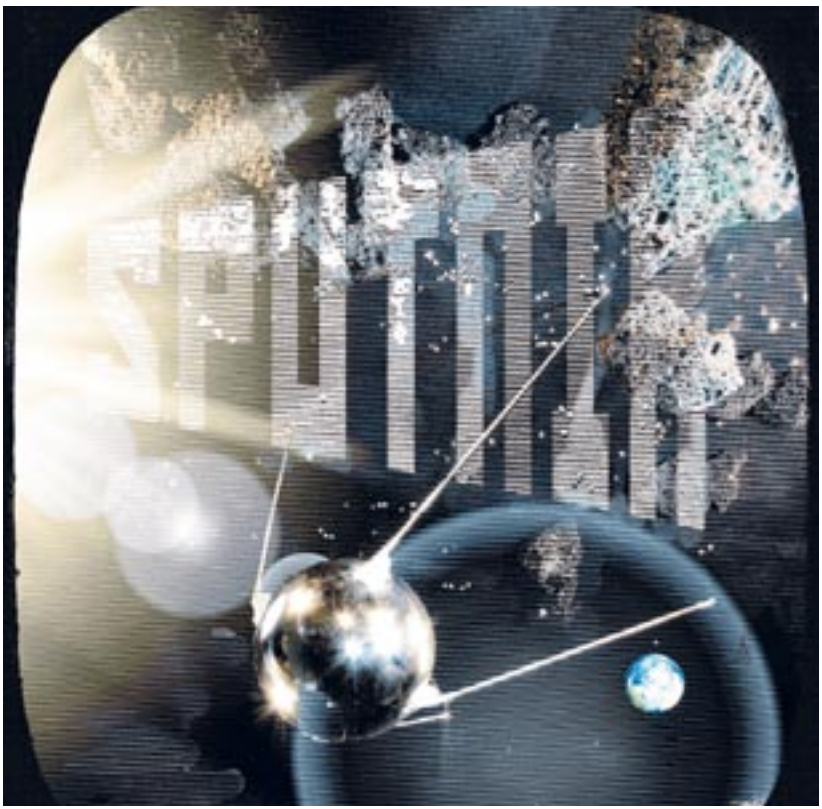
DIGITAL NEWSBOOK

Science

The New York Times

The Space Age

ON OCTOBER 4,1957, A TINY SATELLITE STUNNED THE WORLD. 50 YEARS LATER, SCIENCE TIMES LOOKS BACK — AND AHEAD.



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SHOW ARTICLE INDEX

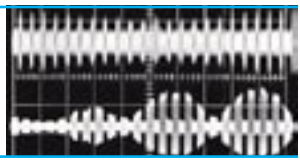
Science: The Space Age

The New York Times

50

LOOKING BACK Sputnik changed everything: history, geopolitics, the scientific world. It launched careers, too, including that of a young reporter who went on to cover the Moon landings. A reflection on the triumphs and disappointments of the space age. BY JOHN NOBLE WILFORD.

LOOKING FORWARD What are the odds of returning to the Moon? Sending humans to Mars? The future is clouded by the costs and risks of spaceflight, and a kind of orbital ennui. One thing is likely, experts agree: private explorers will play a bigger and bigger role. BY JOHN SCHWARTZ.



VOICES: 10/4/57 Reflections by Walter Cronkite, Ursula K. Le Guin and others. Interviews by Claudia Dreifus.

TEACHABLE MOMENTS Sputnik touched off a boom in science education. Then entropy set in. BY CORNELIA DEAN.

SPUTNIK'S CENTURY From Kitty Hawk to the comets: a timeline.

KHRUSHCHEV REMEMBERS Not *that* Khrushchev, but his son, now a professor at Brown. BY WARREN E. LEARY.

Science: The Space Age

The New York Times



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With Fear and Wonder in Its Wake, Sputnik Lifted Us Into the Future

By JOHN NOBLE WILFORD

Fifty years ago, before most people living today were born, the beep-beep-beep of Sputnik was heard round the world. It was the sound of wonder and foreboding. Nothing would ever be quite the same again — in geopolitics, in science and technology, in everyday life and the capacity of the human species.

The Soviet Union had launched the first artificial satellite, a new moon, on Oct. 4, 1957. Climbing out of the terrestrial gravity well, rising above the atmosphere and into orbit, Sputnik crossed the threshold into a new dimension of human experience. People could now see their kind as spacefarers. Their enhanced mobility might someday prove as liberating as the first upright steps of hominid ancestors long ago.

The immediate reaction, though, reflected the dark concerns of a world in the grip of the cold war, a time of fear and division in which the two superpowers, the Soviet Union and the United States, stared each other down with the menace of mass destruction. Sputnik altered the nature and scope of the cold war.

It was an unprepossessing agent of alarm. A simple sphere weighing just 184 pounds and not quite two feet wide, it had a highly polished surface of aluminum, the better to reflect sunlight and be visible from Earth. Two radio

transmitters with whiskery antennas issued steady signals on frequencies that scientists and ham operators could pick up, and so confirm the achievement.

The Russians clearly intended Sputnik as a ringing statement of their technological prowess and its military implications. But even they, it seems, had not foreseen the frenzied response their success provoked.

When the Soviet dictator Nikita S. Khrushchev received word of the launching, he was of course pleased, and he and his son, Sergei, turned on the radio to listen to the beeping Sputnik. They went to bed, the son remembers, without realizing "the immensity of what was happening during those hours."

The Soviet press published a standard two-column report of the event, with a minimum of gloating. But newspapers in the West, particularly the United States, filled pages with news and analysis.

Sputnik's signal reverberated through chambers of the powerful and down ordinary streets. People listened and, from rooftops and backyards, saw in the night a moving point of light, like an errant star. The interrogatory of invention used to be "What hath God wrought?" Now it was "What are the Russians capable of next?"

A signal, serving as an alarm bell of sorts, that reverberated through chambers of the powerful and down ordinary streets.

"No event since Pearl Harbor set off such repercussions in public life," Walter A. McDougall, a historian at the University of Pennsylvania, has written. A younger generation may draw comparison with the terrorist attacks of Sept. 11.

Sputnik plunged Americans into a crisis of self-confidence.

ILLUSTRATION BY JOHN RITTER; PHOTOGRAPHS FROM THE NEW YORK TIMES ARCHIVE

Had the country grown lax with prosperity? Was the education system inadequate, especially in training scientists and engineers? Were the institutions of liberal democracy any match in competition with an authoritarian communist society?

In "The Heavens and the Earth: A Political History of the Space Age" (1985), Dr. McDougall wrote that before Sputnik the cold war had been "a military and political struggle in which the United States need only lend aid and comfort to its allies in

the front lines." Now, he continued, the cold war "became total, a competition for the loyalty and trust of all peoples fought out in all arenas of social achievement, in which science textbooks and racial harmony were as much tools of foreign policy as missiles and spies."

At the time of Sputnik, John F. Kennedy was the junior senator from Massachusetts with no particular interest in space. Yuri A. Gagarin was an unheralded Russian military pilot. John H. Glenn Jr. was a Marine Corps pilot who had recently set a record for the fastest transcontinental jet flight to New York from Los Angeles. Neil A. Armstrong was testing high-performance aircraft in the California desert. Their lives were soon to be changed, as were those of hundreds of thousands of engineers, technicians, other workers and ordinary people everywhere.

Thomas J. O'Malley, an aviation engineer in New Jersey, would move in a few months to a forlorn spit of land at Cape Canaveral, Fla., to be a test conductor in the accelerated development of the Atlas missile, which would eventually lift American astronauts into orbit. "We had one goal," he recalled recently. "To get something up there as quickly as possible."

Christopher C. Kraft Jr. soon found himself working with a task force planning an American response to the challenge. He would become the first flight director of astronaut missions, but at the start, he has written, the morale of American engineers was low. "I wasn't the only engineer who was stunned at how much I didn't know and how much I had to learn," he said.

When the Sputnik news reached Huntsville, Ala., Wernher von Braun was beside himself with restless frustration. Mr. von Braun, a German-born rocket scientist working for the United States Army, said this country could have beaten the Russians into orbit if not for Pentagon orders to resist any thought of adding a small satellite to the Jupiter-C missile he had been testing.

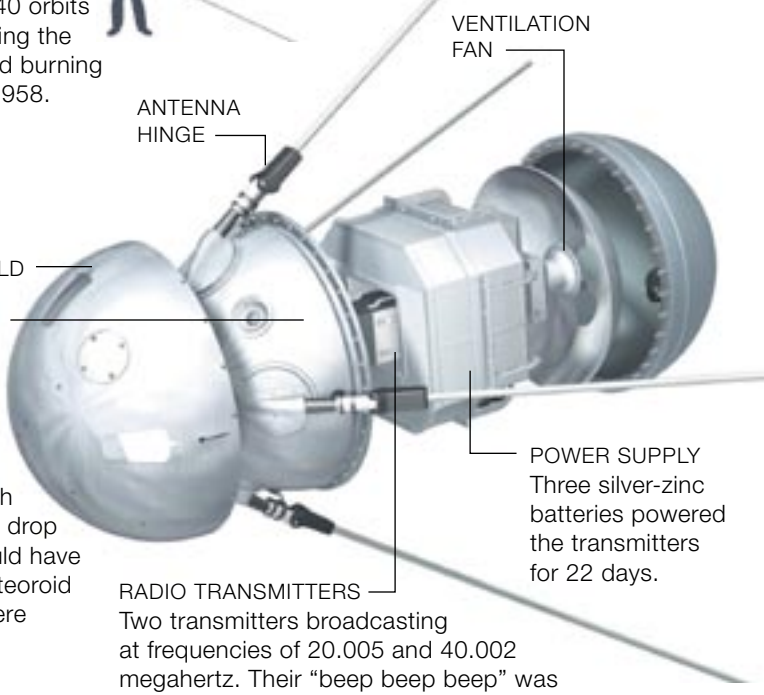
Inside Sputnik

Sputnik 1, the world's first artificial satellite, was launched on Oct. 4, 1957, aboard a Soviet R-7 rocket. Circling the Earth every 96 minutes at about 18,000 miles per hour, it touched off an intense space race with the United States.

The spherical satellite measured 23 inches in diameter and weighed 184 pounds. Sputnik completed 1,440 orbits before re-entering the atmosphere and burning up on Jan. 4, 1958.

ANTENNA SYSTEM
Sputnik had four antennas. Two were 9 feet 6 inches long and the others 7 feet 10 inches.

Sputnik 1
Exploded view



FRONT CASING
One of two hemispherical aluminum alloy casings. The interior was pressurized with nitrogen, and a drop in pressure could have indicated a meteoroid strike. None were reported.

POWER SUPPLY
Three silver-zinc batteries powered the transmitters for 22 days.

RADIO TRANSMITTERS
Two transmitters broadcasting at frequencies of 20.005 and 40.002 megahertz. Their "beep beep beep" was picked up by ham radio operators worldwide.

Sources: NASA; Asif A. Siddiqi; Seiji Yoshimoto, NPO InterCoS; "S.P. Korolev Space Corporation Energia" published by Energia

FRANK O'CONNELL/THE NEW YORK TIMES

To make matters worse, the first American attempts to launch a tiny Vanguard satellite were embarrassing failures. It was the end of January 1958 before Americans succeeded with Explorer 1, boosted into orbit by a multistage version of Mr. von Braun's Jupiter-C. But the much larger Sputnik 2 had already carried the dog Laika into orbit, a harbinger of human spaceflight. The original Sputnik — in Russian, "satellite" or "fellow traveler" — was no onetime fluke.

The post-Sputnik dynamic even reached out and recruited me. I was then a soldier in the cold war. Along with nearly every able-bodied young American man (even Elvis had to put in his two years), I was fulfilling my obligation to interrupt life and career for military service. I had completed college and was a reporter on military leave of absence from The Wall Street Journal, at the Army base in Fort Dix, N.J.

The morning after the Soviet triumph, I was on a one-day pass in Trenton. I bought the papers and spread them out on a coffee shop table. Banner headlines trumpeted the news. The recondite language of rocketry and orbits tied up my head, but I read on. I gave a passing thought to the coincidence of Sputnik's going up on my birthday; at least I should never forget the date the space age began.

My story should at this point resound with destiny's thunderclap or a sudden gust swinging open the door, scattering the papers and leaving me strangely moved. But I had no premonition that Sputnik had set in motion events that would shape my career. It was not until 1959, soon after I returned to The Journal from service in West Germany, that I felt the Sputnik effect.

Newspapers and other media, influenced by Sputnik, were scrambling to expand coverage of science, medicine and technology. I agreed to the managing editor's suggestion that I try my hand writing about medicine.

