Thirty-Six Years After Neil Armstrong

BY BILL WALKER

"The Earth is the cradle of the mind, but we cannot live forever in a cradle."

—KONSTANTIN E. TSIOLKOVSKY, 1911

Thirty-six years ago men could walk on the moon. Today they can't; the only moon rockets on this planet are serving as lawn decorations in Huntsville and Houston. Is this because 21st-century technology is less advanced than that of 1969? Obviously not. America's failure in space is due to our re-enslavement to medieval economics; we believe that government owns everything outside the earth's atmosphere.

Without private property, there will be no markets, no profitable commerce, and no permanent progress in space. How can I be so sure? Because it has all happened before, both on Earth's seas and in space.

China is well known for inventing gunpowder, paper, silk, the compass, the rocket, and more centuries before Europeans could even copy them. But it is less well known that the Chinese actually had an Age of Exploration long before Columbus.

From 1405 to 1420, Chinese fleets under the eunuch admiral Zheng He visited India, Sri Lanka, Saudi Arabia, and Africa's east coast. The ships were gargantuan for the time, some with more than ten masts and with displacements up to 500 tons. The fleets made seven long voyages, carrying Ming vases and other treasures to impress the distant civilizations they visited. They brought a giraffe (and an insufficiently impressed Sri Lankan ruler) back to the emperor.

Then the winds of imperial fashion changed, and the voyages stopped. Not only did the "treasure fleets" never again set sail, but the shipyards were destroyed along with the ship's blueprints and most of the records of the voyages. Later emperors implemented actively anti-maritime policies. By 1520, when Europeans had already been exploring the Americas for three decades, it was illegal for a private Chinese subject to own a ship with more than two masts. The future belonged to the Europeans, with their smaller ships and their vastly greater level of private ownership and economic freedom.

In an exact parallel with Imperial Chinese sea exploration, seven moon-landing voyages were launched (though Apollo 13 had to abort; remember, it's bad luck to be superstitious). Then they stopped. Three years after Neil Armstrong's landing, the first and last NASA moon field geologist (Harrison Schmidt) walked back into a LEM (lunar excursion module) ascent stage and returned to earth to take off his helmet and become a U.S. senator. No one has been to the moon since. No one *can* go to the moon today. Just like the mandarins, NASA destroyed the rockets. Those Saturn Vs and Saturn Is we visit in the museums today were real, operational rockets . . . tossed away and left to collect dust.

Since 1972 NASA has not failed to spend money; it will spend over $16 billion next year. Military space programs are reported to spend even more. But the NASA and military rocket fleets of today are inferior to those of 1969. After an indecisive hiatus of many years, the Saturn rockets were replaced by the shuttle. The shuttle launches payloads at a higher cost per pound, launches only 29 tons versus the Saturn's 125, and is more vulnerable to launch delays through the loss of a vehicle. And the shuttle can never go higher than low earth orbit.

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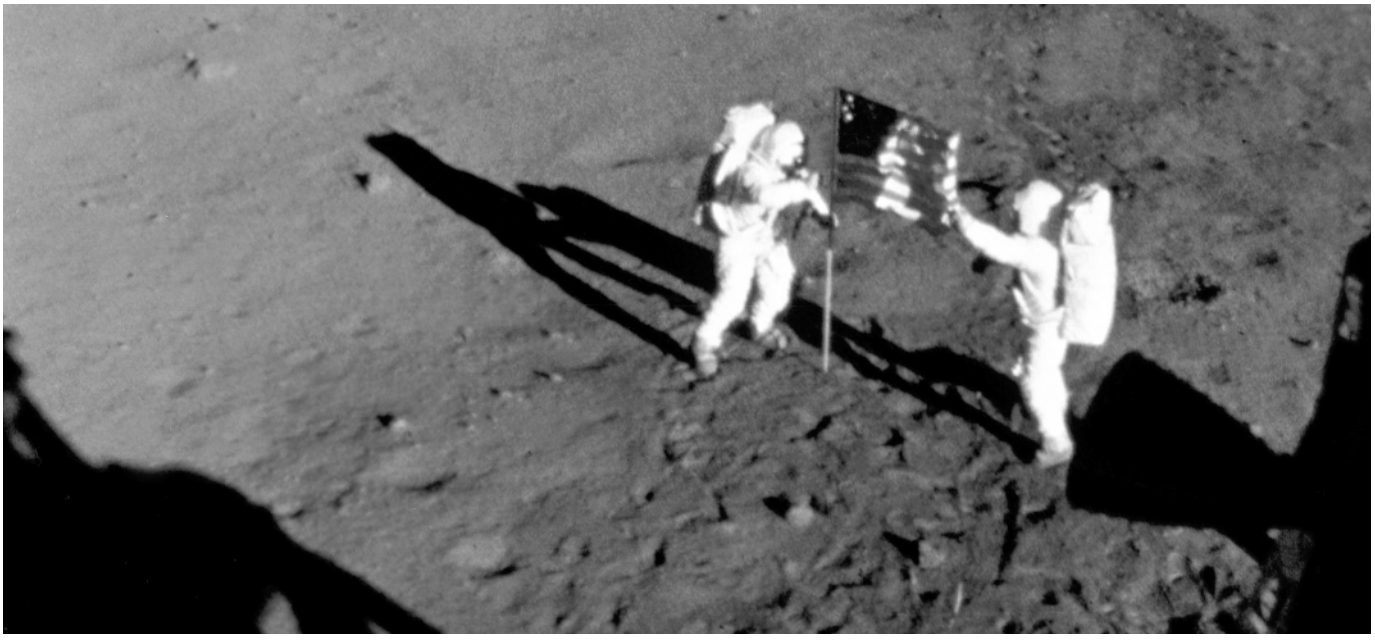

