Back to the Moon

The Moon and Earth as seen from the Orion spacecraft during the *Artemis 1* mission. (Courtesy of NASA.)

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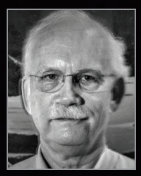


. . . to stay?

Michael J. Neufeld

Despite a lack of public enthusiasm, NASA's Artemis program will endure because human spaceflight has strong congressional support and signals great-power status.

NASA's April 2023 introduction of the members of the *Artemis 2* crew—the first humans scheduled to go to the Moon in over half a century—is a sign that the US and its international partners are serious about human lunar exploration. That is new. Two presidents—the Bushes—gave major speeches announcing that astronauts would return to the Moon and venture on to Mars. But no lasting program emerged from either pronouncement. Humans have not been more than 650 kilometers from Earth since the *Apollo 17* astronauts splashed down in December 1972.

It was not until November 2022 that NASA finally managed to launch the Space Launch System booster and the Orion crew vehicle on the uncrewed *Artemis 1*, at least five years later than originally scheduled. The spacecraft orbited the Moon and returned safely to Earth in December, capping a highly successful test. But will the program last, or will it be like Apollo: a magnificent technical and scientific success that was politically unsustainable? The US sent nine expeditions to the Moon between 1968 and 1972, six of which landed astronauts on the lunar surface. And then the Apollo program came to an end. Will it be different this time?

Despite weak public support for human lunar exploration, I believe it will be sustained this time because of three reinforcing political factors: an entrenched human spaceflight–industrial

THE *APOLLO 17* COMMAND MODULE approaches splashdown in the South Pacific Ocean on 19 December 1972. (Courtesy of NASA.)

complex with strong support in Congress, the signaling of great-power status that results from flying astronauts, and growing space competition from China, notably surrounding the Moon. But to understand that in historical context, one must follow the meandering course of US space policy since Apollo to grasp why it took 50 years for another such program to emerge. It's also necessary to examine what changed in the later 2010s and the political factors that now seem to make an expensive human lunar program more sustainable.

Questions, of course, remain. Does human exploration make any sense when robotic spacecraft are getting more and more capable, efficient, and cheap? And are humans suited to deep-space exploration given the hostile radiation environment beyond the protective shield of Earth's magnetosphere? Regardless, it appears likely that Artemis will last at least into the 2030s and probably beyond. If China lands astronauts on the Moon around 2030, as a Chinese official asserted in 2021,[1] then it is even more likely to endure.

The legacies of Apollo

In hindsight, Apollo's unsustainability was foreordained. Although the program was wrapped in rhetoric of science and exploration, President John F. Kennedy set its core purpose in May 1961: to beat the Soviet Union to a human landing on the Moon or at least be competitive with it. Once the race was won, it was going to be harder to argue for a continuation, especially after the Soviets failed to send cosmonauts to the Moon.

Moreover, as the former NASA chief historian Roger Launius has shown, public support for spending billions of dollars on Apollo was always weaker than space enthusiasts want to remember. Only two 1960s public opinion polls, one of them at the time of the July 1969 *Apollo 11* landing, showed a slight majority in favor. Not long after Neil Armstrong, Michael Collins, and Buzz Aldrin returned to Earth, support plummeted.[2] By the time *Apollo 12* launched in November 1969, a large fraction of the US public was asking what the point was: We beat the Soviets, so why were we doing it again? With the Vietnam War, riots in the cities, urban decay, and a growing sense of environmental crisis, why were we still spending billions on Apollo?[3]

Because of the program's remaining momentum, NASA managed to carry out five more landings out of six attempts. Those expeditions shifted decisively toward science; the program produced a priceless haul of samples and data from different regions of the Moon. The result was a greatly increased understanding of the violent early history of the solar system, which set a baseline for the development of planetary science thereafter. But the public and the politicians cared little about that. Every Apollo lunar landing cost over $400 million (the equivalent of several billion dollars today). Congress had already begun cutting NASA's budget in 1967, and the freefall continued into the early 1970s.