One thing led to another, from medicine to science and space exploration, to Time magazine and eventually to the staff of The New York Times to cover the most ambitious American response to Sputnik: the Apollo program.

Sputnik should not have come as such a surprise. Both the Soviet Union and the United States had embarked on the development of ballistic missiles for carrying nuclear warheads to great distances. They had also announced plans to launch artificial satellites in the International Geophysical Year, a cooperative 18-month scientific undertaking to study Earth and its atmosphere, beginning in 1957. Khrushchev had reiterated Soviet intentions only two months before.

But a shock it was, a wake-up call. One of the intriguing might-have-beens of history is: What if Americans had deployed the first satellite?

One of the intriguing might-have-beens of history is: What if Americans had deployed the first satellite?

Alex Roland, a historian of technology at Duke University and a former NASA historian, said that a first launching by Americans would have merely confirmed their reputation for technological superiority. The costly rivalry for dominance in space, he said, would have probably been waged with much less driving urgency.

John M. Logsdon, director of the Institute of Space Policy at George Washington University, agreed. “If not for Sputnik,” he said, “there would probably not have been Apollo.”

But after Sputnik, there was no stopping the momentum of the space race. Critics attacked the administration of President Dwight D. Eisenhower, who at first had dismissed Sputnik as an

event of only "scientific interest." Soon the Defense Department stepped up missile development. The Democratic Congress established the National Aeronautics and Space Administration.

The perception of a threatening Soviet advantage in missiles persisted. Necessity had dictated the Russian concentration on missiles. Ever since World War II, American bombers had been more capable than those of the Russians, who also had no air bases in striking distance of their adversary's heartland, in contrast to the American bases that ringed the Soviet Union.

An exaggerated estimate of the "missile gap" became a rallying cry of the 1960 presidential campaign and may have been crucial in Kennedy's narrow victory. Not long after he took office, the Russians scored another stunning triumph. In April 1961, Gagarin became the first human to fly in Earth orbit.

After weeks of closed-door consultations, Kennedy went before Congress, on May 25, and declared, "Now it is time to take longer strides — time for a great new American enterprise — time for this nation to take a clearly leading role in space achievement which, in many ways, may hold the key to our future on Earth."

He committed the country to "the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth."

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How brief the space race was, the 12 years from the wake-up call to the first walk on the Moon, but thrilling, mind-boggling, even magnificent at times.

While the Russians forge ahead, Americans begin catching up with the Mercury and Gemini flights in orbit. As the goal comes into sight, there are the countdowns of tingling anticipation. In the dark before dawn, we drive toward the shining light enveloping a spaceship that looks like an obelisk out of antiquity, waiting to be launched. The blast of the Saturn 5, just three miles of sand

and scrub away, beats on your chest and shakes the ground you stand on. Once at full thrust, and unbound, the huge rocket at first appears to be losing its fight against gravity, then slowly rises to the occasion and is off over the ocean, fire and vapor trailing behind. Spacefarers are on their way to the Moon.

Three lunar voyages are most sharply etched in memory. The Apollo 8 astronauts, in December 1968, are the first to reach the Moon, circling it 10 times. Out their windows they see the achingly beautiful Earth, blue and green under swirls of white clouds. On Christmas Eve, the men take turns reading verses from Genesis. It is a gift from on high at a time of turmoil and despair in the year of assassinations, rioting cities and a divisive war.

Then there is Apollo 11. On July 20, 1969, Neil Armstrong steps down the landing craft's ladder and takes "one giant leap for mankind." Buzz Aldrin joins him for the first walk on the Moon. In contrast to exploration's previous landfalls, the whole world is watching on television.

In the current documentary film "In the Shadow of the Moon," Michael Collins, the Apollo 11 pilot who remained in lunar orbit during the landing, recalls that on the crew's world tour afterward, people they met felt they had participated in the landing, too. "People, instead of saying, 'Well, you Americans did it!' " he said, "everywhere, they said, 'We did it!' We, humankind, we, the human race, we, people, did it!'"

The warmth of shared experience was remarkable, given the origins of the space race in an atmosphere of fear and belligerence.

Apollo 11 essentially ended the space race, and public interest in spaceflight was flagging by the time of Apollo 13, in April 1970. The residual self-assurance that committed the country to Apollo in 1961 had given way to self-doubt. The war in Vietnam, another chapter in the cold war, shoved Apollo to the periphery of the national mind.

Apollo 13 is the mission that failed, but a drama of epic dimensions worthy of Homer. Three astronauts go forth on a daring quest, meet with disaster, face death and barely limp back to the safety of home. If anything, this brush with death put a more human face on spaceflight and made it seem more exciting, and dangerous.

By the end of 1972, the last of the 12 men to walk on the Moon packed up and returned home, and no one has been there since. At the conclusion of that flight, Apollo 17, I solicited historians' assessments of the significance of these early years in space. Arthur M. Schlesinger Jr. predicted that in 500 years, the 20th century would probably be remembered mainly for humanity's first ventures beyond its native planet. At the close of the century, he had not changed his mind.

In succeeding years, the Russians and Americans continued spaceflights, at a reduced pace. Most American money went into the space shuttles, the reusable vehicles confined to orbit that never lived up to their promise to make human flight more routine. The public's most lasting images of the program are the Challenger's deadly explosion shortly after liftoff in 1986, and the Columbia's disintegration on re-entry 17 years later.

It was left to the relatively low-budget robotic spacecraft to sustain the impression of exploration and discovery on this new frontier. In that respect, they alone exceeded early promises. Russian and American craft explored Venus. American vehicles landed several times on Mars, and a European capsule reached the surface of Saturn's moon Titan. Two Voyager craft made a grand tour of the four giant outer planets and are now approaching the edge of the solar system. The Hubble Space Telescope still sends images from deep in cosmic time.

Carl Sagan, the astronomer and author, often spoke of this as the golden age of planetary

exploration. “In all the history of mankind,” he wrote, “there will be only one generation that will be first to explore the solar system, one generation for which, in childhood, the planets are distant and indistinct disks moving through the night sky, and for which, in old age, the planets are places, diverse new worlds in the course of exploration.”

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One evening in 1990, I drove across Baltimore on a sentimental journey. Every so often since the fall of the Berlin Wall, the reunification of Germany, the collapse of communist regimes in Eastern Europe and the last gasps coming out of the exhausted Soviet Union itself, I had allowed myself reflections on my two years as a soldier in an unconventional war and the nearly half-century of anxieties of living in a world primed to blow itself up.

I could hardly think of myself outside the context of the cold war. Without the intense Soviet-American competition epitomized by the space race, I would not have become a science journalist who wrote about astronauts going to the Moon to “beat” the Russians. I would therefore not be in Baltimore again, this time with astronomers who were preparing to look into the heavens via a giant orbiting telescope.

I found my way to Travelers Lounge, the bar that had been across from the gate to the Army Intelligence School at Fort Holabird. We used to tarry in the back room there, over pitchers of beer fueling arguments about politics and the American novel. I took a stool and told the bartender that it had been more than three decades since I last had a beer here, back in my Holabird sojourn.

“One of them comes in every few months and looks around,” the bartender said. “We’re about the only thing left from those days.”

So I had seen. The fort was gone. In its place stretched one corporate complex after another, buildings of glass and steel and spreading car parks. The names

I saw were as unfamiliar as their digitized new-technology goods and services. I imagined I was looking on a monument to the cold war, and how apt it seemed.

The conflict we had lived through did not lend itself to heroic and triumphal iconography, nothing like the Iwo Jima flag-raising statue, nothing to glorify war or proclaim victory. So these commercial enterprises rising from cold-war technology, supplanting an old fort, were working monuments to the end of the cold war, monuments that do not look back.

At least Travelers and I had made it through this passage in history. Over my shoulder, I saw families and couples dining, not a beer pitcher or soldier anywhere. I wondered what post-cold-war memories these diners would bring back there in coming years.

I took my leave of Travelers and an era. I had to be fresh in the morning for another meeting with people at the Space Telescope Science Institute. They were tending their own monument to the cold war, which had fostered the Hubble Space Telescope's technology. I wanted to learn more of our — and my own — expanding universe.

Over a long dinner, after the cold war and almost 30 years since the first lunar landing, a former astronaut who walked on the Moon and one of the Apollo flight directors got to skylarking about the good old days, something people do when they think of their past receding and the world changing all around. They laughed almost to tears telling cherished stories, one trying to top the other.

Then a cloud seemed to pass over their faces. Pete Conrad, the astronaut, who would soon die in a motorcycle accident, and Gerald D. Griffin, the flight director, wondered in perplexity what had happened to their good old days. What of those grand prospects of a few decades ago? No humans have flown to Mars, as once predicted, or established a permanent base on the Moon. A

long-sought orbiting space station was finally being assembled in orbit, but no one seemed sure what it was good for, except as a demonstration of cooperation by many nations, including Russia, in a major space endeavor.

Economics and shifting national priorities had thwarted the most ambitious post-Apollo plans.

Dr. Logsdon of George Washington University called Apollo "a product of a specific time in history," and a singular crash program responding to a perceived threat to the country. It did not represent a firm commitment by society to full-scale space exploration.

As Dr. Roland of Duke pointed out, Apollo "did just what it was designed to do, which was to convince the world and ourselves that we were masters of technology, and it wasn't designed to do anything else." As yet, he said, "we have not identified a mission for astronauts that was commensurate with Apollo."

Dr. Roland noted that telecommunications was the only space enterprise that pays for itself and, he added, "It has transformed the world." All other space activities, military and civilian, depend so far on "what states believe are in their best interest to invest in" — and those interests have changed since the cold war.

Let Neil Armstrong, known as a man of few words, have the last word.

"I think we'll always be in space," he said in an interview for NASA's oral history program. "But it will take us longer to do the new things than the advocates would like, and in some cases it will take external factors or forces which we can't control and can't anticipate that will cause things to happen or not happen."

Mr. Armstrong then struck a note sure to resonate with many of his contemporaries. "We were really very privileged," he said, "to live in that thin slice of history where we changed how man looks at himself and what he might become and where he might go." □

Voices: 10/4/57

By CLAUDIA DREIFUS

The launching of Sputnik on Oct. 4, 1957, was a life-changing event — one that ignited imaginations, dictated the course of careers, and changed the way people thought about science, education and global politics. The New York Times asked scientists and others who lived through it (and a few who were yet to be born) to reflect on what Sputnik meant to them.

Homer H. Hickam, 64, author of "Rocket Boys," a memoir adapted for the movie "October Sky."

I was a high school sophomore in Coalwood, W. Va., and I read in the newspaper that Sputnik was going to fly over southern West Virginia. At the appointed hour, our neighbors came to our yard to help me watch it. My father said, "Well, they can all go home because President Eisenhower will never allow anything Russian to fly over Coalwood!"

But at the appointed moment, Sputnik flew over Coalwood. If it had been God in his chariot that had flown over, I could not have been more impressed. It was

awe-inspiring. Sputnik looked like a bright star that moved with such utter purpose that nothing could stop it; and I, in that moment, realized I wanted to be part of the movement into space. In that moment, I decided to get a job with Wernher von Braun.

I ended up having a 17-year career in NASA, as a designer of spacecraft and an astronaut training manager.

Ernst Stuhlinger, 93, former director, space science, Marshall Space Flight Center, Huntsville, Ala., and former deputy to Wernher von Braun.

Exactly a week before the Sputnik launch, on Sept. 27, 1957, I went to our commanding general in Huntsville, Gen. John Medaris, and told him, "General, I have a number of indications that the Russians are very close to launching a satellite."

The head of the Russian Academy of Sciences had mentioned in the news that the Russians were planning to launch a satellite in the next couple of days. The Russians even gave the frequency of the transmitter which would make the sounds of the little satellite audible on Earth. I was in contact with a number of colleagues who told me this.

He didn't believe it. He said: "Ernst, calm down. Don't get nervous. The Russians are not ready to launch a satellite."

A week later, I was in a taxi in Barcelona and I heard the news on the radio. I said to myself, "Well, I told you so."

It was very exciting for me, of course. The next thing I thought was, "I have a lot of admiration for the Russian space people who did that." I thought: "You people in Russia, you won the first round.

You may even win the second round — a man in orbit. But we have a good chance to win the third round, and that will be the trip to the Moon." And then I immediately felt a kind of thankfulness to the Russian colleagues because it was a wonderful wake-up call for us Americans.

When I came back from Barcelona, I met with Dr. von Braun, who also had the feeling that it was very fortunate that the Russians had launched their satellite. He was very excited about it. We had many plans on our hands, and this gave us the assurance that we were on the right track with our plans. And when you think how successful our trip to the Moon was — almost exactly 10 years later — we were on the right track!

