# Space Program Spending Paid for Itself Many Times Over

In April 1976, Chase Econometrics, a consulting firm associated with Chase Bank, released a study which estimated that for every $1 spent in the U.S. space program, $14 was returned to the economy in new jobs, new factories, and increased productivity from new technologies. The study also found that dollars spent by NASA were four times as effective in boosting the economy compared to other R&D spending, and that the effects in the economy of technology that had been developed by NASA were visible within two years of application.

There is no other *legal* activity that can claim that rate of return on investment.

While no listing of individual technology developments could add up to the economic impact of the mission to land men on the Moon, a survey does present examples of how such investments transform economic activity for the economy as a whole.

**Agriculture:** Observing the Earth from space has given farmers a tool with which to evaluate the health of crops, by determining infestation of pests, water stress, efficiency of fertilizers, and other factors. Threats to crops can be determined months before they would be visible from the ground, and action taken in time to avoid large-scale loss of food. Future applications of space technology in agriculture will include the use of automated and robotic systems being developed to grow food in Earth orbit and on other planets.

**Medicine and health:** Medical technologies that have benefitted from, or depended upon, NASA-funded research and development include fluid-flow studies for the artificial heart, miniaturized implantable insulin delivery systems for diabetics, remote monitoring of vital signs in intensive care units, rechargeable cardiac pacemakers, astronaut "cool suit" treatment for multiple sclerosis patients, implantable heart defibrillators, diagnostic tools and technologies, and thousands of other capabilities that have saved lives, improved the productivity of victims of many ailments, and helped prevent disease.

**Energy:** Many ideas for quantitative and qualitative improvements in energy technologies were initiated to enable the production of electricity under the constraints imposed by space flight and the space environment. They were under development to enable the colonization of the Moon, and travel to and development of Mars. Quantitative improvements included the development of compact, high-temperature nuclear fuel arrays for second-generation nuclear fission power plants. Qualitative breakthroughs centered around direct conversion techniques, such as applications of magnetohydrodynamics, and new energy production methods, notably, nuclear fusion.

**Manufacturing:** Industrial processes of every type have been pushed ahead through the use of new materials, computer control, non-destructive testing techniques, quality control methods, and thousands of individual innovations that were required in order to manufacture spacecraft that could withstand the space environment, and support both men and machines. Nastran, a computer software package, was developed at the NASA Goddard Space Flight Center during 1965-70, to analyze the behavior of elastic structures. In 1970, it was released for public use, and it was employed in aircraft and automobile manufacture, bridge construction, and power-plant modeling studies.

**Transportation:** The most significant increase in productivity in traditional transport systems, such as rail, since World War II, came from the application of computers. A dispatching and control system, originally developed by TRW for the Apollo guidance system, was adapted for ground transport, and used in the rail industry. Highly innovative transport technologies, from magnetically levitated vehicles to sub-orbital electromagnetic mass drivers, have benefitted from various space technologies, and will be deployed on a large scale on the Moon and Mars.

**Scientists and engineers:** During the 1960s, NASA provided the resources for thousands of college- and graduate-level students to pursue studies in science and engineering. Grants went to educational institutions to upgrade facilities, to faculty to support their research, and to students to encourage them to study the sciences. The peak year for NASA funding was 1965. The peak year for doctorates granted in the physical sciences (approximately 4,500) and in engineering (approximately 3,500), was in 1971, not because NASA paid for all of these degrees, but because there was great interest in joining in the space enterprise. At the start of the space program in 1960, the United States was graduating fewer than 2,000 Ph.D.s in the physical sciences. The number increased as NASA funding increased, and then declined, as NASA funding declined, with about a five-year lag time. *—Marsha Freeman*