

Quantum physics could get us to Mars

Why the U.S. will go back to the moon

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ORDEAL OR IDEAL?

Why the aviation industry stands by the promise of geared turbofans, despite rollout woes. **PAGE 22**

A black and white photograph of a lunar surface. The terrain is covered in small rocks and dust. Long, dark shadows are cast across the surface, indicating a low sun position. The shadows appear to be from lunar rovers or similar vehicles. The overall scene is desolate and captures the texture of the moon's ground.

ONCE WE WENT



Neil Armstrong, left, and Buzz Aldrin erect the American flag on the moon during the Apollo 11 mission. The picture was taken by a camera mounted on the lunar module.

NASA

TO THE MOON

The circumstances that led the U.S. to undertake the Apollo 11 lunar mission 50 years ago next July, and the five landings that followed, were unique, and they won't be repeated. Even so, space historian **John M. Logsdon** sees reason to anticipate that U.S. astronauts will in the next decade return to the moon.

It seems incredible, almost a half century later. In the 12-month period between December 1968 and November 1969, NASA five times launched the massive Saturn 5 booster. Four of those launches took an Apollo spacecraft and its three-man crew a quarter million miles to the moon, and on two missions the spacecraft's lunar module transported two astronauts to and from the lunar surface. In the coming months, we will properly be celebrating these remarkable achievements.

Many have been hoping in the decades since Apollo that something similar could happen again. Hoping for another “Kennedy moment” is in my view a false hope. The reasons we went to the moon in the 1960s were unique; so was the national commitment of the resources to make Project Apollo possible.

Even so, am I alone in noticing that the United States in 2018 is well along on its way back to the moon? This time around, we are following a “go as you pay” approach, and we have been spending multiple billions of dollars each year for most of the past decade preparing for resuming human exploration. In my judgment, sometime in the 2020s the momentum built up over the past 15 years or so is likely to be translated into missions to destinations beyond low Earth orbit, and particularly to the lunar surface.

Why we went

To understand why an exploration program with the urgency of Apollo will not happen again, it is essential to understand why it happened in the first place. It was, of course, President John Kennedy who decided to send Americans to the moon. Reacting to the Soviet Union being the first to orbit a human, Kennedy on April 20, 1961, asked Vice President Lyndon Johnson to conduct an urgent review to identify a “space program which promises dramatic results in which we could win.” Cold War competition between the two superpowers, not space exploration, was the overriding stimulus.

Johnson's review identified a lunar landing as the best way to meet Kennedy's requirements. Achieving that goal would require both the U.S. and the Soviet Union developing a powerful new launch vehicle and,



▲ **Dr. Robert R. Gilruth**, left, director of the Manned Spacecraft Center (now Johnson Space Center), presents President John Kennedy with a model of the Apollo spacecraft in 1962.

thus, in a technological sense, the race to the moon became a rocket-building contest in which the United States had famed German expatriate Wernher von Braun and his Saturn 5 booster on its side.

In a memorandum dated May 8, 1961, that formed the charter for Apollo, NASA Administrator James Webb and Secretary of Defense Robert McNamara argued that “dramatic achievements in space symbolize the technological power and organizing capacity of a nation” and that the prestige from such achievements was “part of the battle along the fluid front of the Cold War.” Kennedy accepted that perspective, in November 1962 telling advisers that “the Soviet Union has made this a test of the system” and therefore “everything we do ought really to be tied to getting on the moon ahead of the Soviets.” Kennedy backed up his words by marshaling human and financial resources as though he were mobilizing for war. Apollo was formally assigned the highest national priority; NASA's budget went up by 89 percent in 1962 and another 101 percent the following year. After Kennedy's assassination, Apollo became a monument to a fallen young president. Even after

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The Saturn 5 rocket
carrying the Apollo
11 crew lifts off from
Kennedy Space Center
on July 16, 1969.



NASA

astronauts Roger Chaffee, Gus Grissom and Ed White II died in the Apollo 1 fire, there was little thought of giving up the race to be first. Apollo 8, then Apollo 11, took us to the finish line.