Walter Cronkite, 90, former anchor and managing editor, "CBS Evening News."

I was almost certainly in my office at CBS when I heard about the launch. I was rather excited

that we were making a major step forward in the space program — both the Russians and us.

I had been a reporter in the Soviet Union and I knew they were working on space, but I didn't realize that they were going to come to it so much more quickly than we were. In Moscow, you'd read stuff in journals and papers that indicated that there was some progress, but we didn't know what the Russians actually had. We had a sense that they were interested in space, but we didn't know how advanced it was. So when Sputnik came, it was quite a shock for us. It awakened a lot of people to the space program. Sputnik awakened everyone.

Esther Dyson, 56, of EDventure Holdings, investor in space and Internet start-ups, and daughter of the physicist Freeman Dyson.

We weren't astonished by the Sputnik launch in my family, because my father knew Russian scientists and we knew that Russians were really smart.

I'm hoping that the next thing that happens is that the Chinese will do something similar — go to the Moon or do something with Mars. It will have the same impact. People will say, "My gosh, we need to do something with our space program," which at the moment is suffering from a lack of funding, attention and respect. Maybe the Chinese will give us a wake-up call the same way the Russians did.

Sir Martin Rees, 65, astronomer royal of Britain.

The Sputnik launch was widely reported in the U.K. There was a special interest because the Jodrell Bank radio telescope had just been completed, and it was one of the few instruments in the world capable of tracking Sputnik.

I was 15, and I recall watching those reports from Jodrell Bank on my parents' flickering black-and-white television.

Certainly in the U.K. in 1957, there was general admiration of the Soviet space program, though many of us were indifferent as to whether it was the U.S. or the Soviets who had been to space first. It was, for us, a

spectator sport — a byproduct of superpower rivalry.

Of course, we followed the subsequent developments of the Russian space program: first dog in orbit, first man in orbit. When the cosmonaut Yuri Gagarin visited the U.K., he was mobbed by enthusiastic crowds. Harold Macmillan, the prime minister, a man well attuned to the national character, cynically noted that the crowds would have been bigger if the Russians had sent the dog.

Those who are now middle-aged can recall the exciting progress that culminated in Apollo. But for young people today it's ancient history: they know the Americans put men on the Moon; they know the Egyptians built the pyramids. But both episodes seem ancient history — endeavors driven by arcane motives hard now to understand.

Neil deGrasse Tyson, 48, director, Hayden Planetarium at the American Museum of Natural History.

I was born a year and a day after Sputnik. Even as a child in the Bronx, I was aware of its influence on society because the space launches were in the headlines. The move of the United States to compete on the frontier of space created an atmosphere of great interest in science. However, the people NASA was lining up to send into space, in those early years, were many skin shades lighter than I was. It meant that NASA did not have me in mind in this new frontier of space. And so my interest in the universe was not born of NASA, but came from books, teachers and visits to New York's Hayden Planetarium.

I never wanted to be an astronaut. As a child in the 1960s, the civil rights movement was what en-

gaged my attention. There was a limit to how much I could celebrate America putting white military pilots into space, while my family was being denied the option to move into the apartment building of our choice. For these reasons, I became an astrophysicist not because of NASA, but in spite of it.

Ursula K. Le Guin, 77, author of many science fiction novels, including "The Left Hand of Darkness."

I was busy having babies at the time. But I thought Sputnik was cool. I do remember going out to watch the little thing go by. It blinked. I think it blinked as it turned. Sputnik was different from the cold war mindset of the time. I felt proud, as a human. "We've done something." It didn't matter whether it was us or the Russians.

Margaret J. Geller, senior scientist, Smithsonian Astrophysical Observatory.

For many in the physical sciences, Sputnik had a big impact. There was a large increase in spending for science, and there were increased physics courses. The number of undergraduates getting degrees in physics peaked in 1970-1, as a result of this investment.

By the time I went to graduate school, 1970, it was the beginning of cuts in support for the physical sciences. That has continued till today, eroding our scientific and

economic leadership. When I was an undergraduate, people going into science had the idea that the United States would lead broadly in scientific research. That is no longer the national view.

Tom Lehrer, 79, mathematician and writer-performer of satirical songs including "Wernher von Braun" and "New Math."

I was of course aware of Sputnik, but I didn't give it much thought. I was surprised at all the fuss. I was much more impressed by color television.

It did have, however, at least one memorable, though ephemeral, consequence. Americans were evidently afraid that Sputnik was proof that the Russians were getting ahead of us because of the inadequate science and math teaching in our schools. In an attempt to attack the problem, some committee came up with a ridiculous curriculum called "New Math," in which they tried to teach kids abstract concepts that they couldn't understand. The teachers weren't prepared to teach it, and the kids couldn't have cared less about it and its dubious practicality. Despite the money poured into it by the government, the fad soon died of natural causes.

Edward T. Lu, 44, former NASA astronaut.

Sputnik happened six years before I was born. I know that it drove the U.S. to send space-

craft, and later men, into space, and so it indirectly changed where I ended up in my life. I was an astronaut for 12 years, a profession that didn't exist before the events of the 1960s and 1970s.

In 2003, I was on the International Space Station for six months with the Russian cosmonaut Yuri Malenchenko. He told me he'd been named Yuri for Yuri Gagarin, their first man into space. If you look at Russia, there are a lot of Yuris of a certain age because of Yuri Gagarin.

José Vázquez, 44, who teaches the course History of the Universe at New York University.

Though I wasn't born at the time of Sputnik, I experienced the reforms it brought. My teachers told me that after the launching of Sputnik, the public school I attended in Puerto Rico began offering revised science courses that focused on underlying principles and inquiry-based learning. Prior to that, biology primarily consisted of the "fern/frog approach," dissecting frogs and drawing pictures of ferns. Students like myself were not prepared to undertake basic science research.

After Sputnik, there were new policies to attract gifted students from minorities to the sciences. I benefited from those. Without these programs, I would never have had the means to pursue a scientific education. Prior to Sputnik, most Puerto Ricans youngsters were restricted to what was called a "life adjustment" curriculum, where the focus was on vocational education or joining the armed forces.

To me, the impact of Sputnik was transforming. □

When Science Suddenly Mattered, in Space and in Class

By CORNELIA DEAN

The students in Mr. Smoot's science class in 1957 in the Lewis School in Birmingham, Ala., might not have seen Sputnik or heard its beeping, but they felt its presence.

"We stopped having throwaway science and started having real science," recalled Shirley Malcolm, one of the students. "Here I was, a black kid in a segregated school that was under-resourced — Sputnik kind of crossed the barrier. All of a sudden everybody was talking about it, and science was above the fold in the newspaper, and my teachers went to institutes and really got us all engaged. It was just a time of incredible intensity and attention to science."

For many, Sputnik was proof that American education, particularly in science, had fallen behind. Scientists and engineers warned Congress that the cold war was being fought with slide rules, not rifles. In response Congress passed the National Defense Education Act in 1958, providing, among other things, college schol-

To the Heavens

Milestones in the journey from earth to air to outer space.

FROM FIRST FLIGHT TO LANDING ON MARS

Dec. 17, 1903 Orville and Wilbur Wright achieve the first powered and sustained human flight.

1912 A balloon flight discovers evidence of cosmic rays.

March 16, 1926 Robert H. Goddard launches the first liquid-fueled rocket, which reaches an altitude of 41 feet.

NOTABLE EVENTS ▸ **1903** FIRST AIRPLANE

arships and other help for aspiring scientists, engineers and mathematicians. Meanwhile, some of the nation's eminent scientists were collaborating on new ways to teach high school physics, biology and chemistry.

"Those were heady times," recalled Gerald F. Wheeler, who as a young high school physics teacher participated in workshops on one of these plans, the Physical Sciences Study Committee's curriculum for physics. Its ideas were so fresh they were presented on mimeographed sheets rather than printed pages. "It was very high-energy networking," he said. "Science teachers trying to do a much better job teaching."

THE NEW YORK TIMES

APPLIED SCIENCE Long Island students prepared to release a weather balloon in 1957.

Today Dr. Wheeler, a physicist, heads the National Science

FROM FIRST FLIGHT TO LANDING ON MARS

Oct. 3, 1942
Germany's first successful V-2 rocket prototype reaches the edges of space.

Oct. 4, 1957
The U.S.S.R. launches Sputnik 1.

Nov. 3, 1957
The U.S.S.R. launches Sputnik 2 carrying Laika, the first animal in space.

1957 FIRST ARTIFICIAL SATELLITE

Teachers Association, and Dr. Malcolm, an ecologist, is director of education and human resources at the American Association for the Advancement of Science. And the landscape of science education is far different.

"We look at declining numbers of students who think that math, science or engineering is what they want to do," Dr. Malcolm said. "We lived many years off the investment of the race for space," she said, but today there is "a kind of complacency."

She is hardly the first to sound this warning. In 1983, a bipartisan federal commission warned in the report "A Nation at Risk" that the country was engulfed in a "rising tide of mediocrity," citing particularly a "steady decline in science achievement."

More than 20 years later, a panel established by the National Academies, the nation's leading organizations in science, medicine and engineering, said much the same thing. In "Rising Above the Gathering Storm," a report issued in 2005, the panel said the erosion of the nation's scientific and technical strength threatened America's strategic and economic security.

Both of these documents, like other reports and expert recommendations, called for more scholarships for would-be scientists, higher teacher salaries and other efforts to halt a national erosion of technical proficiency.

But none of them produced the widespread ferment and public engagement of Sputnik.

FROM FIRST FLIGHT TO LANDING ON MARS

Jan. 31, 1958 Launching of Explorer 1, the first U.S. satellite.

Oct. 1, 1958 NASA is founded during the Eisenhower administration.

April 12, 1961 Soviet cosmonaut Yuri Gagarin makes one orbit of Earth.

Feb. 20, 1962 John H. Glenn Jr. is the first American in orbit.

1961 FIRST MAN IN SPACE

In the decades after the launching of the satellite, Dr. Malcolm said, "other things refocused your attention," like the civil rights movement, the war in Vietnam, the war in Iraq or even, she said, the celebrity culture of today. Over the years, the education act's initiatives lost their tight science focus or were absorbed by other programs.

The end of the cold war further diminished the national urge "to do anything spectacular in science education," said Charles H. Holbrow, who abandoned an almost-complete doctorate in history and switched to physics after Sputnik. Dr. Holbrow, an emeritus professor of physics at Colgate and a visiting professor at M.I.T., spoke on Sputnik's influence at a recent meeting of the American Physical Society.

There is no shortage of ideas about how to turn things around. But people who study the issue see several problems.

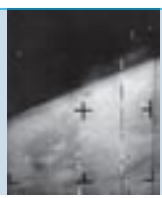
Dr. Malcolm said some of the blame must go to the way classes are taught, with too much emphasis on memorizing terminology and not enough on concepts. Most students receive teaching-to-the-test instruction, she and other experts say, in which science laboratories are organized like cookbooks, with ingredients, equipment and instructions — and results — known in advance.

Ideally, Dr. Malcolm said, students should be given the chance to do real research — to experience framing a question, deciding what

FROM FIRST FLIGHT TO LANDING ON MARS

June 16, 1963
Valentina V. Tereshkova becomes the first woman in space.

March 18, 1965
Alexei Leonov climbs out of the airlock of Voskhod 2 to conduct the first spacewalk.



July 14, 1965
Mariner 4 flies by Mars and takes pictures of the surface.

1963 FIRST WOMAN IN SPACE **1965** FIRST SPACEWALK

kind of evidence is relevant and figuring out how to collect it. "I'm not saying there's not drudgery in science," she said, "but when you get to the point where all the data are sitting in front of you and you start seeing patterns and nature begins to speak — that's a kick."

The Bush administration has started a Mathematics and Science Initiative that aims to draw attention to the need for math and science, train more teachers in the subjects and identify "effective instructional strategies."

But Dr. Holbrow said, "We know what works, that education that engages the students directly in a hands-on way with the materials is much more effective."

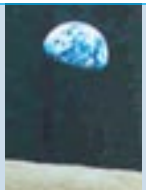
He is among the experts on science education who say that the hands-on approach does not mesh well with the No Child Left Behind law, the Bush administration's major education initiative, which emphasizes standardized tests and focuses on reading and math.

Advocates of the approach note that testing on science will begin next year, but Dr. Wheeler says he does not hold out much hope for it, "because it's not in the yearly assessment, only three times in the 12-year span" from elementary to high school.

Others point to the state and local control over school curriculums, beloved by Americans but rare in other developed countries. Dr. Malcolm said some states or localities may set the curriculum bar too low, while in other countries students are asked "to learn more,

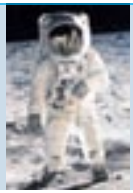
FROM FIRST FLIGHT TO LANDING ON MARS

1966 "Star Trek" debut on NBC. A Times review calls it "TV's first psychodrama in orbit."



