Making Money in Space

Exploring the solar system turns out to be the easy part. The next great challenge will be creating profitable space enterprises

by Mark Alpert, *issue editor*

MARK MAXWELL *LunaCorp*

In 1975 the National Aeronautics and Space Administration sponsored a study to design a commercially viable space station. A team of scientists and engineers proposed the construction of a giant wheel, nearly two kilometers in diameter, orbiting Earth at the same distance as the moon. The station would hold 10,000 colonists in a habitat tube running along the rim of the wheel, which would revolve once a minute to simulate Earth's gravity. The colonists would breathe oxygen derived from moon rocks and eat food grown on the station's 63 hectares of farmland. The study estimated that the station would cost nearly $200 billion in 1975 dollars, which is equivalent to some $500 billion today. But the authors of the study confidently predicted that the station could pay for itself in 30 years through the assembly of enormous solar-power satellites.

Needless to say, the development of space has not lived up to this ambitious plan. The International Space Station, if it is ever completed, will hold only seven crew members and generate negligible income, certainly not enough to cover its $40-billion construction cost. NASA still hopes to strike partnerships with companies interested in manufacturing in zero gravity; the agency is trying to sell research modules on the space station to pharmaceutical, biotechnology and electronics companies. But even NASA officials admit that commercial interest has been cool. So far the only space industry that has proved to be a rousing success is the satellite communications business. Driven by the strong demand for cellular telephone service, companies such as Motorola and Loral Space and Communications are investing billions of dollars in new networks of satellites flying in low-Earth orbit [see "New Satellites for Personal Communications," on page 96].

LUNAR POLAR LANDING of a spacecraft proposed by LunaCorp, a 10-year-old private company. The unmanned probe could be the first commercial spacecraft on the moon, landing in Peary Crater near the moon's north pole in 2002. LunaCorp plans to finance the mission by selling the data collected by the probe's robotic rover.

In recent years, however, there has been a quiet revolution in the space industry. A new generation of entrepreneurs has arisen, many of them scientists or former astronauts. Despite a severe shortage of capital, they have founded small, scrappy companies such as Universal Space Lines, Pioneer Rocketplane, SpaceDev and LunaCorp. Some of these companies are trying to develop low-cost launch vehicles; others are planning lunar and deep-space missions intended to turn a profit. What they all share is a strict allegiance to the bottom line. Their oft-repeated motto is: "To go to space to *stay,* we have to make space *pay*."

