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U.S. Space Policy: The Next Frontier

Report

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Executive Summary

A genuine Space Age is dawning, and the U.S. is well positioned to lead it. Thanks to private-sector innovations in rocketry, spaceflight is on the verge of being cheap, accessible, and routine. These advances open the door for commercial enterprises in orbit and beyond, promising an economic boom. Falling costs can also help the National Aeronautics and Space Administration (NASA) reinvigorate our country's sluggish space programs. The long-delayed dream of returning to the moon—to stay, this time—and then venturing on to Mars is within reach.

Unfortunately, two large hurdles stand in the way of the coming private and public space revolution. First, although SpaceX and other private space companies are pushing technological boundaries, they are being held back by obsolete regulations. Second, NASA is constrained by outdated technology and poor management. For over two decades, the agency has been developing a large rocket capable of launching the planned Artemis moon missions. Regrettably, the resulting Space Launch System (SLS) is years behind schedule, massively over budget, and based on antiquated designs. NASA's inspector general estimates that future SLS launches will cost over $4 billion each. That is unsustainable—and unnecessary. Meanwhile, as NASA flounders, China is rapidly developing its space program, including plans to land astronauts on the moon.

SpaceX, Rocket Lab, and other private American launch companies lead the world in developing affordable, reusable rockets. But our regulatory regime can't keep up with increasingly frequent private launches. To support the growth of this vital industry, the U.S. must reform Federal Aviation Administration (FAA) rules and other regulations.

NASA's crewed space program follows two paths. The traditional path—building expensive rockets that the agency itself owns and flies—has yielded the SLS debacle. The second path involves paying private companies to launch astronauts and cargo on space vehicles that those companies build and own themselves. Despite setbacks, these fixed-price commercial contracts save the U.S. government billions each year. For faster progress, NASA should stop building its own rockets and expand its public-private partnerships.

The Trump administration has a once-in-a-generation opportunity to fix America's broken space policies. This report will offer four key reforms to keep the U.S. in the forefront of the space revolution. The administration, working with Congress, should:

- Lift the regulatory burden on private space companies, especially FAA's onerous requirements.
- Retire the SLS at the earliest opportunity—after the first successful moon landing, if not sooner—while working with private contractors to develop more affordable platforms for lunar and eventual Mars flights.
- Expand NASA's commercial programs, while correcting management issues that have caused some contractors to struggle.
- Restructure NASA for an entrepreneurial era. Once freed from the need to build its own space vehicles, NASA will have more resources to focus on what it does best: basic R&D, mission planning and management, and space science.

These changes will disrupt NASA fiefdoms and invite pushback from Congress. But the current path will lead only to further lost decades in space exploration, ceding key space terrain to China. By empowering private-sector innovation and helping NASA capitalize on those advances, the U.S. can remain the world's leader in the peaceful development of space.

Part 1: Our Challenge in Space

Current U.S. civilian space policy has a public and private component, both of which require deep reform. First, of course, is NASA, with its six-decade legacy of human spaceflight and myriad robotic scientific missions; but the agency faces chronic cost overruns and lax management, which threaten the future of crewed and uncrewed missions. Second is America's private space industry, which has made great leaps in capability and cost reduction but faces arcane regulatory hurdles that could cripple the industry in its cradle. The U.S. military's increasingly robust presence in space is a positive and necessary development, but beyond the scope of this report.

The Trump administration has not yet fully outlined its space policy. Its nominee to be NASA's administrator, the well-liked private astronaut and entrepreneur Jared Isaacman, avoided offering highly specific plans during his Senate confirmation hearing. But all signs suggest that the administration intends to make sweeping changes within NASA and to overhaul space policy more broadly.[1] So far, the Department of Government Efficiency (DOGE) has largely spared the space agency (though anxiety about future cuts has NASA staffers on tenterhooks).[2] On the other hand, a reported Office of Management and Budget proposal would slash 50% from the agency's budget for robotic science missions.[3] One space advocate describes the proposed cut as "an extinction-level event for space science and exploration."[4]

