Toward a New Vision of Manned Spaceflight

President Bush wants to give NASA a second life. Good.

MARK WILLIAMS

FROM May 1961, when Alan Shepard became the first American in space, Gene Kranz was the man to have running Mission Control. He was flight director for *Apollo 11*'s Mare Tranquillitatis touchdown in 1969 and *Apollo 13*'s aborted mission in 1970 (and he was played by the actor Ed Harris in the 1995 movie *Apollo 13*).

When I interviewed him in 2001, Kranz decried America's abandonment of manned space exploration. "NASA is not living up to its responsibilities to make space more accessible," Kranz insisted. "If you compare the situation to the development of the U.S., where they moved from the East Coast to the Mississippi and then onwards, it's almost like we've halted at the Mississippi, and we just keep sending the explorers and scouts across, not the merchants, shop owners, and farmers."

For anyone who had participated in NASA's heroic age, it must have been galling that as the 21st century began, the only operational manned spacecraft in which the U.S. had a hand were the shuttle—an expensive Earth-orbiting truck—and a space station a few hundred kilometers above the planet's surface. After all, to reach the moon in 1969, the U.S. space program had crammed an enormous amount of technological innovation into a single decade. In building the Saturn V rockets—3,200 tons and 36 stories tall—and devising Apollo's computer, imaging, and control systems, NASA had invented technologies with wide applications beyond spaceflight. Some of those technologies (like the telecommunications satellite) are vital elements of today's global civilization. If we had sustained this rate of progress, true believers argue, we might have reached Mars by now.

If we're not exploring Mars, they conclude, it must be NASA's fault. Thus, when *SpaceShipOne*, privately developed by aviation pioneer Burt Rutan and Microsoft billionaire Paul Allen, won the $10 million Ansari X Prize after its second ascent to the edge of space on October 4, 2004, some called it a defining moment—a sign that the era of privatized spaceflight had arrived.

If only for Gene Kranz's sake, it would be pretty to think that the flight of *SpaceShipOne* bears comparison to the opening of the American frontier. But a cheap, reliable means of lifting payloads into low earth orbit, 350 to 1,400 kilometers from the planet, remains the *sine qua non* for opening space. To achieve its three minutes at an altitude of 100 kilometers, *SpaceShipOne* traveled at three times the speed of sound. To reach low earth orbit, it would need to travel 10 times faster than that and consume about 50 times as much energy; during reëntry, that energy would have to be dissipated.

No space plane constructed with existing materials could satisfy those demands and still carry enough fuel to power out of Earth's gravity. *SpaceShipOne*, with a novel hybrid engine that used nitrous oxide (or liquefied laughing gas) and hydroxy-terminated polybutadiene (rubber), is a stunt designed to suck in moneyed space tourists and kindle a private manned-spaceflight industry. In those limited terms, it's a success. Following an announcement by Virgin Atlantic Airways chairman Sir Richard Branson about a new space venture called Virgin Galactic, the X Prize Foundation—the St. Louis nonprofit that sponsored the Ansari X Prize—proposed an annual multimillion-dollar event that, commencing in 2005, could become a jaunty mix of Grand Prix car racing and a kind of Olympics for rocket engineers. Meanwhile, Nevada millionaire Robert Bigelow started talking about a $50 million contest, called America's Space Prize, to build spacecraft that could reach orbit and service inflatable orbital modules now being developed by Bigelow Aerospace.