Richard Nixon and his administration in 1971 seriously discussed canceling the last two Apollo missions and not funding NASA's proposed space shuttle. The agency's plans for a large space station, let alone Moon and Mars programs, were already dead. That the president did not end human spaceflight was in no small part because of a 12 August 1971 memorandum from Caspar Weinberger, then deputy director of the Office of Management and Budget (OMB). He argued that no US astronauts in space would confirm the impression of many at home and abroad "that our best years are behind us, that we are turning inward, reducing our defense commitments, and voluntarily starting to give up our super-power status."[4]

In short, the US would no longer look like a great power if it lacked a human space program. In the end, Nixon approved the space shuttle on the agency's promise that it would drastically lower launch costs, but also because it promised aerospace jobs in California at a time when he was thinking about the 1972 campaign.

The shuttle became the lifeline for another Apollo legacy:

NASA's massively expanded human spaceflight infrastructure, mostly located in the Deep South, plus the giant aerospace corporations that depended on it. Apollo and other large space and military programs had taught the lesson that spreading federal spending to as many states as possible ensured congressional support. The agency became a self-perpetuating system of large engineering centers and military–industrial contractors, each supported by politicians determined to protect the jobs created by spaceflight in their districts.

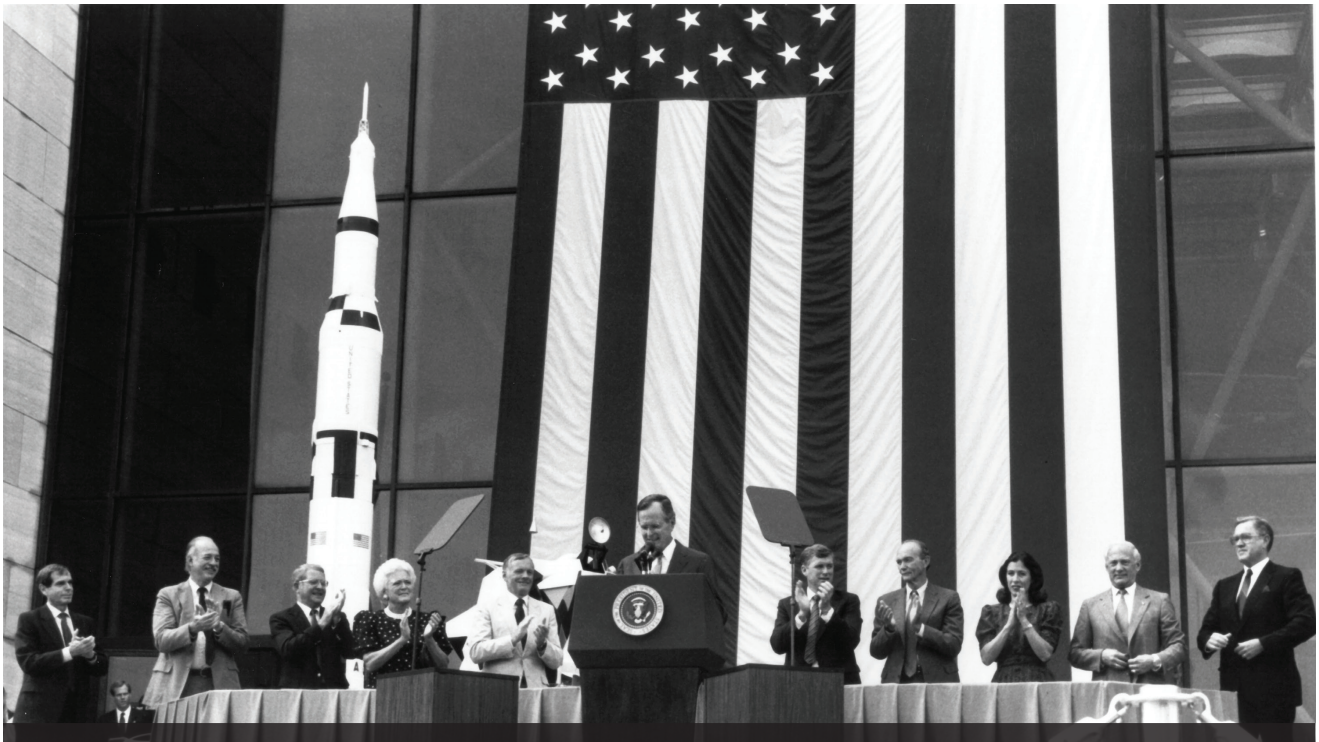
Through lean times, better times, and two fatal accidents, the shuttle remained the space agency's foundation, notwithstanding the vehicle's failure to deliver on NASA's promises of frequent launches and greatly lowered costs. The shuttle did many remarkable things, like broadening access to space to diverse crews, launching and then refurbishing the *Hubble Space Telescope*, and building the International Space Station (ISS). But it remained NASA's core program largely because it was entrenched in its infrastructure and political economy. As long as another use for it could be found, it was hard to terminate: Several attempts to develop a successor went nowhere. The result was that when it was finally retired in 2011 after 30 years of flights, the US had to depend on Russia to send astronauts to the ISS.

