THE NEW ATLANTIS
A JOURNAL OF TECHNOLOGY & SOCIETY

A New Vision for NASA

Adam Keiper

America's manned spaceflight program is in disarray.

You can see it in the technology. The future of the shuttle fleet is unclear. The International Space Station, a shadow of what it was meant to be, begs for a purpose. Plans for new spacecraft are jumbled and uncertain.

You can see it in the people. The achievements of the U.S. astronaut corps routinely go unnoticed. Critics of NASA have said the agency has a "broken culture." The loss of the shuttle *Columbia* further demoralized a program that was already suffering from sagging spirits and lagging schedules.

And NASA isn't just haunted by the ghosts of astronauts lost: the agency is forever haunted by its own former glory, by the memory of the flags and footprints on the Moon.

We are now at a peculiar moment in humanity's journey into space. America's space shuttles sit cold and quiet, but China, a nation with a burning ambition for prestige and power, has just had its first successful manned space mission. Other countries, and many private companies, are eyeing new ways to exploit space. Yet the agency that won the Space Race is now in the third decade of the Space Malaise, with creaky technology and no long-term goals.

To put America's space program back on the path to greatness, we must first take a hard look at the causes of its stagnation and its failures, and then must give it a new purpose—one directed to exploration, discovery, and adventure.

Columbia and the Culture of NASA

America's space agency is now forty-five years old. Created one year after the Soviets launched the first artificial satellite in 1957, NASA was soon charged by President Kennedy with the goal of landing a man on the Moon by the end of 1969. Between July 20, 1969 and December 14, 1972, twelve Americans walked on the Moon—but after meeting that goal, NASA fumbled for direction. The final Apollo lunar landings were scrapped, although the program still had enough momentum to complete two spin-off projects: the Skylab space station and a test docking with a Soviet spacecraft.

After Apollo's anticlimax, public interest in spaceflight waned. Since then, NASA's manned spaceflight program has, with a few exceptions, only obtruded on the national consciousness when things have gone wrong—most terribly in the accidents that destroyed *Challenger* and *Columbia*. For the public and for pol-

---

Adam Keiper *is managing editor of* The New Atlantis.

icymakers, the focus in the months after both those accidents was on mourning the dead, investigating the causes, improving the safety of the space shuttle, and doctoring to NASA's bureaucratic stiffness.

The official inquiry into the *Challenger* accident revealed serious problems in the way NASA handled matters of safety. Now the Columbia Accident Investigation Board has concluded—quite damningly—that some of the same attitudes and behaviors that doomed *Challenger* crept back to doom *Columbia* seventeen years later. Crept back—or never left.

According to the board's thorough final report, *Columbia* was destroyed because it "re-entered Earth's atmosphere with a pre-existing breach" in the front of its left wing. The hole in the wing caused the crew no problems in space, but during the shuttle's descent at more than twenty times the speed of sound, hot air—superheated to thousands of degrees by friction with the shuttle—entered the hole and began to disintegrate the wing. The shuttle's automated control systems worked "furiously" to keep *Columbia* on its planned flight profile, and performed so well that neither the crew nor ground control recognized the seriousness of the problem as the shuttle streaked lower and lower. Then, after shedding debris, the shuttle broke up over Texas, less than 1,000 seconds after re-entering Earth's atmosphere. Minutes ticked by and flight controllers "still had no indications of any serious problems." As the expected tracking and communications signals failed to appear, it became clear to shuttle managers that there had been a major problem—finally confirmed by live TV coverage of the shuttle's break-up.

According to the board's report, the crew died of "blunt force trauma and hypoxia" when the crew module broke up more than twenty miles above the ground. Pieces of the shuttle fell in eastern Texas and western Louisiana. In the weeks that followed, searchers found more than 84,000 pieces of *Columbia* debris—including an intact flight data recorder—most of which were assembled in a hangar and used by investigators to determine the cause of the accident.

Relying on photographic evidence, sensor data, and information learned from the wreckage, the board found that the hole in the wing was caused by a piece of foam insulation which broke off from the area where *Columbia* was attached to its external fuel tank—the rust-colored hulk that towers over the spaceward bound shuttle. The foam was jarred loose at 81.7 seconds into the launch. Less than two-tenths of a second later, it hit the wing. Although the foam was light—roughly the dimensions and weight of three rolls of household paper towel—it was moving at 545 miles per hour relative to the shuttle, so it had enough momentum to damage the thermal protection panels on the wing. In fact, when the investigators replicated the impact by firing foam projectiles into a mockup of the wing, they found that the foam could crack the wing's thermal panels, or even punch a large hole in them.

The heartbreaking conclusion of the investigation board is that the crew of *Columbia* could perhaps have been saved. The damaged shuttle couldn't have docked with, or even reached, the International Space Station, but by working around-the-clock for three weeks, another shuttle—*Atlantis*, only a few weeks from its own launch—could have taken off with a crew prepped for a rendezvous and rescue spacewalk. (This would have been the first case when two shuttles were in space at the same time.) And even if no other shuttles were available for a rescue mission, the astronauts on *Columbia* might at least have improved their chances of survival by using "onboard materials to rig a temporary fix" for the damaged wing, and then modifying their flight plan to make the re-entry less stressful for the crippled spacecraft.

Yet these options were never even raised, because the mission's managers were convinced that the foam strike, which they knew about by the second day of the flight, didn't endanger the shuttle. While many of the engineers working on the mission were worried about the impact—some even thought that the foam might have damaged the shuttle's landing gear badly enough to require *Columbia* to make a never-before-tried water landing—the mission's managers weren't receptive to the engineers' concerns. The managers "displayed no interest in understanding" the foam problem, according to the investigation board, so the concerned engineers "found themselves in the unusual position of having to prove that the situation was *unsafe*—a reversal of the usual requirement to prove that a situation is *safe*."