The unprecedented and unpredictable role of Elon Musk looms over all discussions of space policy. As CEO of SpaceX, the world's most successful space-launch company, Musk brings unmatched expertise to the administration. At the same time, his company is the U.S. government's biggest supplier of commercial space services, including $13 billion in NASA contracts over the past decade.[5] That creates the potential for massive conflicts of interest (which cannot easily be sidestepped, given that no other company is currently capable of filling SpaceX's vital role). Musk's flamboyant involvement in political disputes has also made him a lightning rod for criticism. As the White House rolls out its new space policy in the coming months, the administration's opponents are likely to portray Musk—whether fairly or not—as the mastermind behind any controversial moves. Traditionally, support for NASA has been a zone of relative bipartisan consensus. But if the early months of the Trump administration are any guide, that era of comity on space policy may be coming to end.

Any political conflict over space policy would come at an unfortunate moment: both NASA itself and federal regulations of private spaceflight require urgent reform. Many of the needed changes will require overturning decades of tradition and will upset powerful constituencies. The White House will need all the allies it can find if it hopes to achieve a lasting transformation. For outside analysts and space advocates, the best course is to focus on clear goals and policy reforms that make sense, notwithstanding one's political affiliation. This report will aim to outline such policies.

The White House has a strong record to stand on. During Trump's first term, his administration launched the Artemis program, which refocused NASA's manned-space program on achieving long-term human habitation of the moon, with Mars as the next objective. The Trump team also redoubled support for NASA's commercial space programs, which incentivize private companies to launch astronauts and provide other crucial services. As the second Trump administration turns its attention to space, both those initiatives are in trouble.

Despite its problems, NASA still has important strengths. The agency's various science missions and crewed space program are making progress—albeit halting, at times. NASA's space telescopes, *Perseverance* Mars rover, and other research probes provide crucial data and inspiring images every day. The agency's Artemis program has bipartisan support in Congress and has attracted an

array of international partners eager to participate in planned missions. After many delays, the enormous Space Launch System (SLS) rocket and conjoined **Orion** capsule, designed to carry U.S. astronauts back to the moon, are finally on a credible track toward their first crewed flight. At the same time, NASA's innovative commercial space programs have dramatically lowered the cost of low-Earth-orbit (LEO) missions by outsourcing launches to the private sector. According to a 2024 Pew Research poll, NASA remains among the federal government's most popular agencies.[6]

But regular, massive cost overruns threaten both human and robotic NASA programs. By the time the James Webb Space Telescope launched in late 2021, its budget had ballooned to over $10 billion,[7] more than twice the original target.[8] To accommodate those and other cost overruns, other missions have been canceled, cut short, or delayed. For example, NASA recently cancelled its plan to land the robotic VIPER rover on the moon.[9] The planned 2027 VERITAS mission to Venus—which saw its budget virtually eliminated in NASA's 2024 budget request[10]—has been pushed to 2031. The *Perseverance* Mars rover is currently collecting geological samples that are cached on the red planet's surface, waiting to be picked up and returned to Earth on a future Mars Sample Return (MSR) mission. But in April 2024, the agency announced that it was putting the MSR project on indefinite hold while it seeks less expensive alternatives.[11]

NASA's manned space program is in even worse condition. The SLS rocket and **Orion** capsule—both crucial to the Artemis lunar program—are running wildly over budget and have yet to carry humans into orbit, much less to the moon. Despite spending nearly $24 billion on SLS and another $20 billion on the capsule—and blowing past the original first-mission target of 2015—NASA has managed to launch just a single, uncrewed test flight of the platform to date. Seemingly every component of the Artemis program is setting records for spending and delays. The agency has invested over $1 billion in new lunar space suits; they aren't complete. NASA's inspector general (IG) estimates that the next-generation SLS launch tower will cost $2.7 billion; it is unlikely to be completed for another half decade.[12] *Ars Technica* dryly notes that the tower will cost nearly twice as much as "the largest structure in the world, the Burj Khalifa, which is seven times taller."[13] In all, the IG estimates that the agency will have spent $93 billion on the Artemis program between 2012 and 2025.[14]