Going to the Moon and Mars—or not

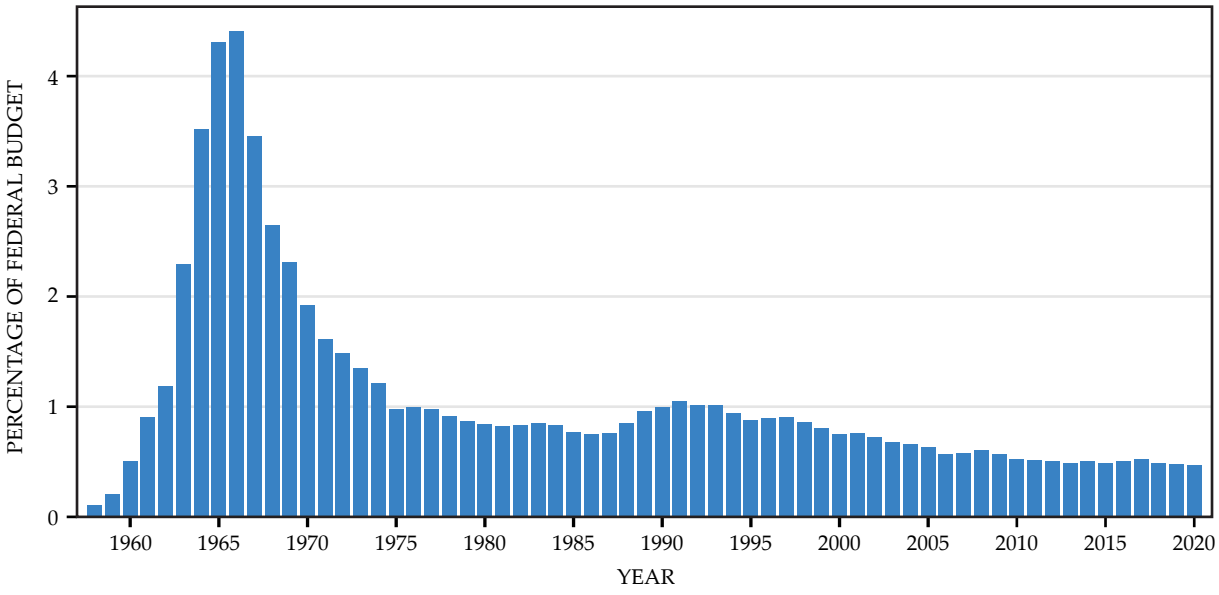
The two fatal accidents, those of *Challenger* in 1986 and *Columbia* in 2003, did produce soul-searching. Both failures sparked reconsiderations of US civil space policy that led two presidents—George H. W. Bush and George W. Bush—to propose striking out for the Moon and Mars. Both felt they needed to articulate a bold vision for space that ultimately meant sending astronauts to the red planet. Both proposals failed because of weak public and political support.