Astronauts Neil A. Armstrong (left) and Buzz Aldrin, July 20, 1969. NASA.

When the shuttle staggers into orbit again, it will carry even less useful cargo; NASA has loaded it down with "safety gear" to repair its own flaking tiles. Now and for the foreseeable future, American astronauts can only reliably travel to the International Space Station by buying tickets for seats in obsolete 1970s-technology Russian capsules. The European Ariane 5 rocket can carry ten tons into geosynchronous orbit. China, India, and Japan also have rapidly expanding booster programs. The United States is no longer pre-eminent in space.

NASA has no concrete plans to remedy this situation. As John Cserep of the Space Frontier Foundation points out: "NASA's unbroken string of cancelled vehicle programs stretches back to the Reagan Administration's X-30 NASP, and continued with the X-33, X-34, X-38, 2GRLV and, most recently, the Space Launch Initiative or SLI. The two remaining 'X-vehicle' programs—the X-37 and X-43—are both well behind schedule and over budget, making their cancellation likely."

The first moondoggle proved that even a government agency could put men on the moon. But it also proved that government space efforts are a dead end, unless private property, markets, and freedom follow them. There is a huge legacy of never-used space technology from the moon-race period. This technology could indeed let men return to the moon, protect life on earth from asteroid extinction events, and even bring new life to Mars. But this is only possible if we abandon the Imperial Chinese model of centralized bureaucracy. The solar system can only be opened by multiple ventures launched by industrialists and homesteaders.

Most people have the impression that space is impossibly difficult, waiting for far-future technological breakthroughs. Nothing could be farther from the mundane truth; rocket science just ain't "rocket science" anymore. In the 1960s the Atomic Energy Commission developed not one but three nuclear rocket technologies: NERVA, ORION, and POODLE.

Nuclear Rocket Engine

NERVA was a nuclear rocket engine that worked much like the fictional engines in Robert Heinlein's 1940s book *Rocket Ship Galileo.* A nuclear reactor heated hydrogen and expelled it through a nozzle. NERVA-style engines were tested from the late 1950s through 1972 when the program was shut down. Twenty-three different engines were tested. The later models ran for hours at a time, producing 250,000 pounds of thrust. One of the test engines is in on view outside the Huntsville space museum. (There are some nice pictures of NERVA at www.lascruces.com/~mrpbar/rocket.html.)

The nuclear engines tested in the mid-1960s were twice as efficient as any chemical rocket. Although NERVA actually ran cooler than a chemical rocket, it was exhausting pure hydrogen instead of water or water and CO_2. Since temperature is the average kinetic energy of molecules, at any given temperature H_2 molecules have to go a lot faster than H_2O molecules. This gave NERVA's exhaust about twice the "specific impulse" (newton-seconds of thrust per kilo of fuel) of any chemical rocket.

NERVA was a potential quantum leap ahead in space propulsion, but not just because it was more efficient. NERVA carried its energy in its nuclear fuel rods, not in its hydrogen tanks. NERVA rockets can refuel anywhere there is liquid or gas, cruising the solar system for years before needing to replace the nuclear fuel rods. A NERVA-powered cruiser could pump water out of the ice inside the thousands of ex-comets that we now call "near-earth asteroids," or pump its tanks full of CO_2 from the Martian or Venusian atmosphere, or methane from Titan's. So instead of trying to bring all the fuel it would ever need from earth, a NERVA could live off the land. Once launched from earth a NERVA could shuttle between the moon, asteroid colonies, and Mars settlements for years.