Why we stopped

Kennedy's 1961 commitment and the measures taken to achieve it created enough momentum to carry Apollo through to his "before this decade is out" goal, but that momentum quickly dissipated. By December 1969, even after the successes of Apollo 11 and Apollo 12, President Richard Nixon was asking why the United States needed to continue sending astronauts to the moon. There was no good answer to his question; the Cold War rationale underpinning the race to the lunar surface had been rendered moot by winning that race, and there were no other compelling arguments for continuing an ambitious program of human exploration. Suggestions that missions to the moon be followed soon by journeys to Mars were quickly dismissed by the White House. The Nixon administration decided to shut down the Saturn 5 production line, and NASA chose to cancel two of the remaining six lunar landing missions and apply freed-up funds and engineering talent toward developing the space shuttle fleet, which would be limited to low Earth orbit. As

▼ **U.S. President Richard Nixon** greets the Apollo 11 astronauts aboard the aircraft carrier USS Hornet on July 24, 1969, shortly after their capsule had splashed down in the Pacific Ocean. NASA

the last lunar landing mission, Apollo 17, left the moon in December 1972, Nixon stated that "this may be the last time in this century that men will walk on the moon." By his decisions, he had made that statement a self-fulfilling prophecy.

Nixon was very sensitive to public opinion, and he judged that the American public was not interested in continuing an Apollo-paced space program. He told NASA Administrator Tom Paine in January 1970 that "the polls and the people to whom he talked indicated to him that the mood of the people was for cuts in space." Apollo was an overwhelming success in achieving the leadership goal set out by Kennedy, but it turned out to be a dead end in terms of a sustainable program of human exploration.

The vision persists

Even so, the belief has persisted, at least among space advocates, that the primary rationale for sending humans into space is, as Apollo 11 astronaut Michael Collins has frequently written, about "leaving" — going somewhere away from Earth. After being in the background for more than a decade, that objective found eloquent expression in the 1986 report of the presidentially appointed National Commission on Space, which proposed as the U.S. space program's 50-year goal "Human Settlements beyond Earth Orbit, from the Highlands of the Moon to the Plains of Mars." That proposal was incorporated into the final space policy of the Reagan administration, issued in early 1988, which set as the long-range goal expanding "human presence and activity beyond Earth orbit into the solar system." This aspiration soon found concrete expression when President George H.W. Bush, on the 20th anniversary of the lunar landing, called for a Space Exploration Initiative that would return humans to the moon, "this time to stay," and then send them on initial voyages to the Red Planet.

Bush's proposal was premature. In the aftermath of the Challenger accident and with the space station program struggling to gain traction, neither the Congress nor NASA was ready to take on an ambitious exploratory effort. The Bush initiative was essentially stillborn. But the idea that the primary justification for government-sponsored human spaceflight was to someday travel beyond Earth orbit lived on, even as shuttle flights and space station assembly dominated U.S. spaceflight activity for the next 20 years. In the aftermath of the 2003 Columbia accident, the Columbia Accident Investigation Board said all members agreed "that America's future space efforts must include human presence in Earth orbit, and eventually beyond." The board's conclusion had a major influence on President George W. Bush's January 2004 announcement of his Vision for Space Exploration. Bush's



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proposal, echoing both Reagan's 1988 policy and his father's 1989 initiative, included plans to "extend a human presence across our solar system" and to "return to the moon by 2020, as the launching point for missions beyond."

This 2004 proposal, which also included shuttle retirement, marked a turning point. Since then, no one has argued, as was the case before the Columbia accident, that the long-term focus of the government's spaceflight program should be centered on full exploitation of low Earth orbit. Rather, the debate has assumed that the focus should be on human exploration beyond Earth orbit. These discussions have centered on which destination should take priority, which exploration hardware to develop, what schedule would be feasible, and, of course, the level of funding that is likely to be available. In fits and starts, and ever so gradually, we have been implementing the vision laid out in 2004.