In fact, the board found that on at least eight occasions the mission's managers missed opportunities to determine the extent of the damage caused by the debris. They could have asked other government agencies to deliver satellite images of the shuttle. They could have asked the crew to download video footage of the launch, or even to attempt an inspection of the wing. Eight days into the flight, the mission's managers did eventually get around to telling the crew about the foam strike—"not because they thought that it was worthy of the crew's attention but because the crew might be asked about it in an upcoming media interview," according to the board. The crew was told by e-mail that the foam hit caused "absolutely no concern for entry."

In NASA's miserable handling of the foam question, "bureaucracy and process trumped thoroughness and reason," according to the investigation board. The board's report describes NASA's "organizational culture" as seriously flawed: Dissent is stifled; management hierarchies are far too rigid; important information is watered down as it moves up the chain of command; and a "cultural fence… impairs open communication between mission managers and working engineers."

Worse still, many of the organizational flaws that brought down *Columbia* were the same that were responsible for *Challenger*, "such as inadequate concern over deviations from expected performance, a silent safety program, and sched-

ule pressure." What's more, "the board strongly believes that if these persistent, systemic flaws are not resolved, the scene is set for yet another accident."

The NASA responsible for the *Challenger* and *Columbia* accidents is a "less technically and organizationally capable organization than the Apollo-era NASA," the report says. To get a taste of just how different NASA's "organizational culture" was three decades ago, one need only read *Failure Is Not an Option*, the memoirs of Gene Kranz, the flight director for the Gemini and Apollo missions. Kranz writes of his tough young team working long and wearying hours, racing to identify and solve problems, always soliciting opinions from engineers and everyone else involved. His motto was, "Spaceflight will never tolerate carelessness, incapacity, and neglect."

When asked recently by the Associated Press what he thought about the "culture" problem at NASA, Kranz emphasized the need for accountability: "Look, these people are professionals," he said. "They're being paid a professional wage. If they have a problem, I expect them to stand up and speak up. Period… We've got 19- and 20- and 21-year-olders over in Iraq right now who have to make daily decisions. It's no ambiguity. I don't think we should expect anything less of the people who are working in the space program. Daily decisions, no ambiguity."

But it seems that today's NASA leadership has another approach to fixing the agency's culture problems: "trying to make NASA's shuttle program a warmer, fuzzier place," according to the AP. "To these reformers, that means being super-sensitive about their words, their tone, their height, even the shape of their conference table." Wayne Hale, the new deputy director of the shuttle program, says he is "stocking up on sociology books." Here is his reply when asked why he doesn't try to return to the management techniques that worked so well for NASA in the 1960s and 70s:

> They were dealing with all white males, and there was a lot of in-your-face, militaristic almost [communication]… I'm still a student at this, but if you want to inhibit communication, that's a good way to do it these days.

Hale and the other new officials in the shuttle program would do well to remember that the managers they replace, the ones who left after the *Columbia* accident, betrayed the trust of the astronauts and the entire country; as the accident investigation board report puts it, "some Space Shuttle Program managers failed to fulfill the implicit contract to do whatever is possible to ensure the safety of the crew." Hopefully, Hale's sociology books will instruct him on how to inculcate accountability among the managers and banish the complacency that brought down *Columbia*. But there is good reason to be skeptical.

The Shuttle: An Unmitigated Failure

One reason some NASA managers were untroubled by the foam impact on *Columbia* is because flying foam wasn't a new phenomenon. *Columbia* was the old-

est shuttle of the fleet, and on its very first launch in 1981, it sustained so much damage from debris that more than 300 of its 30,000 thermal protection tiles had to be replaced. Of the 79 shuttle launches for which NASA has decent photographic imagery, 65 launches show evidence of foam shedding. Even in many of the cases where NASA doesn't have launch images available, damage on the shuttles after their return to Earth indicates foam hits. Sometimes the foam damage was quite serious; the mission commander for one 1988 flight said his shuttle "looked like it had been blasted by a shotgun."

In seven known instances, including *Columbia*'s final flight, the foam came off the external fuel tank from the top-left spot where the tank and the shuttle connect. Five of those seven incidents involved *Columbia*. By the time of *Columbia*'s demise, shuttle managers didn't think of foam as a big deal any more; they became "conditioned over time to not regard foam loss or debris as a safety-of-flight concern," according to the investigation board. That foam hits were mostly harmless was taken for granted—so much so that even *after* the shuttle was lost, NASA's managers wouldn't accept that foam might have been at fault. "It just does not make sense to us that a piece of debris could be the root cause of the loss of *Columbia*," said shuttle program manager Ron Dittemore four days after the accident. "There's got to be another reason."

The sad truth is, even though the complexity of the space shuttle is a marvel of technical engineering, its design is fundamentally flawed. The shuttle is a bastardized version of a concept that doesn't completely make sense, and it has never been able to do what it was intended to.

The shuttle was originally envisioned as one small part of man's grand future in space. Going back at least to the early 1950s, space enthusiasts and rocket experts—including Wernher von Braun, the former Nazi rocket pioneer who became the genius behind America's successful rocket program—envisioned an orbiting space station that could serve as the launching base for trips to the Moon, Mars, or beyond. Massive vessels for long-distance voyages would be assembled in space and would remain there, while smaller spacecraft would shuttle back and forth between the space station and Earth, carrying people and supplies.

For a half-century, some version of this integrated vision, with its logical progression and simple concinnity—shuttle to station, station to ship, and thence to the planets!—has remained in the background of America's space aspirations, always coloring the long-term thinking of planners and policymakers, even when it's not openly acknowledged. For a while, it seemed as though the enormously successful Apollo program would demolish this grand scheme by proving we could bypass the shuttle and space station, and just hurl astronauts straight to the Moon. But as the Apollo missions wound down, the vision of the space station resumed ascendancy.