1968 FIRST MEN IN MOON ORBIT

Dec. 24, 1968 Christmas Eve broadcast from Apollo 8 astronauts in Moon orbit.



1969 FIRST MEN ON THE MOON

July 20, 1969 Neil A. Armstrong and Edwin E. Aldrin Jr. land on the Moon.

to know more, to work harder."

Some experts on science education also point to the typical sequence of high school science instruction: biology, chemistry and then physics. It would make more sense in reverse, these people say, because the principles of physics underlie chemistry, which is crucial for an understanding of biology.

Perhaps the leading champion of this "physics first" approach is Leon M. Lederman, a particle physicist, Nobel laureate and former director of Fermilab whose focus lately has been on improving science and math education. He said the current biology-chemistry-physics sequence dates from the late 19th century, when "we didn't know enough" and biology was considered a "descriptive" subject.

In fact, Dr. Lederman said, "biology is the most complicated of all subjects, and it is based on chemistry and physics." And, he added, "there is nothing in chemistry, no fact of chemistry or process of chemistry that if you ask 'Why does this happen?' you don't go back to physics."

He said that about a thousand high schools had adopted the "physics first" approach, and preliminary reports were encouraging. But if students took physics first, there would be a big increase in physics enrollments and an increased need for people to teach it. And drawing people trained in science into the nation's classrooms is already a problem.

FROM FIRST FLIGHT TO LANDING ON MARS

Dec. 15, 1970
Venera 7 lands on Venus and transmits data for 23 minutes.

April 19, 1971
The U.S.S.R. launches Salyut 1, the first space station.

Nov. 13, 1971
Mariner 9 enters orbit around Mars.

1970 FIRST SOFT LANDING ON ANOTHER PLANET **1971** FIRST TO ORBIT ANOTHER PLANET

"We do not respond to market forces with regard to our science-math people," Dr. Malcolm said.

Dr. Lederman believes that "the only way we are going to get serious is if we rouse the public."

"A public that has a sense of science makes democracy work," he said. "If you don't understand the language in which people are discussing global warming or all the other issues, you cannot have a democracy.

Today "echoes" of Sputnik-era science curriculums live on in some textbooks, Dr. Wheeler said, but "in terms of the mass market, it just did not make it." In part, he and others say, that is because many teachers found these programs difficult to teach and worried that they reached the brightest students but left the others behind.

Organizations like the National Science Foundation have programs to advance science education, and the American Association for the Advancement of Science has Project 2061, aimed at producing widespread science literacy by the time Halley's Comet makes its next appearance.

And in response, in part, to the "Gathering Storm" report, Congress last month passed the 21st Century Competitiveness Act, which, among other things, would provide more money for science education.

"But that was just the authorization," Dr. Malcolm said. "I don't know where the money is going to come from." □

FROM FIRST FLIGHT TO LANDING ON MARS

Dec. 2, 1971
Mars 3 lander lands on Mars and returns 20 seconds of video.

May 14, 1973
Launching of Skylab, the first U.S. space station.

Continued ▸▸
More milestones in the journey from earth to air to outer space.

Present for the Beginning: A Khrushchev Remembers

By WARREN E. LEARY

PROVIDENCE, R.I. — He is 72 now, a distinguished engineer and author who holds several advanced degrees and a senior fellowship at the Watson Institute for International Studies at Brown University. But 50 years ago, he had a singular vantage point on the Soviet Union's triumphant leap into space.

Sergei N. Khrushchev, then 22, was an engineering student who often traveled with his father, the Soviet premier Nikita S. Khrushchev. In a recent interview at his office here, he recalled that his countrymen were startled by the speed and intensity of America's response to the success of Sputnik.

"The U.S. couldn't believe someone could be ahead of them in technology," Dr. Khrushchev said in fluent English tinged with a Russian accent. "It was shock and fear. We were surprised by the reaction."

It was not that the Soviets missed the importance of Sputnik, he said, "but it was seen as

To the Heavens

Milestones in the journey from earth to air to outer space.

FROM JUPITER TO INTERNATIONAL SPACE STATION

Dec. 3, 1973 Pioneer 10, launched in 1972, passes Jupiter.

July 20, 1976 Viking 1 touches down on Mars.

NOTABLE EVENTS ▸

1973 FIRST SPACECRAFT TO PASS JUPITER


LEFT, THE NEW YORK TIMES; RIGHT, RICK FRIEDMAN FOR THE NEW YORK TIMES

WITNESS TO HISTORY Sergei N. Khrushchev with his father, Nikita S. Khrushchev, in 1959 in Moscow, and today in the United States.

one more thing in Soviet technical progress, one more achievement."

"We had built the first nuclear power plant, our MIG fighters were breaking aviation records, we had launched a successful jet airliner," he continued. "It was one more thing for us and we were proud, but it was a shock in the United States."

The day after the launching, Pravda ran a small article on its front page describing the development in dry, clinical language, telling people how to listen to the new moon's signal and promising bigger and more capable scientific satellites. Elsewhere in the world, newspapers ran banner headlines and multiple articles

FROM JUPITER TO INTERNATIONAL SPACE STATION

1977 "Star Wars" premiere

1979 Voyager 1 passes by Jupiter and spot volcanoes erupting on its moon Io.

April 12, 1981 NASA launches space shuttle Columbia.

1981 FIRST SHUTTLE LAUNCHING

speculating about what it meant for the future.

Once that reaction became clear, Dr. Khrushchev said, Soviet officials quickly decided to make the most of it. "We must make a big noise about this," he said his father declared. "Yes, make a big noise."

The following day, Pravda devoted most of its front page to Sputnik, its banner headline reading, "World's First Artificial Satellite of Earth Created in Soviet Nation." The issue included congratulations from scientists in the West; a map showing the satellite's track over the Soviet Union and (for good measure) American cities; and even poems with titles like "Leap Into the Future."

Roald Z. Sagdeev, a former director of the Soviet Institute for Space Research who is now a professor at the University of Maryland, said that even if the United States had launched a satellite before the Soviets, there still would have been active competition in space because both powers had rockets and visionary people to make it possible.

"But when Sputnik went up first," Dr. Sagdeev said, "there was this feeling of 'My God, we are catching up with the United States! In a few years, maybe we will go ahead.' That hope meant a lot to the Soviet people."

Sergei Khrushchev is taller than his father, but when he turns, his profile bears a momentary resemblance to him. He recalled that his father, who had wanted to be an engineer before being swept

FROM JUPITER TO INTERNATIONAL SPACE STATION

June 18, 1983 Sally K. Ride becomes the first American woman in space.

1985 The Nimbus 7 satellite confirms that the ozone layer is disappearing over Antarctica.

Jan. 28, 1986 Space shuttle Challenger disintegrates 73 seconds after launching.

Feb. 20, 1986 Space station Mir, meaning "peace," is launched by the U.S.S.R.

into politics, had a keen interest in missiles and space.

In the 1950s, deeply concerned about an attack from the United States, Khrushchev pressed his military to develop intercontinental ballistic missiles that could reach American soil.

Sergei P. Korolev, an engineer and management mastermind considered the father of the Soviet space program, was in charge of developing that nation's first ICBM, the R-7. A crucial moment in space history occurred on Feb. 27, 1956, when Khrushchev and an entourage (including his son) visited Korolev's offices and saw a full-scale model of the huge R-7 rocket. As the impressed visitors were about to leave, Korolev asked Khrushchev for a moment to discuss another project.

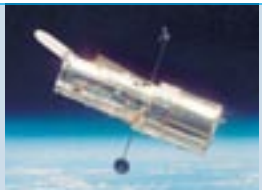
"Then Korolev took Father to a corner," Dr. Khrushchev said, "and showed him a model of a strange object that he said the R-7 could send into space and fly around the Earth like a small moon. He talked about how eventually these objects could go to the Moon and even send people into space."

Korolev said the feat could be done at little cost and would be a prestigious first for the Soviet Union.

"Father was very interested," Dr. Khrushchev said, "and had only one question: Would this hurt the ICBM program in any way or put it behind schedule? Korolev said no, and then he got the O.K. from Khrushchev to proceed."

FROM JUPITER TO INTERNATIONAL SPACE STATION

1986 The Vega and Giotto spacecraft photograph the nucleus of Halley's comet.



April 24, 1990 Launching of the Hubble Space Telescope.

1992 The COBE satellite measures the microwave afterglow of the Big Bang.

That event led to the night of Oct. 4 the next year, when Khrushchev was visiting Ukraine to witness military maneuvers, talk with local officials and discuss with some generals his plan to oust Marshal Georgi Zhukov, the World War II hero suspected of planning a coup.

It was late in the Mariinsky Palace, where the premier's party was staying, but Khrushchev stayed up talking to officials around a dinner table as he awaited a telephone call, which came shortly before midnight. "Father came back from another room with a smile on his face, and I knew then that Sputnik had been launched," Dr. Khrushchev said.

"'An outstanding event has happened,' Father announced. 'Korolev has called me and reported that a little while ago the artificial satellite was put into orbit.'" As Khrushchev talked about rockets and what the event meant, those in the room listened politely but with little interest, Dr. Khrushchev said.

The aide who had summoned Khrushchev for the phone call returned to the room and turned on a radio in a corner, setting it to the right frequency for the group to hear a few moments of the beeping of the satellite signal before the craft faded over the horizon.

"Father listened intently and happily," Dr. Khrushchev said. "When it was over, he ended the meeting and went to bed. It had been a good day." □

FROM JUPITER TO INTERNATIONAL SPACE STATION

July 4, 1997 Pathfinder delivers the Sojourner rover to Mars.

Nov. 20, 1998 Zarya, the first component of the International Space Station, is launched.

Continued ▸▸ More milestones in the journey from earth to air to outer space.

1997 FIRST ROVER ON ANOTHER PLANET

When Space Age Blasted Off, Pop Culture Followed

By RANDY KENNEDY

It was not the most eloquent line uttered in movie history, and it may have been one of the silliest: "Greetings, my friend. We are all interested in the future, for that is where you and I are going to spend the rest of our lives."

But the sentiment, as intoned by the celebrity psychic Criswell at the beginning of the 1959 astro-disaster "Plan 9 From Outer Space," was a perfect way to explain the influence that the space race, then in its infancy, was already beginning to exercise on American popular culture and art, from movies and television to architecture and design.

An effect was much more than simply a spillover from the silvery streamlining of the space program. It was an increasing preoccupation with the future and technology that helped change not only the country's look in the 1950s and '60s, but also, in some ways, its very conception of itself, as if seen anew from space.

The architect Buckminster Fuller, one of the space age's most ardent proselytizers, put it much more coherently in his book "Operating Manual for Spaceship Earth": "We are all astronauts."

Deciding which cultural offerings from those post-Sputnik years were deep and lasting and which were probably not (space-age bachelor-pad music? "The Jetsons"? "Barbarella"? Tang?) will always be topics of impassioned debate among space aficionados. But a half-century into that once-imagined orbital future, it has become a little easier to put the era into cultural perspective.

The worlds of fashion, furniture, comic books and children's toys were all profoundly affected, often for the good.

Television and the movies, as evidenced by examples like "Plan 9," "Lost in Space" and "Invasion of the Saucer Men," in which an alien's severed hand crawled around wreaking havoc on the big screen, did not fare quite as well.

Even so, it is difficult to imagine cinema without Stanley Kubrick's "2001: A Space Odyssey." And it is almost impossible to imagine that movie, made in 1968, looking the way it did in the absence of an American space program, even with earlier influences like the spacey designer Raymond Loewy or the architect Eero Saarinen, whose curvy 1948 Womb chair looks like something made specially for Kubrick's set.

In the realm of art, the influence was smaller and, usually, less direct. The cultural scholar Dave Hickey said he always felt that the "the ice-white cube," which became the standard kind of ascetic interior in museums and galleries by the '60s, could be traced in part right back to NASA.

"I remember thinking at the time that, all of a sudden, we were looking at art in clean rooms like those where the astronauts suit up," Mr. Hickey, a professor at the University of Nevada, Las Vegas, said in a recent interview.

Robert Rauschenberg was probably the most famous artist to use space imagery front and center, incorporating pictures of astronauts and space capsules into his works in the '60s.

At Bell Laboratories, which was intimately tied up with NASA in its earliest years, Billy Klüver, an engineer, organized groundbreaking collaborations with artists, including Rauschenberg and Andy Warhol, to inject space-age technology into artworks, a program whose legacy is still felt today.