The origin of the senior Bush's 1989 Space Exploration Initiative (SEI) was the aftermath of the January 1986 *Challenger* disaster, which caused significant changes to space policy. President Ronald Reagan ended the ill-advised attempt to make the shuttle into the sole US government launch vehicle. Commercial satellite launches would be left to US rocket makers, who would be encouraged to market their vehicles. NASA would also, as soon as it could, get out of the business of launching military and intelligence payloads on the shuttle. On the horizon was launching the modules of what would become the ISS, which Reagan had approved in 1983. The European Space Agency (ESA), Canada, and Japan soon joined that program, and their modules and contributions would need shuttle launches too.[5]

But many inside and outside the space advocacy community felt that the agency was aimless, bureaucratic, and unimaginative, leaving the US human space program stuck in low Earth orbit. Reagan appointed a national commission headed by former NASA administrator Thomas Paine. It produced a grandiose plan for a massive expansion of the agency's program and budget to fund human infrastructure across the inner solar system, including bases on the Moon and Mars. It not only had zero chance for success but also had the bad luck of coming out days after the *Challenger* accident. The first US woman in space, Sally Ride, then



PRESIDENT GEORGE H. W. BUSH speaking at the Smithsonian's National Air and Space Museum on 20 July 1989, the 20th anniversary of the *Apollo 11* landing. In the speech, Bush announced his Space Exploration Initiative, which aimed to return astronauts to the Moon and take them to Mars for the first time. On stage with Bush are NASA administrator Richard Truly (third from left) and *Apollo 11* astronauts Neil Armstrong (fifth from left), Michael Collins (fourth from right), and Buzz Aldrin (second from right). (Courtesy of NASA.)



PERCENTAGE OF THE FEDERAL BUDGET allocated to NASA since its establishment in 1958. It peaked around 4% at the height of the Apollo program in the mid 1960s but is now at half of 1%. (Adapted from 0x0077BE/Wikimedia Commons/CC0 1.0; data for years 2018–20 courtesy of Roger Launius.)

headed another committee that in 1987 produced a more modest report. She highlighted Mission to Planet Earth, a program designed to investigate the biosphere and environment, as one of the options, although she was not allowed to make that the preferred option in the report.[6]

When George H. W. Bush became president in 1989, he thought the moment was right to articulate a grand new vision for NASA. A space enthusiast, he gravitated immediately to the human spaceflight community's fixation on missions to the Moon and Mars, but he paid surprisingly little attention to the political demands that huge NASA budget increases would require. He announced the SEI on the steps of the Smithsonian's National Air and Space Museum on the 20th anniversary of the *Apollo 11* landing: 20 July 1989. Astronauts were to set foot on the Moon by the beginning of the 21st century and on Mars by 2020.

Initial reaction in the media and in the Democrat-controlled Congress was skeptical. The space agency quickly initiated a study that by fall 1989 produced the politically toxic estimate that it would take half a trillion dollars to establish bases on the Moon and Mars. Although additional studies dragged on for a couple more years, the SEI was effectively dead on arrival.[7]

Lack of direction

The shuttle and the proposed space station were important factors in NASA's huge estimates and failure of imagination. With the funding for those programs providing the foundation for many of NASA's centers and their relationships with contractors and politicians, agency engineers and executives could not imagine curtailing or canceling those programs or skipping the Moon and going directly to Mars, as some new voices in the space community were advocating. Any Moon or Mars architecture would have to be built in addition to the shuttle and station.

Bush had appointed a former shuttle astronaut, Richard Truly, as NASA administrator. Truly's first reaction to the SEI was that he couldn't see how ambitious new programs could be piled on to the agency's existing structure. It was an accurate perception. But seeing that it was something the president wanted to do, Truly went along and did nothing to change the process that produced a gigantically expensive and unimaginatively narrow set of options.