NASA planners energetically went about drawing up budgets and programs, the boldest of which would launch a Mars expedition by 1981. Yet even if the nation could afford to embark on this grand adventure, there was no political support for it in the late 1960s and early 1970s (aside from a short-lived burst of Mars mania from Spiro Agnew). With the pressure of the Space Race over, and with other major domestic and international concerns dominating the political agenda, neither President Johnson nor President Nixon was willing to commit to a massive new space program.

So the plans were whittled down. Mars was out of the picture. No more Moon missions. No space station. All that was left of the grand vision was the shuttle.

The years of political maneuvering, fighting, and painful compromises over the size, design, cost, and function of the space shuttle are deftly chronicled in *The Space Shuttle Decision, 1965-1972* by T. A. Heppenheimer. In the end, the shuttle was supposed to "revolutionize transportation into near space, by routinizing it," in President Nixon's awkward phrase. Since most of the shuttle system was designed to be reusable, it was supposed to "take the astronomical costs out of astronautics," Nixon said. The shuttle would serve both military and civilian projects—and would offer a cheaper alternative to satellite makers who would otherwise have to pay for disposable rockets to carry their satellites into space.

By all of those criteria, the space shuttle has been a failure. As the Columbia Accident Investigation Board points out, the shuttle "has never met any of its original requirements for reliability, cost, ease of turnaround, maintainability, or, regrettably, safety." It cannot be launched quickly to respond to sudden needs, since it takes so long to refurbish after each flight. It's no longer used to carry commercial or military payloads. And the shuttle certainly hasn't "routinized" space. Far from it. Of the five shuttles America has launched into space, two have been lost. The shuttle fleet was supposedly going to make about 50 flights every year; in fact, the fleet has made only 113 flights in the last twenty-two years—and lost fourteen astronauts along the way.

Even the essence of the shuttle concept must be deemed a failure. The shuttle was supposed to make it cheaper to reach orbit, since most of the shuttle system is reusable. Unfortunately, the desire for cheap reusability is what dictated the shuttle's dangerous design. The shuttle and its crew has to "sit right in the middle of all the turmoil of launch… the most vulnerable position possible in terms of engineering design and safety." So says former NASA aerospace engineer Homer Hickam, the author of *Rocket Boys* (a.k.a. *October Sky*). As Hickam sees it,

> the space shuttle program may well be NASA's Vietnam. A generation of engineers and managers have exhausted themselves trying to make it work and they just can't… The truth is no amount of arm-waving and worrying about "culture" can fix a flawed design… Simply put, had that spaceplane been on

top of the stack, the destruction of *Columbia* would not have occurred because its wings would have been out of the line of fire. *Challenger* would probably not have happened, either. Had the spaceplane been above the explosion, it likely would have been able to punch out and glide back home.

Incidentally, the shuttle's reusability hasn't actually made reaching orbit any cheaper, since the shuttle remains expensive to launch and refurbish. Although it's very difficult to calculate the cost, most estimates peg the price of each shuttle launch at around $450 million (a tenfold increase over what the planners hoped).

The shuttles were originally intended to serve only ten or twelve years, but NASA now estimates that the fleet may have to last until 2020 or beyond. A "Shuttle Service Life Extension Program"—basically a series of planned upgrades—should make that longevity possible. But investments in shuttle upgrades, like investments in other areas of shuttle infrastructure, have been "mired by the uncertainty surrounding the shuttle program's lifetime," according to the *Columbia* accident investigators. If the shuttle is just going to be phased out anyway, or so the logic goes, what's the sense in spending on upgrades?

The Space Station: A Bottomless Pit

In the 1960s, the Mercury spacecraft were designed with one goal in mind: putting a man in orbit. The purpose of the Apollo spacecraft was to make the Moon shot. But the space shuttle was designed with no clear objective. It was originally dreamed up, as Gregg Easterbrook wrote in an insightful and prescient 1980 *Washington Monthly* article, as "a space truck to lug things back and forth to orbit. The craft itself would have no scientific function. It was assumed by [shuttle designers] that, once the shuttle was approved, somebody could devise some missions for it." The shuttle concept may have made sense as part of the grand scheme for humanity's spacefaring future—*shuttle, station, ship, and beyond!*—but without even a space station, as a 1988 *Time* magazine article put it, NASA was "riding a splendid shuttle to nowhere."

Naturally, NASA did find things for the shuttle to do. Originally, the shuttles carried commercial satellites into space, but after the *Challenger* accident, the Reagan administration ended that practice; to ease the schedule pressure on NASA, shuttles were forbidden from carrying commercial payloads except in extenuating circumstances. (As a result, since 1986 all those businesses wanting to send their satellites into space have had to find companies, frequently foreign, still using those supposedly outmoded disposable rockets.) The shuttles were used for classified military missions for a time, but those ended in 1992. Shuttles are still often used for science experiments; for launching or repairing NASA satellites and telescopes; and for educational programs.

Today, of course, the shuttle has a place to go: the International Space Station. With a pedigree that can be traced back to the same grand vision that

inspired the space shuttle, the International Space Station is but a humble thing compared to some of the space stations, bases, and colonies imagined in the 1960s and 70s—but it's much bigger than any previous space station actually built.

America's first space station was Skylab, launched in 1973, and staffed with a series of three three-man crews for less than a year. Skylab was made of hardware left over from the Apollo program; in fact, the station's vast main body was converted from a Saturn V rocket—the same kind of giant rocket used to send astronauts to the Moon.