Many cultural critics say probably the biggest impact can be seen in architecture. Especially in California and elsewhere in the West, the work of architects like John Lautner transformed

the look of cities and highways with upswept winglike roofs, domes, satellite shapes and starbursts that became the dominant visual language of motels, diners and gasoline stations.

Professor Hickey describes the look as "somewhere between Hindu temples and launching pads."

The look, sometimes called Googie, after Lautner's design for the Googie's coffee shop in Los Angeles, predated the Sputnik launching and had influences back to Wayne McAllister's curvaceous hotels and drive-ins, to Frank Lloyd Wright and even to Futurism in the 1920s. It took off along with the space race and produced buildings that tried very hard to bring the Jetsons to life, like Lautner's 1960 Chemosphere, a saucer-shaped house that looks as if it is preparing to hover out over the Hollywood Hills.

Kenneth Frampton, the architectural historian, said it was often difficult to disentangle the threads of the space-age look, whose origins come from early airplane and jet design. Mr. Frampton added that the lines of influence that began with Fuller's geodesic domes and other futuristic ideas could be traced across the ocean to Archigram, the visionary group of British architects who proposed far-out projects (never realized) like capsule-shape living pods and suits that could expand and double as structures.

Their spirit has in turn inspired and animated many contemporary high-tech architects like Rem Koolhaas, Zaha Hadid and Renzo Piano, whose tubular, machinelike Pompidou Center, built with Richard Rogers, seems to evoke the space race in very specific ways.

"You could draw certain parallels between the structure of the Pompidou and the structure of the rocket-launching facilities at Cape Canaveral," said Mr. Frampton, who teaches at Columbia. "They might not have been thinking about it, but I think there is some kind of unconscious affinity there." □

FINDINGS

Wanted: Billionaire Risk-Takers Seeking Eternal Renown

By JOHN TIERNEY

If you are a billionaire, ideally a decabillionaire, pondering your legacy, I have a proposition and a question for you. The proposition is immortal glory for you (plus, as a potential spinoff, the survival of humanity). The question is: How many rich people are still admired five centuries after their death for what they did with their money?

Try to name some pre-1500 plutocrats. It's not easy. You might come up with a pharaoh or two still remembered for his tomb, or art patrons like the Medicis. But these are risky role models. How could you be sure anything you built would even last 500 years, much less impress our descendants? What are the odds that modern art will be remembered in 2600 as a second Renaissance?

But consider these role models: Prince Henry the Navigator, King Ferdinand, Queen Isabella. Prince Henry ensured his place in history textbooks by financing

To the Heavens

Milestones in the journey from earth to air to outer space.

FROM AN ASTEROID TO STARDUST

Feb. 12, 2001
The NEAR Shoemaker spacecraft lands on an asteroid called Eros.

April 28, 2001
Dennis A. Tito pays a reported $20 million to become the first tourist in space.

NOTABLE EVENTS ▸

2001 FIRST LANDING ON AN ASTEROID

the 15th-century Portuguese expeditions down the African coast that began the Age of Exploration. Then Ferdinand and Isabella sponsored Columbus, turning themselves into permanent one-name celebrities: a Brad and Angelina for the ages.

You're too late to start a new age of exploration — Nikita S. Khrushchev and John F. Kennedy beat you to it — but a new world is there for the taking. Why waste your money on football teams or America's Cup yachts when you could send the first humans to Mars?

This is a once-in-a-planet's-lifetime opportunity to win eternal renown — and perform a lasting public service that won't be done anytime soon by any public agency. Politicians are understandably leery of a Mars mission, and not only because the payoff would come decades after the next election. It's hard to make a moral case for cutting social programs and science research (like climatology or unmanned space probes) to spend tens or hundreds of billions of dollars to put a human on Mars.

But a billionaire doesn't have to answer to voters. You can take the long view of Mars as our next home, a wilderness to be "terraformed" into a livable backup planet in case of disaster on Earth. And you can get to Mars much more quickly and cheaply than NASA, because you can avoid pork-barrel spending and you can take more risks. It's not

FROM AN ASTEROID TO STARDUST

Feb. 1, 2003
The shuttle Columbia breaks up on re-entry.

Oct. 15, 2003
China launches Yang Liwei into orbit.

Jan. 2004
Two NASA rovers find evidence of past oceans on Mars.

Jan. 14, 2004
President Bush announces a plan for the Moon and Mars.

a public scandal when private explorers make fatal mistakes.

Robert Zubrin, the head of the Mars Society, figures a private explorer could get there within a decade for $8 billion to $10 billion, and a good chunk of that cost — maybe all of it — could be offset with revenues from media rights and marketing tie-ins. Elon Musk, the Paypal founder who's now building rockets in his new company, SpaceX, guesses it could be done for just $5 billion.

"It would be neat to have a one-time $5 billion mission to Mars," he told me, "but $5 billion is still far too much. There's no way that we could establish any kind of base on Mars or any kind of self-sustaining biology there. We need to get that first mission to under $1 billion, and then the later missions down to under $100 million."

Mr. Musk says his goal is to help establish a colony on Mars by lowering the cost of launching payloads into space, but his company's not ready to go up there until the venture looks profitable.

Sir Richard Branson is in a similar position with his new company, Virgin Galactic, which is hoping to make money by taking customers on suborbital flights.

"We'd leap at the chance to go Mars," he told me, explaining that he'd be glad to start working on it if NASA offered prizes for entrepreneurs who came up with the best plans and pieces of hardware for the mission. The prizes would be a wonderfully cheap way to spur innovation,

FROM AN ASTEROID TO STARDUST

June 21, 2004 SpaceShipOne is the first privately developed, piloted craft to reach space.

Dec. 16, 2004 Voyager 1 crosses into the outer layer of the solar system.

Jan. 14, 2005 The Huygens probe lands on Titan, Saturn's largest moon.

Jan. 15, 2006 The Stardust mission returns the first comet samples to Earth.

2004 FIRST PRIVATE SPACECRAFT

2005 FIRST LANDING ON ANOTHER MOON

but NASA and Congress show no interest in offering them.

So for now it takes someone with deep pockets to aim for Mars. If you don't want to put up all the cash yourself, you could form a consortium, like the Peary Arctic Club that financed the attempts to reach the North Pole, or the private investors who joined Ferdinand and Isabella in sponsoring Columbus.

There's also a clever way that you could raise money — and stoke public interest — while retaining control. Offer everyone a chance to ride on your spaceship. You could run a straight lottery on the Internet, or sell shares in a corporation that gave each shareholder a ticket in a lottery. There could be regular drawings, with each winner getting a chance to undergo training and testing with the astronauts.

The grand winner, the one who gets a seat on the spaceship, could be chosen either by you or by the public. Imagine the ratings for "Martian Idol." (If you'd like to see some preliminary market research on the lottery, check out tierneylab.blogs.nytimes.com, where I'm asking nonbillionaire readers how much they would spend on tickets.)

> How much would nonbillionaires be willing to spend on lottery tickets to win a seat on a spaceship?

I think you could more than break even on the expedition, but maybe it sounds too complicated. If you're too busy to organize an expedition yourself, you could instead offer a prize or a series of prizes (and let the X Prize Foundation manage it for you). By putting up $5 billion, preferably more, you might start a competition as exciting as the race to the South Pole a century ago.

A prize would be blessedly simple for you, but it does have one drawback. Although prizes spurred many of the early feats

in aviation, we remember the winners, not the sponsors. How many people know that a New York hotelier named Raymond Orteig put up the $25,000 prize won by Charles Lindbergh for flying from New York to Paris?

But everybody remembers the Spirit of St. Louis, just as they remember the Santa Maria and the Mayflower and Apollo 11. So here is my last piece of advice. Whether you offer a prize or send your own expedition, insist that the ship carrying the first humans to Mars be named after you. Sure, you'll be accused of egotism, but pay the critics no heed. They'll be dead soon enough. Your name will live forever. □

ESSAY

One Giant Leap, Followed by Decades of Baby Steps

By DENNIS OVERBYE

This was going to be a sour grapes column.

On Oct. 4, it will be 50 years since Sputnik launched the world into the so-called space age.

Some space age. It has been 35 years since anybody was on the Moon, or more than 300 miles from Earth, for that matter. NASA says it will be 2020 before astronauts get back to the Moon, meaning that it will have taken twice as long this time from presidential declaration (Bush in 2003) to actual landing than the first time around, when President John F. Kennedy declared in 1961 that America would land on the Moon within the decade, and Apollo 11 launched eight years later. You are free to make your own guesses about Mars.

If you're not a reporter covering the space program or a scientist who uses space instruments, you probably have never met anyone who has seen the curve of the Earth with his or her own eyes. It is as if the response to Christopher Columbus's voyage had been confined to mapping the reefs off Spain.

It wasn't supposed to be like this.

When Sputnik was launched, transforming what my parents thought of as an unhealthy obsession with science fiction and all things atomic or cosmic into the stuff of patriotic heroism, my friends and I already knew how the future was supposed to unfold: Arthur C. Clarke (Sir Arthur now), Robert A. Heinlein, Isaac Asimov and Ray Bradbury, among many others, had laid it all

NASA

THUNDERING TO THE COSMOS Space shuttle Endeavour, atop its towering plume.

out in stories and novels that we stole from the local drug store: the space stations, the Moonbases and Mars colonies, the lonely asteroid prospectors, the nuclear wars back home, the eventual dispersal of humanity to far flung stars where Earth is only a dim legend.

The great space visionaries

like Wernher von Braun, Robert H. Goddard, Hermann Oberth and Konstantin Tsiolkovsky, as well as the men and women of NASA, all drank the same Kool-Aid. But NASA, as the current administrator Michael D. Griffin will be the first to tell you, works for the president. As a result, true believers over the ages have had to hitch their wagons to whatever political star is in vogue.

Sputnik was an almost accidental outgrowth of the arms race, as Matthew Brzezinski's new history, "Red Moon Rising," makes grippingly clear. Neither Nikita S. Khrushchev nor Dwight D. Eisenhower understood at first how important and ominous that little beeping ball orbiting the Earth was. After the United States reclaimed its missile manhood by landing men on the Moon, President Richard M. Nixon had no more use for the Apollo program.

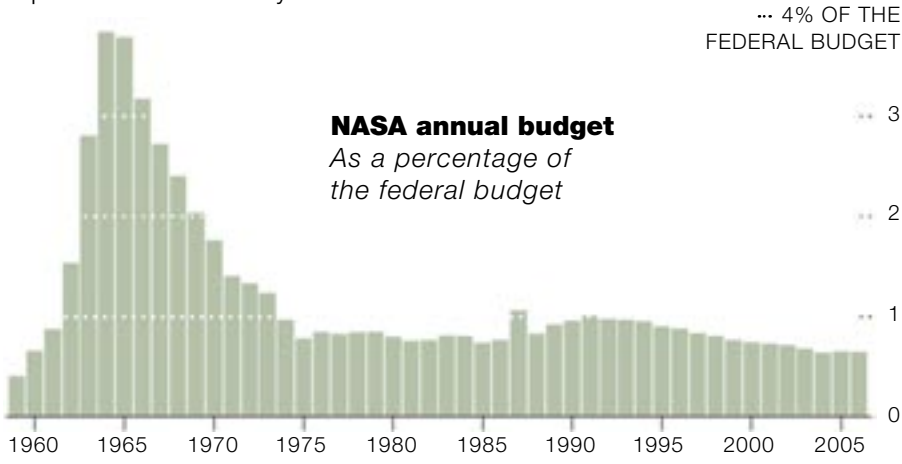
Space aficionados have been wandering in the political wilderness ever since, looking for a way to make cosmic affairs matter again. Curiosity? It doesn't seem to be enough to loosen the purse strings these days. American economic competitiveness? A recent NASA slogan, "NASA explores for answers that power our future," didn't exactly stir the blood. To escape some planetary apocalypse like an asteroid or plague? So far we can't seem to get out of our own way regarding greenhouse gases and global warming.

Wandering in the political wilderness, looking for a way to make cosmic affairs matter again.

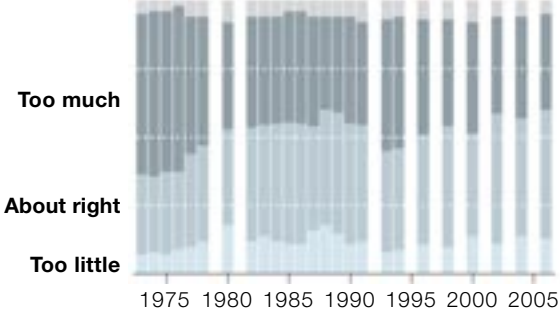
I can think of many much worse ways than space exploration to put my tax dollars to work, but the space dream has been dead for me since the early 1980s, when I chanced to see a particular photograph of a shuttle launching. The photo was taken from a

Space and the Public

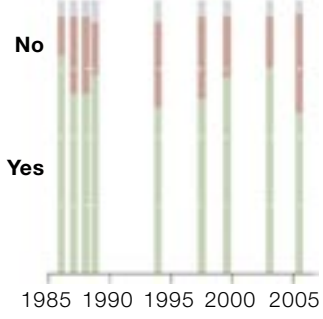
The NASA budget peaked in the 1960s, while public views on space exploration remain fairly stable.