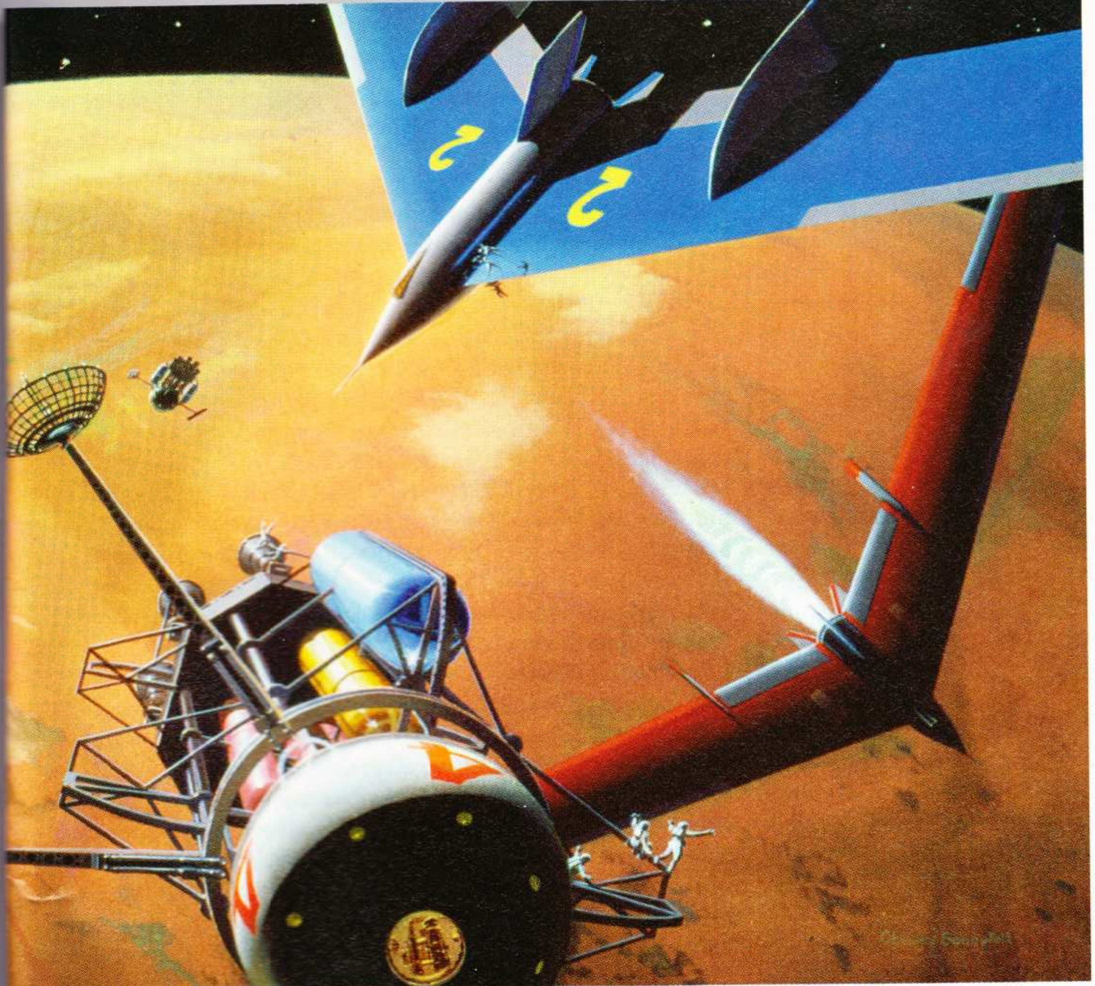
Even without this private-sector activity, 2004 saw revived interest in manned spaceflight. In January, the Bush administra-

Flight Readings

Report of the President's Commission on Implementation of U.S. Space Exploration Policy: A Journey to Inspire, Innovate, and Discover
www.nasa.gov/pdf/60736main_M2M_report_small.pdf

Speech by President George W. Bush, January 14, 2004
www.nasa.gov/pdf/54868main_bush_trans.pdf

New Moon Rising: The Making of America's New Space Vision and the Remaking of NASA
By Frank Sietzen Jr. and Keith L. Cowing
Apogee Books, $33.95



BONESTELL SPACE ART

tion announced a new mission for NASA that included sending astronauts to the moon, Mars, and beyond. Bush-haters dismissed the initiative as a cynical ploy. But in coming decades, even if the private sector can reach Earth orbit with reduced launch costs, the cutting edge of spaceflight—deep-space exploration—will necessarily be the province of expensive, government-funded programs.

The Bush initiative has now defined the goals for one such program. Furthermore, this is the first time any U.S. administration has set forth a policy of *continuing* exploration. The agency's new mission statement fulfills the fondest desires of true believers like Gene Kranz. "The greatest need is for NASA to establish some sense of direction," Kranz said in 2001. "I would like to see a set of goals for the next 50 years and a plan for the next 20, with a Mars mission set for around 2025."