Another important context for the failure of Bush's SEI was the lack of public support for a greatly expanded civil space program, especially for trips to Mars, which reinforced the lack of interest in Congress.[8] Since the huge peak in spending for Apollo, which reached 4% of the federal budget in the mid 1960s, NASA's share has fallen to less than 1%. Brief bumps for shuttle development in the mid 1970s and to replace the lost *Challenger* in the later 1980s raised it to around 1%, but the agency's share then fell thereafter because the overall federal budget grew faster than NASA's did. (See the bar graph above.)

Appropriated budgets do not tend to change quickly because OMB and congressional appropriators assume that a certain level of spending is the agency's or department's fair share. It usually takes a sense of national crisis to drastically alter a budget allocation—which happened to NASA only once, for Apollo. When Bush proposed the SEI, the public and the politicians more or less accepted the status quo; doubling or tripling NASA's budget was a nonstarter.

Bush and his vice president, Dan Quayle, share blame for that political failure, but both felt betrayed by the space agency's tone-deaf response to the challenge. Disillusionment with NASA's leadership grew in the early 1990s, nota-

bly after the embarrassing flaw in the *Hubble Space Telescope*'s mirror came to light in mid 1990. In early 1992 Bush forced Truly to resign and made an outsider, Daniel Goldin, administrator. It was no coincidence that Goldin, a vice president at the defense contractor TRW, had primarily worked on classified space programs. Although Reagan's controversial Strategic Defense Initiative was fading, ballistic missile defense contractors had developed a reputation for being fast and innovative and for slashing the long time scales and huge budgets typical of the military–industrial complex that effectively includes NASA.

Goldin implemented what became known as the "faster, better, cheaper" approach to robotic spacecraft programs, with mixed but important results. He survived Bush's loss in the 1992 election and continued as Bill Clinton's agency chief because of his reputation as a reformer, notwithstanding his sometimes-abusive management style. But Goldin was stuck with the entrenched shuttle and station programs and with a stagnant or slightly declining budget: The sudden end of the Cold War and the disappearance of Soviet competition undercut the argument for NASA. To serve foreign-policy goals and save the space station, which was already years late and billions over budget, the Clinton administration negotiated a merger with the Russian program, creating the ISS. Ideas for human space programs beyond low Earth orbit were completely off the table.

OMB officials and Goldin started a new planning effort in 1999 to figure out what the agency should look like beyond 2000. That planning was the root of what would eventually become the Orion spacecraft for Artemis. But it took another fatal shuttle accident, that of *Columbia* in February 2003, to spark a more substantive public discussion of NASA's future. Beyond reviving criticisms of how the agency handled the vehicle's safety, the tragedy underlined how the shuttle was inherently less safe than earlier spacecraft. The accident report recommended that it be retired once the ISS was completed. Both the report and the public discussion surrounding the incident highlighted NASA's failure to develop a shuttle replacement and the human spaceflight program's lack of direction.[9]

Constellation

President George W. Bush spoke at NASA headquarters on 14 January 2004 to unveil the Vision for Space Exploration (VSE). The shuttle would be retired in 2010 following completion of the ISS. NASA would develop a crew exploration vehicle to fly to the ISS, the Moon, and eventually Mars. Its first flight would be in 2014, which implied that the agency would depend on the Russians to get to the station for at least four years. (It turned out to be nine.) The younger Bush was aware, as was his father, that the Moon was not popular as a primary goal because the US had been there before. But

SPACEX SPACECRAFT have supplied the International Space Station since 2012. This image from 2019 depicts a SpaceX Dragon cargo craft attached to the ISS while the station flies over the Indian Ocean. (Courtesy of NASA.)

THE *ARTEMIS 2* CREW is introduced on 4 April 2023. From left are Jeremy Hansen, Victor Glover, Reid Wiseman, and Christina Koch. (Courtesy of James B. Blair, NASA.)

he emphasized a return—by 2020 and perhaps as early as 2015—as a necessary step to developing the technologies for traveling to Mars.