SURVEY: *Are we spending too much, too little, or about the right amount on the space exploration program?*



Given the costs and risks, do you think the space shuttle is worth continuing?



Sources: NASA History Office (annual budget); The General Social Survey, conducted by the University of Chicago (spending poll); The New York Times/CBS News nationwide telephone polls.

THE NEW YORK TIMES

chase plane. It shows a tower of smoke rising upward from the Earth's surface, which is blurred by the haze of altitude and clouds. Near the tower's glowing top, like a pinhead on Jack's beanstalk, is the space shuttle, dwarfed by its own plume, roaring away as hard as it can.

There, on a pillar of violence, is your dream of transcendence, of freedom, of escape from killer rocks in the sky, boiling oceans or whatever postmodern plague science comes up with. Of galactic immortality.

That picture broke my heart. I'd seen rocket launches before and been appropriately chastened by the thunder and heat it took to break free of gravity, but I had never seen it from such a perspective. So much work for such a small step into the universe. How could this ever be routine, economical or safe?

Don't get me wrong. In the long run, humans or their successors have no choice but to get out there where the asteroids and cosmic rays roam. The Earth, after all, is doomed to boil in a billion or so years.

Recently I sent an e-mail message to Sir Arthur asking him how he felt about the progress, or lack thereof, in space exploration since Sputnik. In addition to being a visionary writer, he invented the idea of the communications satellite, and for the last few decades has been plugging the idea of a space elevator, which could haul people and things nonviolently to geosynchronous orbit, 22,240 miles high, perhaps with superstrong nanotubes. He was encouraged by the prospects of such a contraption and the advent of what he called "citizen astronauts."

"I remain optimistic that the best is yet to come," he wrote from Sri Lanka.

In fact, the last 50 years haven't all been a letdown. Science, despite being relegated to the tail end of NASA's budget, has begun to illuminate space and the universe to a degree no one imagined, probably because none of my sci-fi gurus foresaw Moore's

Law, by which the capabilities of computer chips have doubled every year and a half.

Who dreamed that space would be peppered with black holes popping off X-rays? Who dreamed that you could have a baby picture of the universe when it was only 400,000 years old and a seething fireball? Spy satellites have allowed the United States and Russia to take the first timid steps backward from atomic catastrophe — surely that deserves a Nobel Prize for some spook somewhere.

As I write this, the Mars Phoenix lander is approaching Mars with, among other things, the names of 250,000 Earthlings, including those of my wife and daughter. Voyager 1 is leaving the solar system with a recording of Beethoven, Chuck Berry, whale songs and the sound of a kiss, among other things. It won't be long before space probes are carrying genome sequences and even genes.

In this context the grapes don't seem so sour to me (although there is a lot more science they could be doing).

Our machines have gone ahead of us. But someday people will hike through the canyons of Mars.

Our machines have gone ahead of us. But someday people will hike through the canyons of Mars. I just don't know when or how or who. Maybe it will be the Chinese, who seem to still feel that they have something to prove as a nation. Maybe it will be billionaire adventurers — like the Google founders who just put up a $25 million prize for the first private Moon lander, who are free to risk their own money and don't have to answer to Congress when things go wrong, as they sometimes will — who make the dream come true, for at least a few.

There will always be someone willing to ride a pillar of fire into

the unknown, but it won't be me. I don't want to go to Mars anymore. I no longer have the stuff — if in fact I ever did — to camp out in a tin can for two years. I'd be afraid to be so far from the Earth and my family for so long.

I don't want my daughter to go either, for the same reason. When our children do go off forever across the void then we will have a chance to find out if we are as strong as our ancestors who bundled their children onto ships in the hope they would reach a better world across the ocean. Someday, somebody will go and not come back, and humans will have escaped their nest, for better or for worse.

There is no galactic immortality. Everything we are and have done, the whole Milky Way with its billions of stars, is eventually destined to be swallowed up in a black hole. Neither ourselves nor our works will survive the end of the universe, if dark energy eventually blows it apart, no matter what we do. All we own is the present, so it behooves each of us to live each moment impeccably, guided by whatever lights we choose. Speaking only for myself, while we are around we might as well embrace the light and the unknown, the violence and vastness that terrify us.

My sci-fi dreams are dead, but Sir Richard Branson and his fellow space entrepreneurs say they have business plans. If Mr. Branson manages to get the cosmologist Stephen Hawking into space and back, he will have done more for the cause of space exploration than 25 years of space shuttles going around in circles.

Watching the Apollo astronauts recount their travels to the Moon in the documentary "In the Shadow of the Moon," I was wiping away tears for a time when we had bold dreams and leaders who, for whatever motives, could make them happen. Neil Armstrong's footprints on the Moon are as crisp as the day he made them.

I will always be glad I was alive when he took that small step, even if we are still waiting for the next big leap. □

New Horizons Beckon, Inspiring Vision if Not Certainty

By JOHN SCHWARTZ

Fifty years of spaceflight have taken people to the Moon and have sent unmanned vehicles zipping to the fringes of the solar system. What could the next 50 years bring?

Much more, or potentially not much more. Government-financed space travel could stall in the face of America's growing aversion to risk and a kind of orbital ennui. NASA has, after all, already tried for more than a decade to develop follow-on vehicles to the flawed space shuttle and is in the process of trying again.

Private enterprise is stepping up, but the industry is still fragile.

Michael D. Griffin, the NASA administrator, said in an interview that he was confident of one thing for the foreseeable future: "We're going to have a space program."

Beyond that, all bets are off.

"The one thing of which we can be certain," Mr. Griffin wrote in a recent essay on the Web site of the magazine Aviation Week and Space Technology, "is that in trying to envision the world of 2057, two generations in the future, we will be wrong."

Experts in government, industry and science agree, however, that these three broad trends will shape the coming decades in space:

NASA has embarked on a program to return to the Moon by 2020, not just for what some critics call "flags and footprints," but also for a lasting presence with scientific research and prepara-

tion for expeditions to asteroids and, eventually, Mars. The space shuttle program is being wound down by 2010 to create the next generation of vehicles.

Other nations, notably Russia and China, have ambitious plans and could spur a space race like the one that sent Americans to the Moon. "It took Sputnik for us to recognize what the Soviet Union was up to," said Harrison H. Schmitt, who flew the last mission to the Moon, in 1972. "I don't know what it will take this time."

Private enterprise is moving ahead, beginning with space tourism and, later, transport services for NASA and other governments to outposts like the International Space Station. Beyond that, ventures could include mining on asteroids and manufacturing drugs in space.

John M. Logsdon, director of the space policy institute at George Washington University, says a big question has yet to be answered.

"At the level of government, I think we're still struggling as

Moon or Mars, or both? Economic incentives or political? And who will lead the way?

to why we're sending people to space," Dr. Logsdon said. "It's a decent question, and I think it's an unanswered question."

That leaves the manned space program at a precarious point, he said, adding: "If the current proposals to restart human exploration fail politically, indeed, the human space flight endeavor conducted under government auspices might well lose its momentum. I obviously hope that doesn't happen. But it's far from a slam dunk that we're going back to the Moon and on to Mars."

Entrepreneurs say they have the answer — money. Peter Diamandis, a founder of the Ansari X Prize, the $10 million competition to put a pilot in space without government financing, said that with all the energy and minerals to be

found there "the first trillionaires are going to be made in space."

In the next 50 years, Mr. Diamandis said, "economic engines," not political ones, will push the space frontier.

Dr. Logsdon is skeptical. "There are a variety of alluring prospects that have been around almost since the start of the last 50 years that are still there as alluring prospects," he said. "And we are not further along in knowing whether they can be turned into reality or not." The continued reliance on chemical rockets, for example, limits the weight that can be taken into space.

ILLUSTRATION BY JOHN RITTER; PHOTOGRAPHS FROM NASA, SPACEX

Yet much has changed in the last 50 years that could lay the foundation for the next 50. A new generation of ultrawealthy entrepreneurs who grew up with a space fascination are pouring personal fortunes into making space businesses real.

Paul G. Allen, a founder of Microsoft, paid for SpaceShipOne, the tiny craft that won the X Prize in 2004. Elon Musk, a founder of PayPal, is developing rockets through his company, Space Exploration Technologies, and has NASA financing that could lead to his spacecraft's carrying people and supplies to the International Space Station.

Jeffrey P. Bezos, founder of Amazon.com, is developing rockets at a site he owns in western Texas.

Robert Bigelow, who made his fortune in hotels, is developing a space transportation system and a space station that could be used as an orbiting hotel or a research base.

The official charged with regulating commercial spaceflight, Patricia Grace Smith of the Federal Aviation Administration, said in an interview, "When I look out 50 years from now, I fully expect that we will have actual, operational spaceports" that are commercially operated and owned.

At the dusty, sprawling Mojave Air and Space Port in California, dreamers and pragmatists join in planning the future.

Jeff Greason, the founder of Xcor Aerospace, one of several rocket companies there, said his industry was ready to talk big again after years of having to shake off the pixie dust of science fiction. "We had to stop focusing on the grand and glorious future," he said, "because otherwise, people weren't going to take us seriously as a business. We very consciously turned the vision thing off."

"We're making progress on real businesses that turn profits," he added.

Other companies are already in the game. Mr. Greason's neighbor, Scaled Composites, is working on a successor vehicle to its SpaceShipOne.

Richard Branson's company, Virgin Galactic, which will buy the vehicles, has a long list of potential space tourists.

Esther Dyson, a longtime technology guru who is encouraging investment in space, said the de-

velopment of rocket businesses paralleled the early days of personal computing and the Internet. Early government financing created technologies whose use was largely limited to government and academia.

"So eventually these commercial types came in, and suddenly a whole lot of revenue came in," she said. "It benefited the research types, as well as the commercial types. And it created an infrastructure for the public."

That led, in turn, to today's Google, Netscape, Google Earth, "all these wonderful things we take for granted."

Mr. Greason predicts that government will take the lead in long-range exploration, but that industry will take up the slack closer to home. Just as the military relies on private air carriers, he said, "the government efforts will become customers of the private efforts."

NASA will meanwhile be trying to extend the reach of humanity. Mr. Griffin, its administrator, laid out a rough timetable for the goals that President Bush set in 2004.

He sees the mileposts clearly along the way, returning to the Moon by 2020, with a "small lunar outpost" a few years later, on the way to "towns on the Moon." The first flights to Mars could occur in the next decade, he said, so that by the 100th anniversary of spaceflight in 2057, "we can be looking back at the 20th anniversary of the first human landing on Mars."

If the United States wants to lead the way, he said, the clock is ticking.

"This is the last generation of Americans which is going to have the unquestioned opportunity to lead that enterprise," Mr. Griffin said. "Because in the next generation we are going to find, at least, Russia, China, India and Europe fully as capable as we are. It will be a matter of interest and politics and societal will or desire. But it will not be a matter of capability."

Whoever takes them on, the challenges will be greater than any that spacefaring nations have

yet faced. They involve radiation levels that science does not yet know how to protect against and problems like reduced gravity and Moon dust, which is ultrafine-grained, chemically reactive and highly abrasive, all of which may mean serious health problems for astronauts.

At a conference in June on lunar settlements, Dr. James S. Logan, a former chief of medical operations at the Johnson Space Center and a founder of Space Medicine Associates, a medical consulting group, pointed out that the previous missions to the Moon involved just 600 total man-hours on the surface, a figure likely to be exceeded on the first return mission.

In his presentation, Dr. Logan pointed out that the earlier exposure times, "while significant," did not provide strong evidence that long-duration exposure would be safe.

At a conference on space medicine this year at the Baker Institute for Public Policy at Rice University, Peggy A. Whitson, an astronaut who is about to take her second stint aboard the International Space Station, said radiation would continue to be a concern.

"We have to just accept the fact that if we're going to explore," Dr. Whitson said, "we're going to have to accept a higher level of radiation" than, say, OSHA permits for atomic workers.

Dr. Jonathan Clark, a former NASA flight surgeon on the panel with Dr. Whitson, said, "To me, an unacceptable level of risk would be a radiation exposure that would result in acute and substantial performance effects, either fatality or cognitive decline."