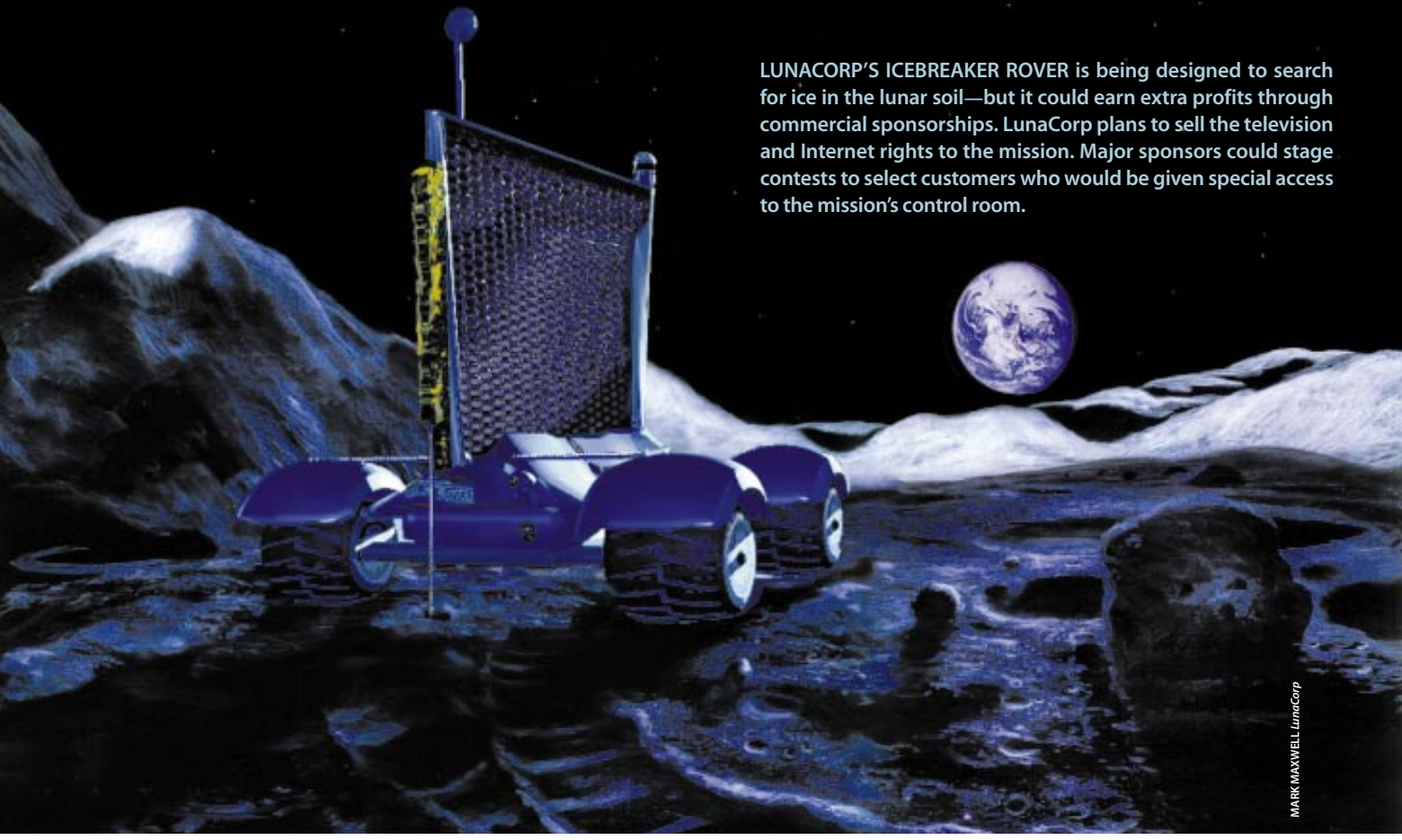
Economics in Orbit

The primary constraint on space enterprises is the high cost of escaping Earth's gravity. Lofting a payload into low-Earth orbit using expendable rockets or the space shuttle costs between $10,000 and $20,000 per kilogram. The pressing need for cheaper launches has led NASA to invest in the X-33, a prototype for a lightweight, fully reusable space plane. Lockheed Martin is building the X-33 and plans to follow it with a commercial vehicle called VentureStar, but smaller companies such as Rotary Rocket and Kistler Aerospace are rushing to build their own reusable launch vehicles [see "The Way to Go in Space," on page 58].

To stimulate the competition, the X Prize Foundation has offered a $10-million award to the first privately funded team to fly a reusable three-person spaceship on two consecutive suborbital flights. Sponsored by the St. Louis business community, the X Prize is modeled after the prizes offered to pioneer aviators early in the century, which promoted the growth of the aircraft industry. The launch vehicle companies want to follow the same growth curve; they hope to decrease their operating costs by flying their vehicles as often as possible, like commercial airliners. But is there a need for so many spaceflights? Currently there are about 90 launches a year, most of them carrying communications satellites into orbit using expendable boosters, such as the Ariane, Delta and Atlas rockets. A single reusable launch vehicle that could blast off into space twice a week could conceivably loft every commercial payload planned for the next 10 years.

The space industry obviously needs to do more than boost communications, navigation and weather satellites. For many years, NASA promoted the idea of space-based manufacturing, claiming that certain pharmaceuticals, semiconductor materials and other products could be manufactured with better quality in an orbital station than in an Earth-based factory. Unfortunately, high launch costs have prevented most companies from considering the idea. But even if cheaper vehicles became available, very few products could be manufactured in orbit and sold profitably on Earth. Most products made in space simply would not be competitive with products made on the ground—in part because Earth-based manufacturing techniques are continually improving.

