratory work.

The development of fusion power, pushed forward due to the need to travel deeper into space, will make available to those of us who remain on Earth a virtually inexhaustible supply of energy both in the form of electricity and heat, and also in the form of coherent electromagnetic radiation, such as lasers of varying wavelengths, which can be used for industrial processing.

Living and working on Mars will require the creation of whole new processes for the mining of life-supporting consumables from its atmosphere and surface, and raw materials for manufacture. The carbon dioxide atmosphere, which is poisonous for humans, could be breathable for plants in protected greenhouses that are heated and shielded from radiation.

The goal is to make this new world habitable; to perform the scientific experiments in astronomy, geology, biology, chemistry, agronomy, and plant physiology to unlock some of the secrets of the formation of our solar system, the development of the planets, and life on Earth.

The Apollo program opened up the solar system to man's exploration. Now we must rehearse and prepare for the next century's goal of man on Mars, first on Earth-orbiting space stations, and then on the Moon. While we do that we must continue to send unmanned representatives of our intelligence to the planets that cannot yet be reached by man, and to more distant objects.

With an international effort that takes advantage of the 30 years of space science and technology we have inherited, and brings into participation all of the "old" and "new" nations which must be part of this effort, the next step can be taken. The returns cannot be imagined today, but they will far exceed our expectations.