If the effects are so debilitating that the mission fails, Dr. Clark said, "it's pointless to go."

There could be other problems with a Mars mission that scientists are just beginning to explore. At the Rice conference, Dr. Nick Kanas of the University of California, San Francisco, a psychiatrist who has studied astronauts, described what he

called the "Earth out of view" phenomenon.

Dr. Kanas's research has found that one of the most positive parts of going to space is seeing the Earth. But on a trip to Mars, the Earth would dwindle to a bluish speck.

"No one in the history of humans has ever studied what it's like to see the Earth as a little dot," he said.

In an interview, Dr. Kanas said losing the visual connection with the home planet could be a "unique stressor."

Communications would slow markedly, with lags of more than 40 minutes, he said. Ready access to powerful telescopes and libraries of Earth images might help, but it would be important to fight those feelings of "extreme isolation and loneliness."

Mr. Griffin acknowledged that problems like radiation presented grave challenges in each new environment, but added that he was confident that protections would be discovered, just as early sailors learned that sauerkraut and lemons could protect them from scurvy on long voyages.

And he predicted that the lessons learned about bone growth, cell biology, damage prevention and repair would help treat diseases on Earth.

Mr. Schmitt, the Apollo astronaut, agreed. Despite very real risks of living in space and on other planets, he said, "I don't see any showstoppers."

Stuart Witt, general manager of the Mojave Air and Space Port, takes an even longer view. In his office, with composite craft being designed in nearby buildings, Mr. Witt noted that five centuries ago, Magellan left Spain with five ships and 270 men. Two years later, one ship returned, with 18 men.

He quoted from memory a passage from Charles Van Doren's book "A History of Knowledge: Past, Present, and Future" (1991), pointing out that after the surviving ship returned loaded with valuable spices, subsequent expeditions "never lacked for sailors to man them and for captains to lead them."

"They knew that the spirit of exploration was far bigger than any individual," Mr. Witt said.

The argument resonates with Mr. Griffin: "Every time that humans have invested in the past in breaking through new frontiers, it's been to our profit.

"It may be tough on the individual explorers, but it's been pretty beneficial for the human race — as we sit here," he continued, waving his arms to take in his office, Washington and America, "in what once was the New World."

"We'll lose people," he said flatly, and risks must be minimized. But exploring is "embedded in our DNA."

The urge to go beyond might actually be ingrained in the helical curves of our genes as one of the many behavioral traits now being linked to genetic propensities, said Jeffrey M. Friedman, director of the Starr Center for Human Genetics at the Rockefeller University.

Indulging in a bit of speculation at a reporter's request, Dr. Friedman said "it's very plausible to suggest" that there might be a primal urge to explore and take risks.

"And you sort of have direct evidence of it in the history of human migrations," he added.

In any population, there would be a spectrum of traits from stay-at-homes to explorers, with those at either end of the spectrum prospering in some circumstances and suffering in others.

The future holds promise and peril, as any visitor to Mojave can see. At Scaled Composites, an explosion last month killed three employees. The accident involved the nitrous oxide that Scaled Composites uses as a propellant, though there was no rocket test at the time. The accident is under investigation.

Meanwhile, the company continues to develop its next craft, and Virgin Galactic said no customers had canceled. When asked whether the accident gave him second thoughts, James Lovelock, the 88-year-old British scientist and author, said, "I have no qualms whatever." □

Two Early Pioneers Continue Their Work at the Frontier

By KENNETH CHANG

NASA

Twenty years after Sputnik, on Sept. 5, 1977, NASA's Voyager 1 spacecraft was launched from Cape Canaveral. Its twin, Voyager 2, had been launched a couple of weeks earlier, on Aug. 20, 1977.

Three decades later, both Voyagers continue traveling outward, still taking measurements and still radioing their findings back to Earth. Voyager 1, now more than 9.6 billion miles away, is the most distant human-made object, traveling at 38,400 miles per hour. It has entered the outermost neighborhood of the solar system, the heliopause, where the winds of charged particles flying out from the Sun have diminished to subsonic speeds.

When the solar winds come to a stop, Voyager 1 will have officially left the solar system and entered interstellar space. That moment is not expected until 2015. But remarkably, scientists say, the spacecraft might continue transmitting its data back to Earth. Voyager's power supply, a chunk of radioactive plutonium, should last until 2020.

Voyager 2, which took a slower trajectory, is a mere 7.8 billion

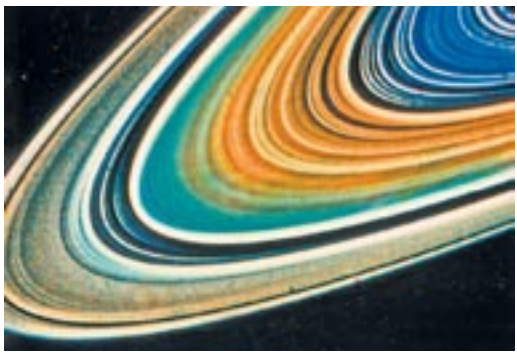
miles away and has yet to reach the heliopause, although there are signs that it is very close. "I'd be surprised if we haven't crossed it by the end of this year," said Edward C. Stone, project scientist of the Voyager mission.

Voyager 2 might make it to interstellar space a decade from now.

Various components of the spacecraft have worn out, scientists say, and the Voyagers now rely on backup systems. But the outer solar system is a relatively benign place. The Voyagers were built to survive the intense radiation belts of Jupiter and, while crossing Saturn's rings, possible impacts with ring particles. After those obstacles had been passed, "then we knew had a good chance of lasting a long time," Dr. Stone said.

Dr. Stone, who was named to project scientist in 1972, hopes to last a while longer, too.

"I've been working on this for 35 years," said Dr. Stone, now 71. "I'm not going to give up yet." □



PHOTOGRAPHS BY NASA

OBSTACLES After the two Voyager spacecraft traveled through Jupiter's radiation belts, they sent back images like these of the particle-filled rings that surround Saturn.

From the Start, Space Race Was an Arms Race

By WILLIAM J. BROAD

Sputnik forced the Eisenhower administration to consider a scary new world of space arms. It did so in two ways: talking peace and preparing for war.

That duality held firm for much of the ensuing half century. Washington publicly encouraged peaceful uses of space even while spending billions to explore futuristic weaponry like death rays fired from rocket ships.

By and large, those arms remained as fictional as those in "The War of the Worlds." But analysts say the Bush administration is now tilting the balance toward deploying real armaments, mainly antimissile interceptors that would speed into space to smash enemy warheads. But it also wants to loft jets that can shoot deadly laser beams and orbital battle stations that can hurl swarms of lethal munitions.

Space weapons are "still definitely part of the program," said Philip E. Coyle III, a former director of weapon testing at the Pentagon. "But they don't emphasize it because the arms-control people come out of the woodwork."

Critics say the overall program is costly and unnecessary, and the funds better spent on countering such threats as terrorism.

Today, the biggest item in the nation's arms budget is building antimissile weapons. For next year, the administration wants nearly $11 billion, including a down payment on a $300 million effort known as the Space Test Bed.

"We believe that space offers a lot of flexibility," Lieut. Gen. Henry A. Obering III, director of

the Pentagon's Missile Defense Agency, told the Senate in April. The test bed, he added, will reveal "what is within the realm of the possible and what is not."

That challenge drove the Eisenhower administration as well. Sputnik raised alarms that Soviet nuclear warheads could soon fly halfway around the globe to obliterate the United States, and in response the administration scrambled to find ways to shoot them down.

The crash program eventually cost many billions of dollars and explored such ideas such as lasers, particle beams and other would-be weapons that now seem quite bizarre.

Project Defender, as it was known, got under way in 1958 as a secret rush involving thousands of the nation's best scientists. One bright idea was to destroy Soviet missiles early in flight with Ballistic Missile Boost Intercepts, or Bambi.

The scientists wanted to put hundreds of battle stations into orbit. Tracking intercontinen-

NEW YORK TIMES FILES

LOCKHEED MARTIN

REAL OR IMAGINED From top: an illustration for "The War of the Worlds" by H. G. Wells; a rendering of a Boeing 747 equipped with a powerful laser.

tal ballistic missiles by their fiery exhaust, the stations would launch rocket-propelled Bambis that would smash the rising missiles to smithereens. To increase the odds of a direct hit, the weapon would release a rotating wire net 60 feet wide.

Soon, Pentagon experts seized on a new device known as the laser that they hoped would one day fire rays of light strong enough to smash rockets and warheads.

By then, however, critics were attacking the entire antimissile effort as deeply flawed. They argued that an enemy could deploy cheap decoys among its warheads to outwit antimissile arms, and that a leaky shield would be worthless because a single nuclear blast could do so much damage.

At the same time, military scientists were finding it harder than they had expected to zero in on enemy targets. The designs grew ever more grandiose and elaborate, like an orbital battle station bearing no fewer than 3,000 nuclear arms.

"It turned out that it was a lot easier to draw this stuff than do it," remarked John E. Pike, director of GlobalSecurity.org, a private group in Alexandria, Va., that tracks military and space endeavors.

Eventually the Pentagon scaled back its space efforts, designing land-based interceptors meant to fly into space on a moment's notice. And Washington began talking to Moscow about halting the burgeoning antimissile race.

The costs of the race were becoming clearer to both superpowers. Even a flawed antimissile system would require the other side to take expensive countermeasures. And even a leaky defensive shield might make a nuclear strike less unthinkable, undermining the global "balance of terror" that had thus far prevented a nuclear war.

These doubts prompted Washington and Moscow to ratify a 1972 treaty sharply limiting their antimissile forces.

But by the late 1970s, the idea

of arms in space seemed to grow more alluring. In secret, atom scientists hailed the X-ray laser, which was to channel a nuclear blast into beams that shot across space to zap enemy missiles.

Inspired by such reports, President Ronald Reagan issued a call on March 23, 1983, to make enemy missiles "impotent and obsolete." His research effort, scorned by critics as "Star Wars," after the movie, cost taxpayers more than $100 billion.

John D. G. Rather, a laser expert who was an official at a military contractor during that era, said corporate greed undermined the effort from the start. "It became a tug of war," he recalled, "where everybody and their brother wanted a piece of the action."

In 1994, the dissipated effort suddenly came back to life as Republicans swept to power in the House. Their "Contract With America" explicitly called for the rapid deployment of antimissile arms.

The Clinton administration fought the initiative, but in May 2000, George W. Bush, then a candidate for president, promised to deploy defensive arms "at the earliest possible date."

In 1994, Republicans brought the effort to develop and deploy and antimissile system back to life as part of their "Contract With America."

In July 2004, at a secluded Alaskan base, military contractors loaded a first interceptor rocket into a deep silo, followed over the months by 15 more in the wilds and 2 others at a sister base in California. In theory, the sites can now fire interceptors at North Korean warheads in space. The system has cost up to $40 billion so far.

The Bush administration is pushing more exotic efforts, in-

cluding a fleet of Boeing 747s equipped with powerful lasers. The jets would zap enemy missiles, letting the debris fall back onto enemy territory. To date, the program has cost $4.3 billion.

Last month, a prototype jet with a bulbous nose for aiming the laser completed its low-power flight tests. Engineers are to install the big laser next year, with the project's annual cost at $549 million. Rick Lehner, a spokesman for the Missile Defense Agency, said the summer of 2009 should see "the first shoot-down of a missile."

The administration's Space Test Bed is a first step toward orbital antimissile arms. The secretive plan has drawn sharp fire from antimissile critics, and Congress for now has eliminated its budget for the next fiscal year.

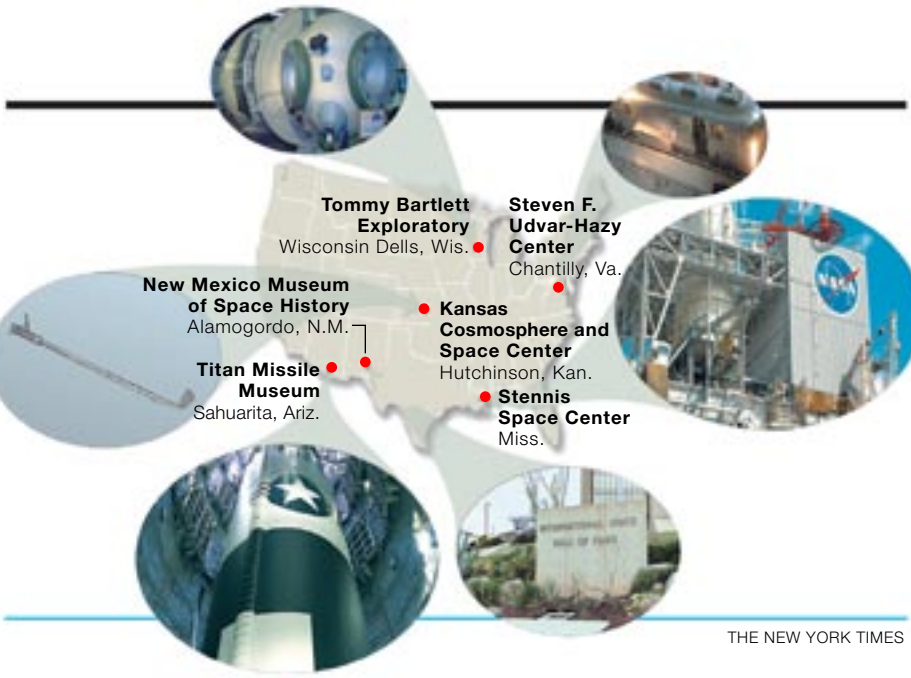
The Union of Concerned Scientists, a private group in Cambridge, Mass., in May called the plan costly, ineffective against speeding missiles, but probably good at shattering satellites.