The assembly of solar-power satellites—the main



LUNACORP'S ICEBREAKER ROVER is being designed to search for ice in the lunar soil—but it could earn extra profits through commercial sponsorships. LunaCorp plans to sell the television and Internet rights to the mission. Major sponsors could stage contests to select customers who would be given special access to the mission's control room.

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purpose of the giant space colony conceived in 1975—seems more promising, given the expected growth in worldwide energy consumption. Because a solar collector in a geostationary orbit would not be subject to the day/night cycle or to atmospheric interference, it would receive about eight times as much light as a solar collector on the ground. The power could be transmitted by microwave beams from the satellites to antenna arrays on Earth. A large solar-power satellite, with a collector three to six kilometers in diameter, could conceivably generate five billion watts of electricity, about five times the output of a conventional power plant.

In 1997 NASA released the "Fresh Look" study, which reexamined the costs and benefits of solar-power satellites. The study noted that solar power from space could become a competitive energy source, but only if launch costs declined to less than $400 a kilogram, a more than 20-fold reduction from current levels. The idea also faces technical hurdles—scientists must improve the efficiency of microwave-power transmission—and billions of dollars would have to be invested in the project before the first watt of electricity could be generated. Solar-power satellites will probably not be seriously considered by the private sector until the next energy crunch.

In the near future the best way to make money in space may be to take paying passengers there. One of the strongest advocates of space tourism is former Apollo astronaut Buzz Aldrin, Jr., the second man to walk on the moon. Aldrin has founded a company called ShareSpace to promote mass-market space travel. "People have come up to me and asked, 'When do *we* get a chance to go?'" Aldrin says. A 1997 survey of 1,500 Americans showed that 42 percent were interested in flying on a space cruise. Two travel companies, Space Adventures and Zegrahm Space Voyages, are already taking advance reservations for seats on suborbital flights, even though the launch vehicles have not yet been built. Tickets for the first flights are expected to cost between $50,000 and $100,000.

A 1998 NASA study endorsed the concept of space tourism, concluding that it may grow into a $10-billion-a-year industry in a few decades. John Spencer, director of the Space Tourism Society, predicts that by 2040 there will be orbital hotels carrying hundreds of travelers. "The romance of space will be a key selling point," he says. These projections, however, are based on the assumption that the next generation of vehicles will be more reliable than the space shuttle or expendable rockets. In the satellite launch industry, a failure rate of 1 percent—one loss for every 100 launches—is considered remarkably good. But such a failure rate would doom the space tourism business.

Staking Claims in the Asteroid Belt

Space entrepreneurs are also eyeing Earth's moon and the asteroid belt. The recent discovery of signs of ice at the lunar poles has revived talk of a manned base on the moon. But the near-Earth asteroids, which travel in orbits that cross or graze Earth's orbit, may be better sites for commercial development. Many of these asteroids are easier to reach than the moon, and they are rich in iron, nickel, cobalt and platinum-group metals. In fact, a two-kilometer-wide asteroid holds more metal than all the ore mined on Earth since the beginning of civilization.

Of course, it would be difficult to transport so much metal from the asteroids to Earth's surface. Dropping large quantities of ore into the atmosphere would be impractical, not to mention dangerous. Asteroid resources could be more profitably used to support other space enterprises—for example, to construct space hotels or solar-power satellites in Earth orbit. The most precious resource from the asteroids is actually not a metal—it is water ice, which could provide propellants for spacecraft at one-thousandth the cost of launch-

ing the fuel from Earth [see "Tapping the Waters of Space," on page 100].

An asteroid-prospecting mission is already in the works. SpaceDev, a fast-growing publicly held company, plans to send a $50-million spacecraft, the Near Earth Asteroid Prospector (NEAP), to the asteroid 4660 Nereus by 2002. It would be the first commercial deep-space mission; SpaceDev hopes to make a profit by selling the data sets from NEAP's scientific instruments and by offering payload space on the probe to university researchers. For $10 million, SpaceDev will deliver an ejectable payload that could land on Nereus's surface. NASA has recognized NEAP as a Mission of Opportunity, meaning that research groups can receive NASA funding for scientific instruments carried on board the spacecraft.