Despite all that investment, SLS/**Orion** will be obsolete before it enters regular service. At a time when SpaceX and other companies are slashing launch costs by building reusable boosters, SLS is an old-school expendable system; every component except the **Orion** capsule must be discarded throughout every flight. As a result, the IG projects that each SLS/**Orion** mission will cost at least $4 billion. For context, NASA's 2025 budget for all programs is $25.4 billion.[15] At that rate, NASA will be able to afford to launch the new rocket only roughly once every two years—nowhere near the rapid mission cadence necessary to build a lunar base. Worse, the current SLS design doesn't have enough power to deliver the larger payloads that later planned Artemis missions will require. SLS will need a $5.7 billion upgrade to handle those future payloads—a project that will further boost launch costs and is, in turn, also years behind schedule.

In other words, despite being absurdly expensive, the SLS/**Orion** project is moving at a glacial pace, already technologically outmoded and incapable of fulfilling the grand Artemis goals. According to NASA, Artemis aims to "establish the first long-term presence on the Moon."[16] But as the IG notes, Artemis risks ending up "like Apollo, with more flags and footprints, but no sustained presence."[17] Unsurprisingly, there is a growing push to drastically curtail or cancel the project. Independent space analyst Casey Handmer describes the rocket system as a "national disgrace."[18] Michael Bloomberg last year advised that the "next U.S. president should rethink the program in its entirety."[19] Some of Trump's advisors on space policy, including Elon Musk, advocate scrapping SLS immediately.[20]

But scrapping SLS/Orion immediately would create a new set of challenges. Unless a massive technical workaround could be implemented quickly, no other system is ready to carry U.S. astronauts to the moon on the current timetable. Moreover, the Artemis program's fundamental goals are sound. Building a long-term base on the moon makes sense both as the next step in human space exploration and as a way to build experience for eventual missions to Mars. Given that China aspires to land its "taikonauts" on the moon by 2030, an American return to the moon also has strategic value.[21]

In his inaugural address, President Trump promised to "plant the Stars and Stripes on Mars."[22] Those words suggested that the White House might be planning to cancel Artemis's first-step moon missions in favor of an immediate push for the red planet. Any attempt to bypass the moon entirely would be fiercely resisted in Congress. During his confirmation process, Jared Isaacman also reassured senators that he believes it is vital for U.S. astronauts to return to the moon.[23] But in his written testimony he stated that NASA "will prioritize sending American astronauts to Mars," while mentioning the moon as a kind of waystation in that plan. That wording suggested an effort to keep the nominee's words aligned with the president's stated goals. It remains unclear exactly how the White House intends to balance its Mars ambitions with NASA's longstanding lunar plans. Indeed, the policy likely remains in flux.

More than 50 countries have signed the Artemis Accords, the diplomatic agreement launched during Trump's first term that outlines shared goals and responsibilities in space. These countries have signaled their desire to work with the U.S. in building a peaceful presence on the moon.[24] If the U.S. vacillates in its leadership role, China will eagerly fill the vacuum. This report will outline a plan for NASA to reach the moon at the earliest possible date, while working to replace SLS with a more sustainable platform for flying manned missions. The money saved by eliminating SLS will also allow a much more aggressive program to put U.S. boots on Mars.

The next administration must accept the lesson of the SLS/Orion fiasco: NASA's traditional model for building space hardware is broken. And that failure imperils all the agency's other goals, crewed and uncrewed alike. The problems facing SLS/Orion aren't new, space advocate Lori Garver told the Manhattan Institute.[25] As NASA's deputy administrator (2009–13), Garver fought against bloat in the agency's programs. "Apollo was the single real success in human spaceflight, a program that came in on time, on budget, and delivered," she said. "The shuttle and the [International] Space Station are really the only two major [crewed] programs NASA has done since then, and they were both extremely over budget, extremely delayed, and didn't deliver on the goals that were given to them."

Fortunately, even as the SLS/Orion project became mired in bureaucracy, Garver and other NASA leaders were pioneering a leaner, more innovative approach. As this report will explore, the agency's commercial cargo and crew programs have made LEO spaceflight routine and affordable, thanks mostly to rocketry innovations on the part of SpaceX, the program's primary vendor.