To make the speech sound visionary, it was again important to make a human Mars landing the ultimate objective, reflecting a long history of public fascination with the red planet. But the commitment to Mars was vague. Learning from the failure of the SEI, Bush proposed only a modest increase in NASA's budget, of $1 billion over five years. But another $10 billion was to come from retiring the shuttle, terminating the ISS not many years after its assembly, and taking money from space-science programs not focused on lunar and Martian exploration.[10]

That budget plan was not without its critics, notably among the space station's foreign partners and the US science community, but it at least prevented the VSE from immediate political failure. Nevertheless, it too proved unrealistic. After Sean O'Keefe, the first NASA chief appointed by Bush, left in early 2005, aerospace engineer Michael Griffin took over. Seeing a lack of clear goals for what was now called the Constellation program, he refocused the human exploration program more firmly on getting to the Moon. But Griffin faced shuttle and ISS costs higher than had been projected and declining interest in the VSE from the White House. Quagmires in Iraq and Afghanistan did not help. NASA got no significant budget increases, and the dividend for retiring the shuttle was years in the future. As soon as Constellation began, launch dates started to recede farther into the 2010s.

The architecture that Griffin settled on was a lengthened shuttle solid-rocket booster with an upper stage, called the Ares I, as the launch vehicle to put the crew exploration vehicle (now called Orion) in low Earth orbit. A heavy lift booster called Ares V, which used a core stage derived from the shuttle external tank and two stretched solid-rocket boosters, would carry the lunar lander, called Altair, and the propulsion stage that would send the combined Orion–Altair craft to the Moon.

The reuse and extension of shuttle technology reflected the entrenched character of what one might call the shuttle–industrial complex. The three large NASA human spaceflight facilities—Kennedy Space Center on Merritt Island, Florida; Marshall Space Flight Center in Huntsville, Alabama; and Johnson Space Center in Houston, Texas—were closely tied to Boeing, Lockheed Martin, and solid-rocket maker Morton Thiokol. Those companies lived off cost-plus contracts that did not penalize them much, or at all, for being late and over budget. As always, that cozy, self-interested system was fortified by US senators and representatives determined to keep jobs in their districts.

In the first decade of the 2000s, the commercial rocket industry was still in its infancy, which made it easy for NASA and the giant aerospace corporations to dismiss new companies as pretenders who couldn't produce anything viable. Several notable startups had folded. Elon Musk's SpaceX was struggling to fly its first rocket, the small-satellite launcher Falcon 1, while Jeff Bezos's Blue Origin had launched nothing and was swathed in secrecy.[11] So there were few viable alternatives. But Constellation's flat budgets, which allowed no Apollo-like investment peak, guaranteed schedule slips while the corporations racked up billions in overruns. Bush's VSE was in deep trouble.

The emergence of Artemis

When Barack Obama won the presidency in 2008, space policy was not high on his priority list because of the Iraq War and a financial crisis that threatened the whole economy. But Constellation was at the top of the agenda for his campaign's space expert, the former NASA official Lori Garver, who soon became

the agency's deputy administrator. During the transition team's investigation, Garver found that four years into the Ares I program, the rocket's launch date had slipped five years. With the shuttle's retirement date also slipping, no extra money was available for the Ares V or Altair. A new blue-ribbon commission recommended various options, one of which involved canceling Constellation and choosing a flexible path to go somewhere other than the Moon—perhaps an asteroid. That is exactly what Obama did in early 2010. The VSE was dead.[12]

That decision produced a firestorm of protest in the old-line space establishment, which faced massive layoffs when the shuttle program ended. Famous Apollo astronauts, including Neil Armstrong, testified before Congress that the country had lost its way without an ambitious human spaceflight program led by the NASA centers and companies who had always done it. Congressional pressure on Obama and NASA led Obama to make his first concession and save the Orion spacecraft, which was essentially a modern version of the Apollo command and service modules.