Jim Benson, SpaceDev's chief executive, says that once NEAP lands its first instrument on Nereus, he will declare his ownership of the asteroid. "If I take the risk to go there, by God I'm going to claim it," he states. Whether such a claim would be legal is an open question. Although the United Nations's Outer Space Treaty of 1967 prohibits nations from claiming sovereignty over celestial bodies, it does not disallow property rights. Benson hopes his claim will set a precedent. But NEAP may yield a more immediate payback: if SpaceDev can make a profit on the research mission, it will serve as a model for other commercial spacecraft.

A similar mission has been proposed by LunaCorp, which plans to send an unmanned rover to the moon's north pole to determine how much ice is buried there. The rover is being developed by the Robotics Institute of Carnegie Mellon University. If all goes as planned, in 2002 the rover will land in a sunlit part of Peary Crater near the north pole, then travel to the permanently shadowed area where ice is believed to lie below the surface. The rover will be able to drill more than a meter into the lunar soil to test for the presence of subsurface ice.

Like SpaceDev, LunaCorp intends to finance its mission by selling the research results to NASA and other space agencies. The company is also trying to raise funds by offering a variety of sponsorship opportunities. For example, an entertainment company could pay for the television rights to the mission. "Because it's a private project, we can offer exclusive rights," says David Gump, LunaCorp's chief executive.

Another company, Applied Space Resources, plans to underwrite a lunar mission by selling moon dust. Denise Norris, the company's founder, wants to land a probe in the Mare Nectaris, just south of the moon's equator, where it will scoop up 10 kilograms of lunar soil and then return the sample to Earth. The company will give away five kilograms to scientists and sell the remaining moon dust to retailers at $6,000 a gram. It seems a fanciful way to pay for a space mission, but Norris points to a historical precedent from the 17th century: the colonization of North America was financed in large part by the sale of exotic items such as tobacco and beaver pelts.

The Space Enterprise Zone

Perhaps the biggest problem facing these companies is a lack of capital. Wall Street does not understand the space industry, and most investors are unwilling to bet on companies building new launch vehicles or planning commercial missions. Even the risk-taking, venture-capital firms have steered clear of the space business. The scarcity of capital has inspired a reworking of an old adage: if God had wanted people to go to space, He would've given them more money.

To stimulate extraterrestrial business activity, interest groups such as ProSpace and the Space Frontier Foundation have called for a rethinking of the government's role in space. They believe NASA should privatize the space shuttle and the International Space Station. The space agency, they argue, should buy launch services from competing companies rather than fund the development of a single vehicle. Rick Tumlinson, the president of the Space Frontier Foundation, says NASA should focus on the exploration of the solar system and leave its operations in low-Earth orbit to the private sector. "NASA astronauts shouldn't be driving the space trucks," he remarks. "They should be going to Mars!"

NASA *is* slowly moving in this direction. In 1998 Congress passed the Commercial Space Act, which requires NASA to draft a plan for the privatization of the space shuttle. The law also establishes a regulatory framework for licensing the next generation of reusable launch vehicles. But space entrepreneurs say more incentives are needed. Some executives advocate the creation of a space enterprise zone similar to the enterprise zones in inner cities. Under the proposal, the federal government would not tax any profits from new space businesses such as launch vehicle companies. Other executives believe, however, that the proposal would do little to encourage investment, because high-tech companies typically do not turn a profit during their first years of operation.

Despite the stumbling blocks, most people in the space industry remain optimistic. They are convinced that in the long run commercial outposts will be established in Earth orbit, on the moon, in the asteroid belt and beyond. Some long-term thinkers have even contemplated the ultimate space project: the transformation of Mars into a habitable planet [see "Bringing Life to Mars," on page 52]. The proposal may seem outrageously ambitious, but ambition is one attribute that today's space capitalists possess in abundance. SA

ZEGRAHM SPACE VOYAGES

SPACE TOURISTS are already booking reservations for suborbital flights planned by Zegrahm Space Voyages, an adventure travel company. A reusable launch vehicle (*left*) that could take six passengers to an altitude of 100 kilometers is in development. Passenger flight suits (*right*) are also being designed.