Meanwhile, starting in the early 1970s, the Soviets built and launched a whole series of "Salyut" space stations. The last two Salyuts had dozens of cosmonauts come aboard over a span of several years. These were succeeded by Mir, the Soviets' biggest space station. Although we now remember Mir for the difficulties that plagued its final years—an out-of-control fire, a collision with a supply capsule, problems with power and with attitude control, and various other crises that made it sound like a zero-g death trap—it was actually quite successful during its long duration in space. It proved the value of modular space station design, with its main segment launched in 1986 and other pieces added throughout the next decade. And it proved that humans could endure very long periods of weightlessness—even in a hot, noisy, dirty, cramped tub filled with Russians.

There were countless aborted attempts to make an American space station after Skylab; some of these plans involved large crews and artificial gravity. Planning didn't begin in earnest until 1984, when Ronald Reagan supported a station to be built "within a decade"—"Space Station Freedom," as he came to call it. At first, NASA promised it could put a station in orbit by 1991 for just $8 billion. By 1987, the estimated cost had risen to $12 billion, even though the launch was delayed till the mid-1990s and the size of the station was reduced. By 1991, the estimated price had grown to $17 billion, even though the size had been reduced so drastically that critics took to calling the latest design "Space Station Fred" instead of "Freedom."

Foreign policy has always played a part in the plans for the space station. President Reagan hoped to involve many allies in the project, as a challenge to the Soviets. By 1993, however, with the Cold War over, the Clinton administration saw the space station as a way to build new ties with Moscow. Thus was born the International Space Station, intended to bring together the latest iteration of the American plan and Russia's designs for a second Mir. (Today, more than a dozen other countries are also involved.) The first pieces were put into orbit five years ago, and there are now six major modules and several smaller components in place; more are on their way.

But the space station faces major problems. The total cost of the station is difficult to pinpoint, with estimates between $30 and $60 billion—and the cost has been going up by at least $1 billion every year. Russia's contributions to the

station have been delayed repeatedly, thanks to that government's budget woes. In order to keep funding the U.S. work on the station, NASA has shifted money from other projects, sacrificing programs like a robotic mission to Pluto (the only planet in the solar system that remains unvisited). Even with such scrimping, the Bush administration has had to cancel several American contributions to the station, including the habitation module that would have allowed the station to house seven astronauts; without that module, the station can only house three astronauts for a sustained period. And in the wake of the *Columbia* accident, the crew size has been reduced to just two astronauts who will have to spend most of their time keeping the station running. Certainly there is no way a crew of two can find the time to perform any but the most rudimentary science experiments.

Congress, with its eye on the nation's pocketbook, has kept the pressure on the station. There have been "twenty-two attempts in Congress since 1991 to terminate" the space station, according to the Congressional Research Service. (They have all failed, of course, but some came close—including one bill that was defeated by a single vote in the House of Representatives.) Even some of the longtime supporters of the station, like Rep. Dana Rohrabacher, Republican of California, have found themselves frustrated by the slow pace of progress. As a speechwriter in the Reagan White House, Rohrabacher had drafted the 1984 radio speech in which Reagan explained his plans for the space station—yet by the late 1990s, Rohrabacher found himself "admitting that if NASA were to propose the space station today, I couldn't support it knowing what I know now."

The station-related pressure from Congress and the White House took an enormous toll on NASA, according to the report of the accident investigation board. The space agency was basically "on probation": NASA "had to prove it could meet schedules within cost" or it would face cutbacks. The agency set an aggressive schedule for launching the remaining U.S. contributions to the space station, and fixed a hard deadline of February 19, 2004, for launching the last core piece. NASA employees were given a screensaver that showed a clock counting down to that date, and the agency resorted to "what some employees termed 'tricks'" to keep up the breakneck tempo. In order to stay on the timetable, many employees of the shuttle program had to work through the winter holidays of 2002-2003; even so, "by December 2002, every bit of padding in the schedule had disappeared." All this just to meet a deadline that was essentially arbitrary.

This pressure doesn't excuse, but may help explain, the safety lapse that doomed *Columbia*: There was, it seemed, no time to pause for mistakes. "No one at NASA wants to be the one to stand up and say, 'We can't make that date,'" the report said. And even now, echoes of that attitude may remain. According to a *Washington Post* article in late October, NASA's most recent mission to the space station—launched aboard a Russian capsule because the American shuttles are still grounded—came "over the strenuous objections of mid-level scientists and

physicians who warned that deteriorating medical equipment and air and water monitoring devices aboard the orbiting laboratory posed increasing safety risks for the crew." One NASA physician quoted in the *Post* feared a replay of *Columbia*: "We are going down the same path in taking risks with the space station crew for the same dysfunctional reasons."

Still, if the space station is in such bad shape—much costlier than planned, much later than planned, much smaller than planned—why shouldn't we just cut our losses and abandon it now? Even those who have studied the matter closely seem uncertain. In a *Weekly Standard* article in 2001, Charles Krauthammer wrote that we should stop "squandering" and "frittering away" our money on the space station; two years later, in the same publication, he said we should keep the station running, although "just enough to sustain it," because "there's too much already invested."

The latter view seems sensible. It is likely that the station's core will be completed after the shuttle fleet starts flying again. And perhaps the station will resume expanding when the economic outlook turns rosier. Part of the station may someday be given over to private entities; in fact, the Russians and Europeans have been collaborating on designing a station module dedicated solely to commercial research. So we should stick with the space station, if only to keep our toehold in space—in case the action on the station picks up again. But the time has come to look further.

Still Lost in Space

The space station has reportedly been designed with a ten-year lifespan, but like the shuttle, it will probably have to stay in service much longer. Ten years seems awfully short, considering how long it took to get the beast up there. Frankly, there's no reason why the space station should have any expiration date at all: since it is modular in design, station components can simply be replaced as they deteriorate or become obsolete.