But NASA cannot rely on a single spaceflight supplier. And the agency's effort to help Boeing develop its own space vehicle capable of commercial missions has been a long misadventure. Over the summer of 2024, Americans watched in dismay as Boeing's Starliner craft suffered malfunctions on its first crewed mission and remained stranded at the International Space Station (ISS) for months. Boeing's failure to build a space-worthy craft, despite $4.2 billion in NASA funding, casts a huge shadow over the agency's hopes that its commercial space program will be the key to sustainable human spaceflight.[26]

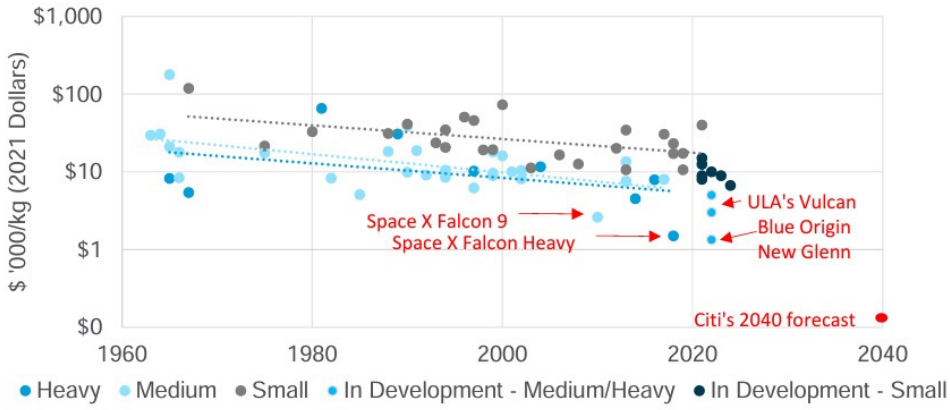
The new administration inherits a space agency that has lately seemed confused about its primary mission. Until weeks ago, the agency's online landing page for the Artemis program stated: "With the Artemis campaign, NASA will land the first woman and first person of color on the Moon, using innovative technologies to explore more of the lunar surface than ever before."[27]

Such language was common at NASA under the Biden administration's "whole-of-government equity agenda."[28] The agency also awarded $2.9 million to a consulting company for a project "to incorporate and deeply engrain diversity, inclusion, equity and accessibility" within NASA's Space Mission Directorate.[29] It required scientists applying for research grants to submit "diversity statements" and express their commitment to DEI goals.[30] And it paid out millions to universities and consulting firms for programs intended to promote environmental justice and DEI.[31] It was welcome, therefore, to see NASA acting administrator Janet Petro move quickly to implement the president's executive order eliminating DEI in federal agencies.[32]

Fortunately, as NASA has struggled, there has been dramatic growth in the private space industry, which is very much dominated by U.S. companies. NASA deserves a good deal of credit for creating the boom, with its forward-looking commercial cargo and commercial crew programs. But private space startups don't just want NASA contracts. Companies—including SpaceX, Blue Origin, Rocket Lab, Firefly Aerospace, and others—are launching satellites for private companies as well as the U.S. and other governments, assembling "mega-constellations" of broadband satellites, carrying space tourists, and selling rocket motors and other space hardware and services. Private capital is also flowing into more speculative and long-range ventures, including asteroid mining and space manufacturing. This growth in space entrepreneurship gives NASA (and other U.S. entities) attractive new options for launching cargo, buying off-the-shelf hardware, and, eventually, contracting for space services, such as in-orbit refueling and conducting moon landings.

Figure 1

Launch Costs to Low-Earth Orbit ($000s per kg., $2021 inflation-adjusted)



Note: We define small payloads of up to 2,000 kg, medium up to 20,000 kg and heavy greater than 20,000 kg.
Source: James Pethokoukis, based on Citibank data

Reforms to U.S. space policy should aim to overcome NASA's problems and to ensure continued growth and innovation in the private space sector. Ideally, those two goals are synergistic: a robust commercial space industry gives NASA better and more affordable options for future missions; and NASA's commercial programs give its private partners high technological goals to shoot for and bootstrap funding to help them get started. But achieving that synergy will require fundamental reform.