(Re)Ignition

The "Report of the President's Commission on Implementation of U.S. Space Exploration Policy" calls for finishing construction on the International Space Station by 2010, and for continuing research there on how weightlessness and radiation affect human physiology. The shuttle will be retired. By 2008, the U.S. will have developed a new manned vehicle: the Crew Exploration Vehicle, or CEV, which will conduct its first mission no later than 2014 and be capable of transporting human personnel to the International Space Station. Using the CEV, American astronauts will return to the moon between 2015 and 2020. A permanent moon base could exploit the moon's lower gravity for the launching of future spacecraft. Though no exact timetable has been set, Mars is next.

If we're returning to space, it's hardly premature. When Kranz—who still has a high-school term paper he wrote in 1950 called "The Design and Possibilities of the Interplanetary Rocket"—gazes up at the moon on starry nights in the small city near Houston where he's retired, the sight must be bittersweet. The last man to walk on the moon, Eugene Cernan of *Apollo 17*, is now 70. All 12 U.S. astronauts who visited the lunar surface will be dead in another generation. A generation after that, most of the global population alive between 1969 and 1972—when NASA's six moonshots came to seem almost as routine as the Concorde's transatlantic flights—will also shuffle off this mortal coil. The Apollo project will then pass into history, like Egypt's pyramids and medieval Europe's great cathedrals. When Sir Arthur C. Clarke was asked what event in the 20th century he would never have predicted, he spoke for many when he said, "That we would have gone to the moon—and then stopped."

The conventional explanation for why NASA faltered after Apollo is that the U.S. went to the moon for national prestige; once that goal had been accomplished, there was no incentive to go any farther. Yet the fact that NASA rejected technologies that might have furthered manned exploration is evidence that America undertook the space race for reasons other than bragging rights. The U.S. space program was a product of the Cold War, of a planet so militarized that even at its poles, the great radar networks of NORAD and its Soviet counterpart ranged against each other and nuclear subs cruised below the ice. In this context, the U.S.S.R.'s 1957 launch of the satellite *Sputnik* potentially extended the battlefield into space. NASA was formed for purposes of American national survival—not prestige.

By 1962, both sides had rocketed men into orbit. The next beachhead was the moon. Here the U.S. had an advantage. After World War II, Wernher von Braun had brought Hitler's rocketeers to America. German ideas profoundly influenced American conceptions of manned spaceflight.

In a series of articles in *Collier's* magazine in the early 1950s, von Braun inflamed popular anxiety about Soviet intentions for space by describing space stations as platforms for spying and launching nuclear weapons. The space race guaranteed that von Braun—first as director of the U.S. Army's missile program, and then as head of NASA's Marshall Space Flight Center—would see his giant Saturn boosters built. But because national security drove the U.S. space program, von Braun's master plan, in which Saturn rockets would be cannibalized while in orbit and refitted as assembly stations for fleets of interplanetary ships, was discarded by NASA for the lunar-orbit rendezvous scheme chosen for the Apollo program. By landing a couple of astronauts in a lunar excursion module, Apollo offered the fastest route to the strategic high ground.

Apollo remains human history's most brilliant project. Yet in the long term, it offered nothing that made space more accessible. If NASA had gone with von Braun's initial plan, an array of space stations might have been orbiting Earth by the 1970s. And there were other beckoning paths that NASA, shaped by the shifting exigencies of the Cold War, chose not to follow.

For instance, the nuclear-test-ban treaty of 1963 halted the United States' Project Orion, a top-secret effort to develop massive spaceships—on the order of thousands to millions of tons—propelled by nuclear detonations. In terms of its physics, Orion wasn't necessarily insane. Stanislaw Ulam, the coinventor of the hydrogen bomb, had conceived the idea the day after the first U.S. atomic-bomb test in 1945. Project Orion was led by Ted Taylor, designer of the U.S. nuclear arsenal's largest and smallest bombs, and included Freeman Dyson, an architect of quantum electrodynamics theory.

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To understand how Orion might have worked, imagine an enormous external-combustion engine. First, a nuclear bomb would be ejected through a hole in the bottom of Orion's hull and detonated. Matter packed around the bomb would become exploding plasma. A thousand-ton aluminum pusher plate, fixed to the ship's stern on giant shock absorbers, would shield and cushion the ship from the blast. The shock would have propelled Orion through space.