No one should be misled by the station's modular design or the shuttle's partial reusability into thinking that America's manned space program has great foresight, or a commendable knack for efficiency and thrift. In fact, the U.S. has a long history of wastefulness in space; we have a habit of throwing away things still in good condition. Our first space station, for instance. Skylab was spacious and sturdy—our first "house in space," one writer called it. When the third Skylab crew departed in 1974, they left packages of film and food by the entrance, in case another crew someday boarded the station. It still had plenty of water and oxygen aboard, too. NASA drew up plans to save Skylab, but those plans depended on the shuttle, which was far from ready for flight. Skylab's orbit decayed badly in 1978 and it became clear that the station would fall to Earth if it had to wait for a still-nonexistent shuttle to save it. But instead of even

attempting a rescue mission with one of its pre-shuttle systems, NASA chose to abandon Skylab. Spaceworthy resources costing billions of dollars crashed into Australia and the Indian Ocean in 1979. More than two decades elapsed before another American space station was open for business.

Something similar happened to Mir in the 1990s. When the Americans and Russians partnered to build the International Space Station, NASA coerced the Russians to abandon Mir in order to better concentrate their efforts on the joint project. A private company called MirCorp offered to make Mir profitable by turning it into "a platform for commercial activities such as in-orbit advertising, satellite construction and repair, recreation, and telecommunications services," according to Edward Hudgins, editor of the Cato Institute book *Space: The Free-Market Frontier*. MirCorp also had plans to bring the first space tourists to Mir, and to tape a TV show on the station. But despite the appeals of MirCorp—and despite Mir's role as a symbol of Russian achievement—Moscow caved to NASA's demands. Mir was deorbited in 2001.

Probably the most appalling act of improvidence in the history of America's space program was the decision to get rid of the Saturn V rocket. Many people believe that NASA cannot presently launch a mission to the Moon because we lost the technology we had in the 1960s "through bureaucratic incompetence," as one UPI writer claimed in October. In fact, the reason we can't go back to the Moon today is because we don't have a rocket powerful enough. The Saturn V, the crowning achievement of Wernher von Braun's rocketeers, was the most powerful rocket ever built. It had a perfect launch success record, and brought our Apollo astronauts to the Moon. But Senator William Proxmire, Democrat of Wisconsin, a lifelong critic of the space program, killed the Saturn V. Here's how Gordon Cooper, one of the original seven astronauts, tells the story in his 2000 autobiography, *Leap of Faith*:

> Proxmire saw to it that the entire Saturn V production and assembly line was shut down in the early 1970s, requiring even the destruction of the machinery and tooling necessary to build the rocket… In his grief over the destruction of his biggest and best rocket, Wernher von Braun, who lobbied Congress hard for a reprieve, told me in one of our last conversations that he considered it among the stupidest things this country—which he dearly loved and I'd never before heard him criticize—had ever done. I agreed… Why would any forward-thinking nation actually *destroy* its own leading-edge technology?… I'm *still* angry about it and will be until my dying day.

Proxmire, who expected to save money by preventing NASA from getting any more Saturn V rockets, didn't realize that the time would come when America would wish it still had the power of that giant for bringing the heaviest satellites into space. The most powerful American rocket in use today, Lockheed Martin's Titan 4B, can't even handle a *fifth* of the payload that the Saturn V could carry

into orbit, let alone make a trip to the Moon.

One other example of waste occurs every time the space shuttle blasts off. Just before the shuttle reaches orbit, its big external fuel tank is jettisoned to burn up in the atmosphere. Those tanks could almost certainly be brought to orbit, where they could be converted into floating labs or used as components for a space station. (Remember, America's first space station, Skylab, was built out of an empty Saturn V.) This idea, which has garnered consistent interest from private companies since at least the 1980s, has largely gone ignored by NASA. So far, 112 external fuel tanks have been detruded from shuttles; if only a fraction of those had been kept in orbit, there's no telling what uses American engineering ingenuity might have put them to.

These examples demonstrate more than just waste; they point to the dismaying short-sightedness of our space program. When seen in the larger context of the shuttle and the space station, neither of which has come close to reaching the modest goals originally set for it, there is no way to escape the conclusion that America's manned space program completely lacks a guiding vision.

This is a conclusion shared by the Columbia Accident Investigation Board, which found "a lack, over the past three decades, of any national mandate providing NASA a compelling mission requiring human presence in space." This aimlessness is not a failure of technology; it is a failure of leadership. "We believe," the board writes in its final report, "that the White House, Congress, and NASA should honor the memory of *Columbia*'s crew by reflecting on the nation's future in space and the role of new space transportation capabilities in enabling whatever space goals the nation chooses to pursue."

Not every country is stuck in a space policy limbo. In October 2003, China—the land where the rocket originated centuries ago—put a man into space for the first time. The capsule in which Yang Liwei circled the Earth was modeled after the Soyuz, the workhorse of Russia's space program. Indeed, the Chinese received a great deal of Russian advice and assistance, particularly in the areas of technology and training.

Yang's trip lasted more than twenty-one hours and took him on fourteen orbits around the Earth. The Soviet Union had accomplished such a flight by 1961, and the U.S. by 1962—years before Yang was even born. But even though we could do the same thing four decades ago, the Chinese spaceflight is no minor achievement: in fact, it's a black eye to our manned space program. Most of the news stories about Yang's flight cast it as a great success for China in a year in which the Americans had to freeze their unsafe space program. For a country vying to be seen as one of the world's great powers, the flight was a perfectly-timed publicity coup. (The Chinese may have been following the example set by the Soviets in 1986: they sought to capitalize on the *Challenger* accident by putting the first manned crew on Mir about two weeks later.)

But more ominously, Yang's flight is an indication that China *gets* space. Western intelligence experts have been suggesting for years that Beijing is making serious advances in military space, and now we see that the Chinese also understand the prestige that comes with space power. According to press reports, China now has its eyes set on the Moon: a robotic probe—no doubt timed to coincide with the Beijing Olympics—is expected in 2008, while a manned mission to the lunar surface could take place by 2020. Meanwhile, what goals does the U.S. have for its manned space program in the next two decades? Endless tinkering on the space station?