Now of course I'm not saying that we in the 21st century should spend our time restoring retro 1960s rocket designs. Nuclear material science has progressed far since 1965. The Timberwind project, funded by the SDI program in the late 1980s, developed improved nuclear thermal fuel elements. Pratt and Whitney has recently proposed a modernized nuclear thermal engine that would run hotter and more efficiently. And there are hundreds of other propulsion concepts out there, both nuclear and non-nuclear. Future space transportation may use jet bottom stages (like Rutan's SpaceShipOne), electromagnetic launch tracks, graphite tethers hanging from orbiting asteroids, gas-fission reactors, fusion engines, combinations of the above, or technologies still unknown. But NERVA serves as proof that sufficiently powerful engines have already been built once, by people working without personal computers, the Internet, or modern materials science. There is no technological barrier to space colonization.

There is no intrinsic economic barrier to space colonization either. Space travel is not "too expensive for anyone but government"—unless it's being done by a government (in which case it may be too expensive period). We already routinely use energy in the amounts necessary for space travel. It takes about as much fuel energy to get from the United States to Australia at 550 mph, plowing through air all the way, as it does to get into orbit. Once in orbit travel becomes much cheaper and easier than on earth. Even moving mountains becomes easy in the vacuum of space. Compared to everyday industrial activities, such as drilling oil miles beneath the ocean floor, maintaining thousands of passenger airliners, and building tunnels under the English Channel or bridges across the Baltic, the capital requirements for private space ventures are modest.

The economic barriers that do exist in space are solely due to NASA's Soviet-style organization. The Saturn V, for instance, carried all its own fuel for a trip to the moon—and back. If a 747 were built that way, it could only take three people to Australia round-trip and the aircraft would be thrown away each time. If markets were allowed to flourish, entrepreneurs would set up fuel stations (among thousands of other businesses) in appropriate locations. Even chemical rockets would be more practical if they could purchase fuel on the moon or other destinations. Nuclear rockets refueling at each stop would make inner solar-system travel routine.

New Worlds of Private Property

Chinese mandarins in the 1430s tried to pretend that nothing outside the Middle Kingdom was important. Likewise, our mandarins are trying to pretend that nothing outside their existing national borders (and docile, taxable populations) could be of any significance. Private property is forbidden even in the earth's oceans (with predictable tragedy-of-the-commons results on fish stocks and pollution), let alone in the rest of the solar system. This absence of private opportunity has caused a general blindness to the rest of the solar system in the business community. Since it can't be owned, it doesn't exist.

There are some limited exceptions. Communication satellites have become a mature multibillion-dollar industry. Weather and survey satellites are economically important. And of course all the ballistic missiles aimed

at the world's cities will pass through space on their way to their undefended civilian targets. But these are rather peripheral uses for the entire solar system.

If a 21st-century version of the Homestead Acts were passed, what would a solar system pulsing with commercial operations look like? At this point we are like Europeans in 1500s trying to see the commercial opportunities in the Americas. We will not be able to predict even a fraction of a percent of the eventual wealth and culture that will flow out of space civilization. But even the little that we can foresee with certainty surpasses all earthbound economic accomplishment. There will be trillionaires out there; there's platinum in them there asteroids.

Currently it costs over $25,000 to put a kilogram into earth orbit by space shuttle, whether you're sending up a computer or a liter of water. Even Boeing subsidiary Sea Launch charges over $1,000 per kilogram, sending your cargo up on old Russian rockets. Ironically, it is easier to transport bulk cargo into earth orbit from millions of miles through space than from the ground. Physics will probably ensure that this remains true even when private launch companies take over from governments.

The Wealth of Asteroids

Hundreds of "near-earth asteroids" are known; more are discovered every year. Some asteroids are energetically "closer" than the moon. To reach them, a vehicle would need to travel only a couple hundred miles an hour. Conversely, to land on the moon you must brake against its gravity, then fight it on takeoff. Since the moon's escape velocity is about 5,000 miles per hour, the rocket must change speed a total of 10,000 miles per hour. And all this speed must be applied quickly; a gentle push (say, from a solar sail) won't get you off the moon, while a small constant thrust can move an asteroid.

Unlike earth's heavily oxidized crust, asteroids come presorted into different ore types. Asteroids range from pure-metal types richer than any earth-surface ore to "rocks" to carbonaceous chondrites rich in water and carbon. (Earth ores are oxide or sulfide rocks; metal asteroids are pure metal; many contain more platinum than any earth ore.)

While it may seem outrageously expensive to talk about moving a whole mountain of ore millions of miles through space, in terms of energy it is much easier than moving the same millions of tons of material out of Africa on trucks, then on ships across the ocean, then back onto trucks, and so on. An asteroid in orbit has no friction to obstruct movement; even the slightest push in the right direction will accumulate. A nuclear rocket could move a carbonaceous asteroid by pumping water or other volatiles from the core; a "mass-driver" could throw chunks of rock or metal asteroid; less patient asteroid miners could deliver gentle kicks with nuclear bombs.