Unlike the situation in the aftermath of Apollo, there are both geopolitical and technical reasons to believe that a U.S.-led mission to the moon will be the outcome. Spacefaring countries around the globe are focusing on Earth's nearest neighbor as a desirable destination. That interest provides an opportunity for U.S. leadership. At least for the initial exploratory missions, it will be the U.S. government in the first position in the effort. This time around we will not be racing a strategic adversary in a zero-sum competition; instead, NASA should lead a global coalition of governments and the private sector in taking the next steps on the lunar surface.

Earth's satellite is basically unexplored territory. The six Apollo landing missions were demonstrations of national prowess more than well-equipped scientific investigations. There is an impressive list of things we do not know about the moon, especially whether it can be a source of economically valuable resources; that itself is reason to go back before setting out for the much more challenging goal of human exploration of Mars. As engineering professor Clive Neal of Notre Dame is fond of saying, there is a "new moon" to discover.



Which future?

In my view, there are only two alternatives for the future of government-sponsored spaceflight. One choice is to continue on the current course — slowly preparing for deep space missions by U.S. government astronauts, with the result, barring a catastrophic accident, being the eventual launch of such missions, first to lunar orbit and then the moon's surface. The other is to end that sponsorship after disengaging from the International Space Station. It is hard for me to think that any U.S. president would fire NASA's astronauts, taking NASA out of the human spaceflight business; such a step would be inconsistent with this country remaining the leading spacefaring nation.

Preparing for resuming space exploration has been incorporated in the policy of the last three administrations. Congress in 2010 wrote into law the statement that "the long term goal of the human space flight and exploration efforts of NASA shall be to expand permanent human presence beyond low-Earth orbit." Billions of dollars have already



◀ **Apollo 11 astronauts**
Neil Armstrong, Michael Collins and Buzz Aldrin ride in a parade down Broadway and Park Avenue in New York on Aug. 13, 1969, as the country celebrated the moon landing weeks earlier.



John M. Logsdon

is professor emeritus at George Washington University and has written books on the space policies of U.S. Presidents Kennedy, Nixon and Reagan. He founded GW's Space Policy Institute in 1987 and directed it until 2008. Logsdon was a member of the Columbia Accident Investigation Board. He has a doctorate in political science from New York University and a Bachelor of Science in physics from Xavier University. He is editor of "The Penguin Book of Outer Space Exploration."

been spent on developing hardware to achieve that goal. There is no indication that the Trump administration or the current Congress have any intention of reversing the overall course that the United States has been following, even as the White House has refocused that course on first returning to the moon. It would take a political decision to stop this flow of events; the decisions to pursue it have already been made and reiterated by three presidents and seven Congresses. The United States will resume human exploration, not as the result of a clarion call by an inspirational leader, but as a result of the normal flow of year-after-year government decisions.

Alternatively, a future president could make a "Nixon-like" decision that "the polls and the people to whom he talked indicated to him that the mood of the people was for cuts in space." I find such a choice hard to imagine, but it is certainly not inconceivable. The perceptive 2014 National Research Council report "Pathways to Exploration" commented that, given political and fiscal realities, "there is at least as great a chance that [government] human

spaceflight budgets will be below the recent flat line trend as they will be markedly above it." A June 2018 poll that prioritized future missions for NASA gave lowest priority out of nine possibilities to sending astronauts to the moon, with only 13 percent of the respondents ranking a lunar return as the top priority.

I am guardedly optimistic that this country will continue to pursue option one, and that a return to the moon will be an early milestone along the way. There will be continuing arguments over whether NASA's current plans are the best way to proceed, and private sector alternatives will compete with those plans for political attention. My bet is on NASA as the leader of the first round of exploratory missions, given its head start and reservoir of experience. It is most likely that it will be a government astronaut who will take the next "small step."

I was at Kennedy Space Center in Florida on July 16, 1969, as Armstrong, Aldrin and Collins set out for the moon. I hope to be there again when the next lunar journey begins. ★