In some ways, it's easier for China to set glorious goals for its space program than it is for the United States to do so. For one thing, China isn't already committed to spending billions of dollars on largely failed ideas like the space shuttle and space station. Also, China's space program is run by the highly centralized People's Liberation Army, which can think up long-range policies and stick to them. Our space program is civilian, and in our democratic system it isn't easy to hold fast to plans that promise distant glory.

In the United States, we don't even have a central body to help steer space policy. Lou Dobbs, CNN's financial guru and the founder of Space.com, wisely argues in his 2001 book *Space: The Next Business Frontier* that we should

> create an external entity to ensure that NASA hits its marks. In other words, set goals and achieve them. There's been a lot of talk about re-instituting a National Space Council, an advisory group last seen under the first Bush administration and eliminated by the Clinton White House. Practically speaking, we should ratchet up the NSC by also setting up a board of directors… [including] a National Space Adviser, key members of Congress, academics, former astronauts or NASA scientists, a retired aerospace executive or two.

At the very least, such an institution could help NASA, Congress, and the White House in choosing which kinds of research are worth pursuing. NASA spent many years and billions of dollars researching next-generation space vehicles with which to replace the shuttle, but the agency has nothing to show for it. In the 1980s, there was something called the National Aerospace Plane. In the 1990s, there was the X-33 and the X-34. In 2000, NASA started the Space Launch Initiative. Each of these projects failed, in a pattern chronicled in the Columbia Accident Investigation Board's report: "Optimistic pronouncements about a revolutionary shuttle replacement, followed by insufficient government investment, and then program cancellation due to technical difficulties"—all in all, a "failure of national leadership." It now appears as if the same pattern is being followed in the plans for the Orbital Space Plane, NASA's latest planned shuttle replacement. An entire panel of witnesses facing a Senate committee in late October testified that NASA should halt the development of the Orbital Space Plane, and two powerful Representatives—the top Republican and

Democrat on the House Science Committee—have complained that they don't see "how the Orbital Space Plane fits into an overall vision for the human space flight program."

The fact of the matter is, there are far too many good ideas for NASA even to begin funding them all adequately, and the agency must encourage private investment in space. Small amounts of private money have already gone a long way in space: for example, a private foundation has set up a $10 million award that will go to anyone who can build a spacecraft capable of carrying three people to an altitude of 62 miles—that's one definition of where space begins—and return safely to Earth, and then do the same thing within two weeks. This contest, known as the "X-Prize," has attracted nineteen teams, and according to recent press reports, some of the competitors may make their first attempts at the prize in the next few months. If NASA's shuttles remain grounded until late summer or fall of 2004, as expected, then the next American to enter space may do so on an X-Prize spacecraft.

The NASA shuttles will probably still be on the ground when the world's first solar sail takes off, too. Just as a wind sail on the water transforms the power of air into movement, a solar sail in space would be pushed along by the minute pressure of photons of sunlight. Theoretically, such a vessel could accelerate to speeds much faster than today's rocket-powered spacecraft. The first test version of a solar sail, completely privately funded, is supposed to enter space next year on a missile launched from a Russian nuclear submarine.

Many other space ideas—like the flyback boosters and "cyclers" championed by Apollo astronaut Buzz Aldrin—deserve attention, but NASA simply doesn't have the money to give them the consideration they merit. There have been attempts to entice more commercial entities into the space arena, including a major space commercialization act in 1998, and another one introduced in the House of Representatives this October. But to really get U.S. industry interested in space, one approach might be this radical idea proposed recently by former Rep. Bob Walker, Republican of Pennsylvania:

> We should also look at tax holiday concepts. What if, instead of depending on the federal government to go back to the Moon [or presumably elsewhere], we created a way for businesses to see a great opportunity in traveling to the Moon. The opportunity is that if they get there and if they establish a permanent station on the Moon, the government will give them 25 or 30 years of tax-free treatment, not just for the facility on the Moon, but for the entire corporation. Now, all of a sudden, at Microsoft, General Motors, or some company that pays substantial taxes, people will be sitting in the boardroom asking, "How do we get there and get there cheap?"

Imagine the new Space Race such an offer would start, as it unleashes the creativity of companies that already excel at doing great things.

Why We Must Go

But for any of these ideas to succeed, America needs to revitalize its manned spaceflight program. We need to go back to first principles: Why should we even bother going into space?

Certainly some policymakers think we shouldn't exert our energies on going to space, since there are so many problems here on Earth—problems like poverty, hunger, or racism—that we should solve before we reach for the heavens. This objection has been heard since the very earliest days of the American space program. Even at the precise moment the Space Race was to be won, just days before Apollo 11 was due to take off in July 1969 with the first men to walk on the Moon, a group of demonstrators from the Southern Christian Leadership Conference staged a protest at Cape Canaveral (complete with mules and the song "We Shall Overcome") to demand that the government spend its money on food and medicine and housing for the poor. All that summer, newspapers quoted eminences ranging from Arnold Toynbee to Reinhold Niebuhr to Mark Van Doren, each of whom criticized the Moon missions for wasting resources that could be better spent closer to home. Three days before Apollo 11 left Earth, Kurt Vonnegut wrote in *The New York Times Magazine* that the money spent on space should have been spent "on cleaning up our filthy colonies here on Earth" instead. In the 1970s, some members of Congress made the same argument, like then-Representative Ed Koch (later mayor of New York City), who said, "I just for the life of me can't see voting for monies to find out whether or not there is some microbe on Mars, when in fact I know there are rats in the Harlem apartments." The identical sentiment is still heard today: The government shouldn't spend money on space, it should spend money fixing things here at home.