As will be discussed in more detail below, NASA's internal policy choices—and outside political pressures—have conspired to burden the agency with unsustainable costs that put many of its goals out of reach. And outdated regulations threaten to hold back progress in private space. NASA's new leadership, the White House, and Congress should immediately implement the following reforms:

- Lift the regulatory burden on private space companies.
- Retire SLS as soon as practicable, thus ending NASA's failed efforts to build and operate its own rockets.
- Repair and expand NASA's commercial programs that rely on private vendors to launch and otherwise assist NASA missions.
- Policymakers must recognize how NASA's role has changed since the 1960s, and reorganize the agency to focus on today's needs, including advanced technology research and development.

NASA is no longer the hegemonic player in U.S. space operations and exploration. The U.S. Space Force has capably taken over space missions required for military defense (in contrast to the days when the space shuttle carried secret military payloads).[33] In civilian spaceflight, SpaceX and other private companies are making technological breakthroughs and launching missions at a pace that NASA can't possibly match. Yet NASA retains deep expertise in space science, in mission planning and management, and in understanding the human element in spaceflight. The space agency should be restructured to emphasize those institutional strengths, while relinquishing most of the hardware-development role that private companies can execute better. NASA no longer has to do it all. It should focus on what it does best.

Part 2: How We Got Here

NASA's current road map was first sketched out in the aftermath of an earlier crisis: the 2003 loss of space shuttle *Columbia*. Understanding the painful reexamination that followed that disaster is key to grasping the agency's current problems and several potential solutions.

On February 1, 2003, *Columbia* was 10 minutes into atmospheric reentry when things started to go wrong. During takeoff 16 days earlier, a piece of debris had struck one of the craft's wings.[34] NASA engineers debated whether the impact might have fatally damaged the delicate tiles that protect the shuttle from the heat of reentry. Ultimately, they decided that the orbiter would survive its return to Earth. But now, as the shuttle passed over the California coast, hot gases punctured the damaged wing and began ripping the vehicle apart. Communications from the spacecraft cut off abruptly. Then, for several agonizing minutes, the ground crew tried to reestablish contact with *Columbia*, unaware that TV stations were broadcasting shots of flaming debris streaking across the East Texas sky.

The *Columbia* tragedy marked an overdue turning point for NASA. Even more than the 1986 *Challenger* disaster, it exposed deep managerial dysfunction within the space agency. It also forced NASA, the White House, and Congress to seek a clearer rationale for why Americans belong in space. Above all, it drove home the need for a more realistic, sustainable technological pathway to orbit and beyond.

In the months after *Columbia* disintegrated, NASA leaders and engineers went through a period of brutal self-criticism.[35] The shuttle program had barely recovered from the loss of the *Challenger* orbiter in 1986. Now, the agency had lost two space vehicles and their crews over a span of just 113 launches. Clearly, this was not sustainable. But before moving on to a new launch platform, NASA had to figure out how the shuttle program went so far off the rails.

NASA had envisioned the shuttle—and sold it to Congress—as an affordable, reusable workhorse. While innovative in concept, the craft instead proved to be a fragile albatross. Even before the shuttle's first flight, analysts worried that the vehicle's novel design and exotic engineering would make it unsafe.[36] Those quirks also made it extremely expensive to fly. NASA later calculated that, in terms of man-hours, the spacecraft required the equivalent of three years of maintenance work for every minute it spent in orbit.[37] On a per-pound basis, it cost more to carry payload on the shuttle than on the huge Saturn V rockets that launched the Apollo missions. Taking the program's full costs into account, the shuttle platform ultimately cost roughly $1.5 billion per mission.[38]

The shuttle's dire economics should have been reason enough to scrap the program early in its life. Instead, NASA leaders offered Congress fanciful forecasts showing future savings (while quietly hoping for future budget increases to cover the shuttle's mounting costs). The 1986 *Challenger* accident made the case against the shuttle even stronger. But NASA decided to keep it flying, partly because of the agency's sunk-cost mind-set. The shuttle also had deep political support. The launch system's components were manufactured in California, Louisiana, Utah, and various other states. Large NASA facilities in Alabama, Texas, and Florida helped manage the program. Congressmen and senators from those states were deeply invested in keeping the shuttle flying. For lawmakers, the shuttle's sky-high costs were a feature, not a bug: they meant more federal money flowing to their states. This unhealthy incentive structure—which rewards inefficiency and cost overruns—today remains one of the greatest obstacles to success at NASA.