Its real value, the group said, "is certain to be recognized, and perhaps responded to, by other nations" in a space arms race.

Critics fault the overall antimissile effort as misguided and unnecessary. Any country stupid enough to fire a missile at the United States or its forces, they say, would suffer annihilating retaliation.

The real danger, they say, is terrorism. The billions the Bush administration is spending on antimissile arms should instead go to such precautions as securing nuclear arms around the globe and protecting the nation's borders and ports.

In March 2004, as the administration prepared to install the first interceptors in Alaska, a group of 49 retired generals and admirals wrote Mr. Bush to argue for such a redirection. In a letter whose lead signer was Adm. William J. Crowe, chairman of the Joint Chiefs of Staff under Reagan and the first President Bush, the group called a financial shift "the militarily responsible course of action." □



THE NEW YORK TIMES

Space Age Artifacts?

The Smithsonian Is Just the Beginning

By HENRY FOUNTAIN

Among the relics of the American space program, a few have achieved iconic status — John Glenn's Mercury capsule, the Apollo 11 command module, rocks from the Moon.

Then there is the Airstream trailer rediscovered last spring at a fish farm in Alabama.

The surplus trailer had most recently been used as housing by the Fish and Wildlife Service. But in late 1969, it was temporary quarters for the Apollo 12 crew on their return from the Moon. Worried that astronauts might pick up a lunar microbe and transmit it to earthlings, NASA outfitted the trailer with blowers and filters, and the astronauts remained in it for a few days until receiving a clean bill of health.

The Airstream is being restored and will be on display beginning in January at the United States Space and Rocket Center in Huntsville, Ala.

There are two other surviving M.Q.F.'s, as the initial-happy agency called the mobile quarantine facilities, including one from Apollo 11 at the National Air and Space Museum's **Steven F. Udvar-Hazy Center** near Dulles International Airport in Virginia.

Living quarters of a different sort can be found in the Wisconsin Dells, where a spare core module of the Mir space station is on exhibition at the **Tommy Bartlett Exploratory**. The 43-foot-long module, one of several built by the Russian space agency, was bought from a Moscow museum a decade ago by Mr. Bartlett, a Midwestern entrepreneur best known for his water-skiing thrill show, which can be seen next door.

One of the world's largest test stands can be viewed at the **Stennis Space Center** in western Mississippi. It is a 400-foot-tall structure where engineers test fired the huge engines used to power the Saturn V Moon rocket. A 39-foot-thick concrete anchor prevented the test structure itself from flying into orbit. The test stand is viewable from a visitors' center, and because rocket testing continues there, it is sometimes possible to watch an actual test.

The Stennis center is all about engines. To see an actual rocket, one of the best places is a museum

dedicated to the arms race, not the space race. The **Titan Missile Museum**, a preserved cold war complex south of Tucson, has a Titan II missile visitors can practically touch. This one was part of a program to hurl nuclear warheads at the Soviet Union. But the same rockets were used to hurl the Gemini astronauts into space.

Not all space relics are so large or so serious. One of the oddest is the hybrid lunar scoop and 6 iron that Alan B. Shepard Jr. used to hit a golf ball on the Moon. It is the property of the United States Golf Association and is now on display at the **Kansas Cosmosphere and Space Center** in Hutchinson.

Mr. Shepard was also the first American in space, riding a Redstone rocket on a suborbital flight in May 1961. He was preceded five months earlier by Ham, a chimpanzee who was the first hominid in space.

Ham's ride was no walk in the park. His capsule landed hundreds of miles off target, and a valve failure caused it to become almost fully depressurized in flight. They were the kinds of mishaps that later made the Apollo 13 crew famous. No one ever made a blockbuster movie about Ham, who died in 1983 at age 27. But those who want to pay him homage can visit his grave at the **New Mexico Museum of Space History** in Alamogordo. □

New Challengers Emerge, Threatening to Take the Lead

By GUY GUGLIOTTA

In March, during an otherwise routine budget hearing, Michael D. Griffin, the NASA administrator, warned members of Congress that China's aggressive space program could "easily" put humans on the Moon before American astronauts are able return to the lunar surface under the space agency's proposed Moon-Mars project.

The China card can be a strong selling point on Capitol Hill, and Mr. Griffin, trying to finance an ambitious human spaceflight program with Mars as the ultimate goal, plays it as well as anyone.

This is America's great space-age paranoia: that the United States has frittered away 35 years of space superiority, and a new generation of rivals is about to shove it into second place.

China is the challenger du jour. It became the third nation to send a human into space in 2003, it put a two-man crew in orbit in 2005 and it plans to send an unmanned orbiter to the Moon this year. It plans to launch three astronauts and conduct its first spacewalk in 2008.

In January, China's military destroyed one of its own derelict satellites with a guided missile in a provocative demonstration of ballistic prowess. Although it is unclear what the Chinese intended, the test left no doubt that space hardware — everything from crucial navigation and communication assets to secret spy satellites — is a very soft target. And no one has more space hardware than the United States.

Despite its achievements, experts say, China is decades away from developing the full array

of space expertise and infrastructure that allows the United States to simultaneously launch astronauts, send unmanned craft to explore outer planets, take spectacular pictures from orbiting telescopes and profile the eye of a hurricane. "We are leagues ahead of everyone else, and it's going to take a lot of time, effort and money to counter that superiority," said Joan Johnson-Freese, chairwoman of the Department of National Security Studies at the Naval War College.

Still, what China can do is "match, compete with or even supplant" the United States "in piecemeal ways," said Eric Hagt, head of the China program at the independent World Security Institute. By putting humans in space, China wins significant prestige, Mr. Hagt said. Putting their own man on the Moon before the United States can return would put the Chinese first in the world.

China is not the only player with space aspirations. India is developing a human spaceflight program and hopes to have astronauts in orbit by 2014. Europe and Japan, which routinely fly astronauts aboard the space shuttle, also have highly developed space science programs. Japan's innovative mission to orbit the asteroid Itokawa has produced a journal's worth of research pa-

AGENCE FRANCE-PRESSE — GETTY IMAGES

THEIR SPACE AGE Top, Fei Junlong and Nie Haisheng before the Shenzhou VI mission. A Japanese satellite at the Baikonur Cosmodrome.

pers, and next year the European Space Agency expects to bring its 30-satellite Galileo navigation network online as an alternative to the Global Positioning System in the United States.

Russia, once America's only rival in space, has been out of the game since the breakup of the Soviet Union. But the Russians these days are flush with petrodollars and looking for ways to reassert their power.

"Russia has the capabilities, the big industrial base, the trained cadre of people and the ability to launch in all kinds of weather," said John Logsdon, a space historian at George Washington University. "It has a relatively unambitious space plan for the next few years, but that could change."

Fifty years into the space age, human spaceflight and space science remain the most traditional measures of prestige and accomplishment, but space has also become a lucrative business and a new territory for military competition.

Fifty years into the space age, human spaceflight and space science remain the most traditional measures of prestige and accomplishment.

The big money is still in building spacecraft for governments, and the major aerospace companies worldwide, like Boeing, Lockheed, the European Aeronautic Defense and Space Company, and RKK Energia, a Russian company, focus on that. Building commercial satellites is a much more modest undertaking. Since 2004, the world has produced 80 of them; China has built 3.

Space's other cottage industry is a Russian monopoly: running a ferry service to the International Space Station with its venerable Soyuz spacecraft. Since 2001, five well-heeled space tourists

have paid $20 million apiece or more to visit the station. Soyuz also carried American astronauts to the station after the 2003 Columbia accident grounded the space shuttle fleet.

With plans for the shuttle to be retired in 2010, the United States is developing new launching vehicles capable of returning astronauts to the Moon and eventually taking them to Mars. That is the kind of big, high-risk idea that has always defined space leadership, and that is where China is competing.

China launched its first satellite in 1970, but its space program languished during the chaos of the Cultural Revolution and internal power struggles. Estranged from both the Soviet Union and the United States, China learned to fend for itself. In 2003, a Long March rocket carried Lt. Col. Yang Liwei aboard the Shenzhou V spacecraft. Colonel Yang returned safely to Earth after 14 orbits and became a national hero.

The Chinese share little information about their programs, but Zhang Oinwei, who heads construction of the Shenzhou spacecraft, said the human space flight program spent about $2.3 billion in the years leading up to Colonel Yang's flight.

In 2005, Shenzhou VI, carrying two Chinese army colonels, orbited Earth for five days. Shenzhou VII, scheduled for launching in 2008, will carry three crew members who will attempt China's first spacewalks.

The Shenzhou (it means "magic vessel") spacecraft are patterned after the Soyuz but are slightly larger. China has said that its goal is to use the Shenzhou to develop orbiting skills and technology and eventually to build a small space station.

Although the Chinese have not formally announced plans to send humans to the Moon, the Shenzhou flights, coupled with plans for science missions to orbit the Moon, put robotic rovers on the lunar surface and return soil samples to Earth show that China has read the Apollo playbook.

Mr. Griffin of NASA has de-

scribed the Shenzhou program as having reached the Gemini stage, recalling the two-man American flights in the mid-1960s that prepared astronauts for the Apollo missions. He told Congress in March that it would "easily be possible" for the Chinese to mount a lunar mission within a decade. If so, China could put humans on the Moon by 2018, a year earlier than the United States, under current American budget projections.

The United States, worried about China's military ambitions, has regarded the Chinese space program warily in recent years, imposing export restrictions on commercial technologies that might also have military uses.

Last year, Mr. Griffin accepted an invitation from Chinese officials to tour their space facilities in the hope of broadening ties. After cordial talks and meetings with civilian space scientists and engineers, however, Mr. Griffin cut his visit short when the military refused to let him visit the human spaceflight training facilities at the Jiuquan Satellite Launch Center in the Gobi Desert.

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"If we are to conduct human space flight activity together, we have to have a great degree of trust, a great degree of sharing, a great degree of openness," Mr. Griffin told reporters at the end of his trip. "Transparency and openness mean being able to see and touch and ask questions and get answers, and China and the U.S. are not at that point."

Despite China's achievements and aspirations, there is no evidence that the Chinese can soon compete with the United States in technical skill or space infrastructure. "This is about political

will," said Dr. Johnson-Freese of the Naval War College. "They are challenging what we are willing to do, or willing to pay for."

Congress seems solidly allied with Mr. Griffin on the need to finance the Moon-Mars project, but the Bush administration's insistence on paying for the program without increasing NASA's overall budget has put some spaceflight advocates on edge. At the same time, scientists interested in robotic missions and space research worry that Mr. Griffin's interest in spaceflight will shortchange those programs.

For those concerned about China, however, there was plenty to worry about after the Chinese shot down a Fengyun-1C weather satellite in January. The destruction of the satellite created more than 900 new trackable pieces of debris, increasing by 10 percent the amount of hazardous space junk circling Earth. China made matters worse by refusing for 12 days to acknowledge responsibility for the satellite's destruction, which was viewed by most of the rest of the world as pure folly.

Western analysts have offered several reasons for China's wanting to shoot down the satellite. China may have wanted to test its ability to destroy enemy satellites in a confrontation over Taiwan; it may have wanted to show the United States how vulnerable satellites are and encourage participation in talks aimed at banning weapons in space; or, it may have just been a long-scheduled test that the military conducted without informing the government.

Some considered the incident as evidence of another cold war rivalry. Representative Dana Rohrabacher, Republican of California, long a space program advocate, said the Chinese "are already in a space race with us, and we haven't recognized it."

But others say the time is ripe to sit down with the Chinese and co-opt them. Dr. Johnson-Freese said the United States should encourage China to put more satellites in space, to "make them as dependent on space assets as we are," and just as vulnerable. □