But this argument is doubly flawed. First, it reveals a misunderstanding of how the federal budget works. It simply isn't true that every dollar given to NASA is a dollar that would instead go somewhere else in the federal budget; money can't just be shifted from one government program to another: something is allocated to be in the budget or it's cancelled. If NASA were eliminated entirely today, it wouldn't make a penny of difference to federal spending on schools or healthcare or anything else.

Second, anyone who argues that government funds should be spent here on Earth instead of being wasted on projects in space misses the obvious fact that the money spent on space programs *is* used here on Earth. The money goes to companies that build rockets and robots and electronics; it goes to scientists, manufacturers, engineers, administrators, and astronauts; it employs people, feeds families, and cycles back into the economy.

That said, many of the arguments in favor of sending humans into space are dubious. The notion that we should head out into space to harvest the resources

of our solar system's planets, moons, and asteroids wrongly assumes that we will be able to find a cost-effective way to get and ship the rare gases, ores, and other potentially valuable materials we might find there. We know neither what kind nor what quantity of resources we will find on these space objects. Developing space resources may someday be enormously lucrative, but at this stage it cannot be our main motivation for heading into space.

Some have argued that we should go into space because it's good for our innovative economy: just look at all the household products that have been spun off from NASA's four decades of space research. NASA is understandably proud of its record in this regard, and does its best to emphasize the progress in clothing, medicine, computers, optics, materials, and so forth, that has been spurred by the space program. But wonderful though they undoubtedly are, spin-offs cannot sensibly be the object of a manned spaceflight program; they are, at best, only an incidental benefit.

Space tourism is often put forward as a viable industry, although no one has yet convincingly made a case that explains the economics of how it would work. Two tourists have already been in space: American Dennis Tito in 2001 and South African Mark Shuttleworth in 2002 each paid $20 million for a stay on the International Space Station. Some companies claim to have data that show that a vast percentage of the population would pay to go to space, and some studies have estimated that the market for space tourism might reach as high as $20 billion in the coming decades. But it just isn't clear how space tourism will transition from the exploits of a few adventurous millionaires into an industry with any hope of making profits.

For decades, we have heard about the value of laboratory research in low-grav and no-grav: experiments with protein crystals could yield results helpful to many industries, and maybe someday we'll be able to produce perfectly spherical ball bearings in space. There is reason to believe that certain areas of biotech research might also benefit from experiments in space. To the extent that all this is true—and even after years of space experiments on the shuttle and in the space station, it's not obvious that this research has been put to much practical use—lab research can't be the chief reason America's national space agency goes into orbit. As much as possible, such research should be privately funded, privately controlled, and privately conducted, and NASA should pursue greater challenges.

The greatest of all challenges is the future of humanity, and scientists and science fiction writers have long said that we must go to space to ensure the survival of the species, and to seed other planets with human life. There is some wisdom in this outlook, but as extinction is not looming, it does not provide us with a sensible reason to go out to space now—although we unquestionably must learn to protect our fragile planet from stray asteroids and other threats from space.

Finally, there is the argument that we should head out into space for discovery, for adventure, and for glory; that we, as thinking, feeling beings, have a moral imperative to explore space; and that we, as the American superpower, have a weighty obligation to lead the way.

Some skeptics have said that there is no need to send humans out into space—no need to go back to the Moon, or to go to Mars, since we have robots that we can send in our stead. The leading proponent of the robo-research crowd is Robert Park, the University of Maryland physicist who has dedicated his life to debunking abuses of science. Park says that since humans on other worlds would have to wear bulky space suits, they would be cut off from the sounds, smells, and textures of their environment. Besides, he says, sending robots is cheaper and safer than sending humans. In his 2000 book *Voodoo Science*, Park describes robots as "simply extensions of our frail human bodies"; they can turn the scientists into "virtual astronauts." Sending humans to explore space gives no advantage—and in fact, as Park said in a TV interview, "if Queen Isabella could have sent a robot" instead of Christopher Columbus, "she would have, because it would have been a lot quicker and a lot cheaper. But she didn't know how."

Park is correct that robots can be very useful research tools, but our human ability to react to and interact with our surroundings—to learn and discern and intuit—cannot be matched by mere robot explorers. For simple, repetitive, or deadly tasks, robotic exploration makes sense, and remotely controlled robots can be an invaluable aid to human exploration—a supplement, not a substitute, for a human presence. Robots can test soil samples and sniff the air and shoot pictures and report the results. But only humans, humans really in a place, have the hands and legs and quirky insights and unexplainable hunches of the *explorer*.

And also the *hero*. In the early days of the Mercury program, as Tom Wolfe describes in *The Right Stuff*, astronauts were considered "redundant." They weren't needed to pilot the Mercury space capsules, the reasoning went, so some critics thought of them as mere passengers, thoroughly unheroic. This attitude disappeared the moment Alan Shepard rocketed off the Earth. It then became clear that the push to space wasn't just about machines or technological brilliance: it was about guts and glory, about the endurance of the human body and soul in the deadly void.

That is why the greatest victories and most memorable achievements in NASA's history have been *human*, not robotic. Yes, we all appreciate the pictures sent back from the Hubble telescope and our little robotic friends on Mars, but the inspirational stuff is in the human story, the adventure of space. We think of the Mercury missions: lobbing men in tiny capsules around the planet. We think of the Moon: the first step, the flags, the golf balls. We think of Apollo 13, and the three lucky men who survived that mission. We think of the rescues: Pete Conrad

and his crew saving Skylab, the dramatic spacewalks to fix the blind Hubble. We think of John Glenn the young hero in space and John Glenn the senior citizen in space. We think of the joy of weightlessness, and we think of the pain of loss: Apollo 1, *Challenger*, *Columbia*. Greatness and daring and hope and regret.

That is why we must go to space: it is the human thing to do.