Senators, notably Richard Shelby (R-AL) and Bill Nelson (D-FL), then collaborated with the giant corporations and, more discreetly, with NASA centers to force the Obama administration to accept a heavy-lift booster that was essentially a redesign of the Ares V. It came to be called the Space Launch System (SLS), but critics dubbed it the Senate Launch System. The result was a spacecraft and booster with no clear objective except to keep the shuttle–industrial complex in business just as that program was about to end. (The final flight was in July 2011.)

Garver was caught in the middle as the primary advocate for the new commercial space industry. She championed what came to be called the Commercial Crew Program, an extension of the one nontraditional project Griffin had approved, commercial cargo launches to sustain the ISS. SpaceX was one of the winners of the cargo competition and proposed a crewed version of its Dragon spacecraft.

The Commercial Crew Program barely survived the attack from the human spaceflight establishment and suffered budget cuts in Congress that stretched out its schedules. Garver left in 2013, feeling that she was undercut by her own boss, Charles Bolden, a pioneering Black shuttle astronaut who was Obama's NASA administrator. In 2014 the agency gave Commercial Crew contracts to upstart SpaceX and, for considerably more money, to old-line Boeing. SpaceX's Dragon crew flights began in 2020; Boeing's Starliner has been a string of embarrassments. As of this writing, it has yet to launch an astronaut.

During the Obama administration, NASA's official objective for the SLS and Orion was to send astronauts to an asteroid to prepare for later trips to Mars. That plan inspired little enthusiasm, and it evolved into something that many found even less inspiring: using a robotic vehicle to retrieve a tiny asteroid and bring it into lunar orbit, where astronauts would sample it. Orion was too small for a months-long trip to a solar-orbiting asteroid and would need an extra habitat module to do that. Instead, the agency examined building a small space station called Gateway in distant lunar orbit, and, like with the ISS, NASA soon partnered with ESA, Canada, and Japan. A lunar landing remained in the long-range plans if money became available. In effect, the remnants of Constellation evolved back into a lunar program through the rear door.

During his administration, Donald Trump placed Mike Pence in charge of space policy. Along with the new NASA administrator, Jim Bridenstine, Pence steered the agency back to human lunar landing as the prime objective. They were easily able to sell Trump on the nationalistic and blatantly political goal of landing on the Moon by the end of 2024. It was never a realistic date (nor is the current target of December 2025). In 2019 NASA officially named the program Artemis after the mythological twin sister of Apollo.

What emerged is a marriage of the old and new ways of doing human spaceflight. On the one side is the congressionally mandated SLS and Orion, which currently cost $4.1 billion per launch—an expense even the agency admits is much too high.[13] As it has done for decades, NASA purchases those vehicles from Boeing, Lockheed, and other aerospace firms under arcane and expensive federal acquisition regulations. (The Orion's service module is supplied by ESA through its contractor Airbus.)

On the other side is the ascendant commercial space industry, especially SpaceX, which gained enormous credibility when its Dragon cargo vehicle worked and its Falcon 9 booster dramatically lowered launch costs by including a recoverable first stage. To get astronauts to the surface, NASA invited corporate proposals for what it called the Human Landing System. The first contract went to SpaceX in 2021 and the second to a Blue Origin–led team in 2023. Based on the model of ISS commercial cargo and crew, NASA contracted for competing services through fixed-price agreements under the Space Act of 1958 rather than purchasing the vehicles. Those agreements are public–private partnerships in which companies are expected to invest some of their own money. Other companies have been contracted to deliver robotic spacecraft and cargo to the lunar surface.

The sustainability of Artemis

Rather than being a product of a grand presidential announcement, Artemis evolved into a lunar—and, at least nominally, Mars—program over the course of a decade, driven primarily by congressional politics and the need to sustain jobs in NASA's human spaceflight infrastructure. Public enthusiasm for sending astronauts to the Moon has remained weak—only 12% of respondents in a recent poll chose it as one of the "top priorities" for NASA (monitoring asteroid threats got 60% and Earth's climate 50%).[14] Artemis seems like a program unlikely to survive politically.