If you happen to be of the persuasion that is terrified by all things nuclear, remember that a large proportion of the earth-crossing asteroids will eventually hit the earth with gigaton explosions if we *don't* alter their courses. If you really care about the long-term future of life on earth, moving asteroids is an essential task to prevent extinctions (and possibly a permanent Ice Age). Asteroid mining provides the ability to defend the ecosystem as a free byproduct.

Another minor safety note: in 2004 a smallish asteroid passed less than 8,000 miles from the earth. It would have made a mere one-megaton blast had it hit. Of course had it hit in India, Pakistan, Israel, or any other hair-trigger hot spot, it might have been rapidly followed by many other manmade blasts. Asteroid mining would warn against such surprises.

Small bits of metal asteroids may be splashed down into shallow seas and mined for use on earth. But the real significance of asteroid mining is that it will allow construction of large, cheap, safe structures in space. Solar-system civilization will probably parallel the history of the Americas in this way. While there was some initial fishing and mining for return to Europe, the real significance of the New World was the civilization and people that grew here.

Another use for moving asteroids and/or comets around is to terraform Mars or other bodies. A variety of techniques have been suggested, from adding fluorocarbons to create a greenhouse effect to simply adding water from carbonaceous chondrite impacts. All the climate-changing effects that worry us so much on earth could be beneficial to a world already empty of life or mostly so.

Mars probably has enough frozen water and CO_2 to provide an ecosystem for plants, if it could all be melted at the same time. Terraforming may seem like a big project to us now, but where else can we put all those mammoths once we restore them from frozen DNA?

Supertankers in Space?

Current U.S. fusion-energy research concentrates on fusion reactions that release a large fraction of their energy in fast neutrons. This neutron radiation requires thick and costly shielding, and the neutrons will perform alchemy on the structure of the reactor itself, changing harmless elements into radioactive isotopes. So even if current fusion reactors can be made to produce more energy than they consume, they will still produce large amounts of radioactive waste.

There is a fusion reaction that produces only heat energy and no neutrons. It uses helium-3, a fairly common isotope of helium, in a reaction with tritium. One great advantage of this reaction is that it would not require vast amounts of shielding, so it could be used in mobile applications (such as rocket engines).

Unfortunately, there is no good source of helium-3 on earth. (The helium that we drill from underground is actually the alpha particles emitted by radioactive elements deep in the earth's crust.) The gas-giant planets (Jupiter, Saturn, Uranus, and Neptune) contain large amounts of helium-3. John Lewis has suggested in his book *Mining the Sky* that this helium-3 could be separated out by cooling (helium-3 displays different properties at low temperatures than the more common helium-4). Fusion releases so much energy that the energy necessary to travel to the gas giant and back is a small amount of the energy available.

So one day tankers may cruise from Uranus or Saturn to earth, holds full of clean-burning nuclear fusion fuel. Or not; just because there is a potential energy payback does not mean that there is an economic return. Better sources of energy may be discovered. But as long as the discovery process occurs on the free market, no one will be forced to pay for any boondoggles.

If President Bush wants to go down in history as the President who *really* put man on the moon to stay, he shouldn't give one more billion to NASA or to the Russian kleptocracy that is currently supplying NASA with transport to the space station. New worlds aren't developed by government bureaucracies, but by industries, foundations, and individuals. To allow some freedom into the solar system, the U.S. government should do the following:

1. Eliminate the regulatory barriers to American space companies operating from equatorial bases (Beal Aerospace, Boeing Sea Launch, and others.). This means no more export controls against American-made satellite-launch rockets on their way to equatorial launch sites. And no more import controls on American companies buying ex-Soviet missiles and commercializing them. Fewer foreign nuclear missiles aimed at us would be a good thing in itself, and U.S. restrictions on their acquisition by private companies (in place since the elder Bush administration) are exceptionally stupid and dangerous trade restrictions.

2. Finally allow a private-property-rights regime in space. This means allowing private homesteading and trading of extraterrestrial property of all kinds: asteroids, planetary surface, orbital slots, and more. If someone (from whatever country) tows an asteroid back into earth orbit, he should own it. Likewise if someone constructs a facility on the moon or Mars, it should be his. Naturally there will be massive whining in the UN from "nations" whose rulers subsist mainly on U.S. Aid to Dependent Dictators. The Ugandan government once tried to claim the geosynchronous satellites over its country; but since they don't have any rockets, their claims were eventually treated with the respect that they deserved.

3. Contract out U.S. government space transportation needs, most military and all civilian. There is no more reason for NASA to be in the launch business than for the Food Stamp program to be in the farming business. If NASA wants to go somewhere in the solar system, it can buy a ticket from a private launch contractor, with competitive bidding.

4. Sell the three remaining 1970s-era shuttles—if anyone can get liability insurance on them.

Thirty-six years since Armstrong has been long enough to demonstrate the futility of NASA's bureaucratic model. America is not Imperial China and shouldn't be repeating the same mistakes. It is time to introduce private property into the rest of the solar system.