Asked today how he could have proposed using several hundred nuclear detonations to launch the Orion spacecraft into orbit 500 kilometers above the earth, Dyson is sanguine: "The worldwide fallout from Orion would have been only about 1 percent of the fallout from atmospheric bomb tests then." Orion would have been a Faustian bargain, but the payoff was raw power: nuclear fission releases a million times as much energy as burning chemical rocket fuel. Dyson, for one, expected to be junketing around the solar system with a crew of 40 by 1970.

Fuel Deficiency

The central claim of Orion still stands today: chemical rockets are ill-suited to deep-space exploration. "Already in 1958," Dyson has written, "we could see that von Braun's moon ships would cost too much and do too little." For chemical rockets, metallurgical physics is destiny. The melting temperature of the engine's alloys limits the velocity of its ejected gas to between three and five kilometers per second. The only way to make a rocket reach even low earth orbit—which takes a velocity of eight kilometers per second—is to use booster stages. By this method, however, lifting one ton of payload into orbit requires about 16 tons of chemical rocket. To make a round trip to the moon, as Apollo did, meant five stages and almost 1,000 tons of chemical rocket for every ton of crewed module.

During the 1960s, NASA declined to pursue either of two strategies that would have made manned spaceflight feasible in the long term. The first was development of von Braun's orbital platforms, where smaller modules lifted out of Earth's gravity could be assembled into larger space-going vessels. The second was the development of an alternative to chemical rockets.

Does NASA's new mission, as framed by the Bush administration, suggest that these lessons have been learned?

New Moon Rising: The Making of America's New Space Vision and the Remaking of NASA, by Frank Sietzen Jr. and Keith L. Cowing, is a book so rushed it seems unedited. Still, it sheds some light, and true believers have reason to be guardedly optimistic. Two major NASA projects, Constellation and Prometheus, will provide the technologies central to achieving the agency's new goals. Constellation will develop several models of the new Crew Exploration Vehicle: the first to carry astronauts into orbit around the earth, the second to travel to the lunar surface, and later versions to reach other planets. An essential part of von Braun's interplanetary strategy is being revived: CEVs may be assembled in Earth orbit. Meanwhile, Project Prometheus will develop a nuclear-powered electric propulsion system that could carry a spacecraft to destinations like Mars.

At first glance, it seems that the technologies that NASA once rejected are being reconsidered. But Freeman Dyson points out that the most important criterion for a nuclear electric propulsion system like that of Prometheus is the weight-to-power ratio, measured in kilograms per kilowatt. To substantially improve on existing chemical rocket systems, Dyson says, the system needs a ratio no greater than five kilograms per kilowatt. Unfortunately, in the current NASA proposal, the Prometheus system would have a ratio of 300 kilograms per kilowatt. "If Prometheus is funded," says Dyson, "it will set back progress in planetary exploring by 20 years. If we are serious about developing a nuclear system, we need a totally new kind of reactor, operating at much higher temperature than existing types." Developing that reactor, he says, will take a long time.

There are other problems. Most significantly, human beings may not be able to survive the levels of cosmic radiation pervading the solar system beyond Earth's magnetic field for the periods demanded by interplanetary missions. Even on the Russian Mir space station and the International Space Station—both within the protective veil of Earth's magnetosphere—weightlessness and radiation have been substantial hazards for astronauts and cosmonauts spending extended time in space. Exposure to cancer-causing cosmic radiation during a three- to five-year round trip to Mars would be equivalent to receiving 25,000 chest x-rays. The Apollo program's proposed tactic for dealing with solar flares—which was to abort the mission and return to Earth—will not be an option. Consequently, NASA researchers in Mountain View, CA, hope to use carbon nanotubes or other nanoparticles *(see "Mitsubishi: Out Front in Nanotech," p. 34)* to detect, diagnose, and treat the cancers and other health disorders inherent in manned spaceflight.

But for prolonged spaceflight, humans would probably require more radical biological enhancements. Future astronauts might differ significantly from their terrestrial kin. This is a long way from the vision of space travel for the masses that was promoted by Gene Kranz and Freeman Dyson. And as with the development of a new reactor, it might take a long time to create these demi-human space-farers. Concerning the future of human beings in space, a Kafka quote might apply: "There is infinite hope. But not for us." ■