But the opposite is true. As the fates of the two Bush initiatives reveal, there is no public or political appetite for a greatly expanded NASA budget. But there is also no appetite for downsizing or eliminating the human space program either, especially in Congress and the White House. When the shuttle program came to an end and the ISS was completed, it freed up budget room for a deep-space human exploration program, even one that, for a while, lacked a convincing purpose or sense of urgency.

Another factor in Artemis's sustainability is human spaceflight as a contemporary symbol of great-power status. Weinberger expressed that clearly in 1971, and it has been implied in multiple presidential announcements since. Traditionally, analysts and space advocates have talked about the space pro-

gram's soft power in terms of prestige, but that is a vague, hard-to-quantify term. NASA chief economist Alexander MacDonald has offered economic-signaling theory as a more potent tool. A strong civil space program is a signal to other countries of the economic, technological, and scientific power of a nation, and, by implication, potential or actual military power.[15]

Israeli space-policy expert Deganit Paikowsky has elaborated a related concept: the "space club." What started as a US–Soviet contest just to orbit a satellite has become a series of ways and levels in which nations—and, more recently, corporations—can signal their geopolitical power. The highest level of the space club consists of nations that can launch their own space travelers: Only the Soviet Union/Russia, the US, and China have achieved that.[16]

Having no US astronauts flying while other countries, notably China and Russia, are continuing to launch theirs is a prospect few US political leaders want to contemplate. A significant fraction of the public would probably feel the same if the Chinese were to land astronauts on the Moon and the US did not. Many space advocates have been fantasizing for years that a new Cold War space race with China would make all their wishes come true. Although a new race of 1960s intensity seems unlikely, leaving the Moon to Chinese astronauts would likely be politically intolerable.

Artemis, finally, has a couple of secondary factors on its side. It is an international program, with hardware contributions from ESA, Canada, and Japan. US space diplomacy has engaged many more nations through the Artemis Accords, a set of ground rules for operating on and around the Moon, Mars, and other objects in the solar system. Politically that makes it more difficult for the US Congress and presidential administrations to cancel Artemis.

There also seems to be a growing global consensus among national policymakers that the Moon's time has come again. As low Earth orbit becomes accessible to privately launched astronauts and tourists, the zone where nations can push the boundaries of technology is in cislunar space. It is where India, the United Arab Emirates, and others are developing their robotic spaceflight capabilities. It is also the easiest place to test the human spaceflight technologies needed for deeper human voyages to destinations such as Mars, although it must be said that the red planet remains 20 to 25 years away—as proponents of crewed travel to Mars have perennially claimed since the 1960s.

That brings us to the final question: Does sending humans into deep space, and spending huge sums of money to do so, make any sense? In the 1960s and 1970s, the space physicist James Van Allen argued that human spaceflight is dangerous and wasteful and that robotic spacecraft can produce much more science for much less money. Scientists have made that argument repeatedly: It was reiterated last year by the astronomers Donald Goldsmith and Martin Rees in *The End of Astronauts*. But they end up admitting that human spaceflight is not going away and just update an old argument that has had little impact on space policy.[17] The achievements of robotic space science—like the Mars rovers and the *James Webb Space Telescope*—have been spectacular, and spacecraft are getting more capable, autonomous, and cost-effective. But human spaceflight will not end any time soon for precisely the reasons I have outlined.

Significant questions remain as to whether humans can adapt successfully to cislunar space and beyond, where radiation exposure is greatly increased and the medical problems of microgravity are no less problematic than in low Earth orbit. It may be that humans are poorly adapted to deep-space travel and may be displaced by cyborgs and intelligent machines in a "post-human" future.[18] In any case, that is too far off for meaningful predictions. If we are going to see whether humans will adapt to deep-space travel, it has seemed to many, including me, that we should do that at the Moon first, where Earth is easily reachable in an emergency. If we find that we do not have the technology to protect human bodies adequately on journeys of years, then we may have to reconsider whether we want to do it.

In the short run, domestic and international political reasons alone will sustain the Artemis program and its Chinese equivalent well into the 2030s. We are going back to the Moon to stay, at least for a while—and maybe for the long term.

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