A Goal Worthy of America

The question remains: Where do we go from here? If we strive to do great things in space, where should we aim?

First, we must be rid of that grand failed vision—*shuttle, station, ship, and still on!*—which has too long held us in mortmain. It has cost us dearly in time, money, and lives.

There are two obvious destinations for our next stop in space. The first is the Moon. No human has stepped on the Moon in three decades. We could put a giant telescope on the far side of the Moon, or we might assemble vast arrays of solar panels for collecting power, which could then be transmitted to Earth. There is reason to believe that we might profitably mine for rare gases in the dusty regolith. Or we could just build a Moon base, a permanent outpost on the lunar surface, a new home for humanity on our nearest neighbor in the sky.

Certainly we must go back to the Moon someday. When the Apollo 17 crew departed, they left a plaque behind saying, "Here man completed his first explorations of the Moon"; it would be unforgivable if we never went back at all, if that brief period of thirteen-hundred days between our first lunar footfall and our last were just an anomaly, a glory never to be repeated. No, man must go back to the Moon, and hopefully America will return before the Chinese arrive.

But there is still a greater option: Mars now.

Mars has a 24-hour day, like Earth. Mars has plenty of frozen water. It has a geologically active surface, and is therefore likely to have many kinds of ore. It has astonishing terrain, including a giant canyon much deeper and longer than our Grand Canyon. And, most important, Mars may once have had life, or some of its precursors.

A manned mission to the Red Planet has been an on-again, off-again part of America's space strategy for decades. Because he was the youngest of the original Mercury astronauts, Gordon Cooper thought it was likely he would get to go on a Mars mission. From the 1950s through the 1980s, all of the Mars expeditions NASA considered were deemed too expensive. Then, on the twentieth anniversary of the first Moon landing, President George H. W. Bush made a grand proposal: a Space Exploration Initiative that would put an American on Mars within thirty years. As Bush put it in a later speech, "I believe that before Apollo celebrates the fiftieth anniversary of its landing on the Moon, the American flag should be planted on Mars." NASA sketched out a plan for Bush,

a massive and uncreative plan—*shuttle, station, ships, then Mars!*—with a price tag of $450 billion. Bush balked, and the Space Exploration Initiative died an ignominious death.

But that bulky plan to reach Mars isn't the only way to get there. Just as the Apollo missions bypassed the shuttle and space station, we could go directly to Mars using technology that exists today. Robert Zubrin, the engineer who developed the "Mars Direct" plan for NASA after the Space Exploration Initiative debacle, says we can "establish our first outpost on Mars within a decade, using well-demonstrated techniques of brass-tacks engineering backed up by our pioneer forebears' common sense." The experts who said the larger plan would cost $450 billion told Zubrin in 1994 that his plan would cost a ninth as much—and he now believes it could be done for less than $30 billion.

Zubrin's plan starts with an unmanned spacecraft sent to Mars—an empty vehicle that will arrive on the planet's surface and start making fuel for the trip back to Earth, using as ingredients hydrogen brought from Earth and the carbon dioxide that makes up 95 percent of the Martian atmosphere. Once that vehicle is fully gassed up, a crew of about four will set out from Earth for Mars on a six-month trip (a much shorter time in space than several cosmonauts and astronauts spent on Mir). On Mars, the astronauts will have more than 500 days to explore and study—on foot and with a long-distance rover—learning about the rocks and atmosphere, and searching for signs of life; such a prolonged mission would be of far greater scientific value than the short "flags and footprints" mission originally envisioned by NASA. The crew would then transfer into the original waiting return vehicle and head home.

Aware of the political difficulty involved in successfully selling a plan like his—and hoping to invalidate the criticism that his plan is unrealistically priced—Zubrin suggested in his 1996 book *The Case for Mars* that the government take baby steps, offering monetary prizes for a series of probative advances on the path to a full Mars mission: $1 billion for the first company to bring a sample of Martian soil back to Earth; $2 billion for the first company to gently put a payload of 10 metric tons on the Martian surface; $3 billion for the first company to demonstrate a system that can put 50 metric tons onto a trajectory toward Mars, and so on. These bite-size advances, with payouts based on achievements instead of mere promises, could make a Mars mission palatable to a visionary government, even one facing big deficits and a war on terrorism.

The Mars Direct plan has its critics, some of whom argue that the mission will be more complex, risky, and costly than Zubrin thinks. Others have suggested that we should not rush to Mars now because the future may bring developments that could help get us to Mars more safely and quickly. Going to Mars now could be akin to "beginning to dig a second Panama Canal using a gold teaspoon shortly before delivery of a steamshovel," to borrow a phrase from one critic.

But without the goal of going to Mars, many of the technologies needed for such a trip may never develop. And even if, as some critics argue, Zubrin's plan is technically defective, we can still fix those defects, if we set our minds to it. If we want to get to Mars, we don't need to start with a perfect plan, we need to start with a clear vision—and the technology will follow.

For more than a year now, NASA and the White House have been holding a "national space policy review"—an attempt to hash out where we should go from here. There are rumors that the space review will culminate in a decision to go to Mars—perhaps with an initial announcement to be made by President Bush on December 17, 2003, in a speech at Kitty Hawk marking the centennial of the Wright brothers' successful flight. It has been suggested that Bush might choose that impressive occasion to propose the establishment of a Moon base, or even to renew his father's pledge to put humans on Mars by 2019.

This is a heartening prospect, since it seemed for a time as though the national space policy review would eventually release a study or report, one that would sit atop the piles of prestigious, if unread, space policy reports going back decades. We don't need more preliminary studies. We need the urgency that comes from commitment to a real enterprise, not continuing debate about the ideal plan. We need a vision. We need a goal.

"The United States was not built by those who waited and rested and wished to look behind them," President Kennedy said. "This country was conquered by those who moved forward, and so will space." It's time to move forward—to Mars.