After *Columbia*'s loss, the conclusion was inescapable: NASA had to retire and replace the shuttle. Ideally, the next era of hardware development would find a way to sidestep the perverse incentives that hobbled the shuttle. But any replacement would also need a clearly articulated purpose that would engage the public and justify the costs of building a new launch platform.[39] A team from President George W. Bush's White House worked with NASA to develop options for the post-shuttle space agency, with some members advocating abandoning manned spaceflight entirely and relying solely on robotic probes for space exploration. NASA administrator Sean O'Keefe feared that NASA itself might be disbanded, with its parts farmed out to other agencies.[40] In the end, though, NASA and the White House worked out an ambitious plan to rekindle some of the agency's Apollo-era glory, albeit on a tight budget.

President Bush unveiled the plan, the "Vision for Space Exploration," in January 2004, less than a year after the *Columbia* disaster.[41] His speech cited both practical and intangible rationales for continuing manned spaceflight: "We have undertaken space travel because the desire to explore and understand is part of our character." The plan envisioned completing the orbiting ISS by 2010, which would require that the shuttle keep flying at least until that date.[1] NASA's road map included a mix of robotic and manned exploration. The Vision plan's marquee goal was to establish "an extended human presence on the moon," which would serve as a testing ground for the technologies and skills that would eventually allow missions to Mars.

The Bush administration's Vision agenda was heavy on inspiration and light on technical details. After the shuttle retired, it suggested, cargo and robotic missions could be launched on existing military or commercial rockets. To ferry U.S. astronauts to the ISS, NASA would have to rely on Russia's Soyuz rockets, a costly and humiliating fallback.[42] But getting humans back to the moon would require an all-new crew vehicle. And getting such a large spacecraft into orbit and beyond would mean building a new heavy-lift rocket system. "Such a vehicle could be derived from elements of the space shuttle, existing commercial launch vehicles, or new designs," NASA's report on the program suggested.[43] Within a year, NASA would unveil plans for Constellation, a massive new rocket—built partly using engines and other components developed for the shuttle—with a spacious, six-astronaut capsule on top. NASA administrator Michael Griffin, who took over

[1] In the end, the shuttle made its last flight in July, 2011.

the post in 2005, called it "Apollo on steroids."[44] Ultimately, **Constellation** would be scrapped as unaffordable. It would be replaced by the similarly bloated SLS rocket combined with the **Orion** capsule already in development.

The question hovering over all these plans was money. NASA's report on the Vision program claimed that it would allow for exploration "in a sustainable, affordable, and flexible manner"—much the same as it promised Congress that the space shuttle would be a bold new step into space and a cost-effective orbital truck. Steve Isakowitz, a Department of Energy official who served on the Bush administration's post-*Columbia* task force, later discussed this tension with a NASA historian. The White House wanted a plan that was "bold in vision and cheap in expense," he said.[45] Two decades later, NASA has failed to achieve either of those objectives. NASA's core manned-mission goal—an extended return to the moon using massive rockets—is certainly bold. But the project is years behind schedule and the antithesis of cheap.

But NASA's Vision plan also included a brief sketch of a different path: in a single bullet point, little noted at the time, the document mentioned that NASA would also "pursue commercial opportunities for providing transportation and other services supporting the International Space Station and exploration missions beyond low-Earth orbit."[46] Several NASA leaders, weary of the agency's ponderous approach to hardware development, quietly backed the proposal.

The concept was elegantly simple. Traditionally, NASA hired aerospace contractors to build rockets and space vehicles that were then owned and operated by the agency itself. As with fighter jets and other military hardware, these projects were generally built using "cost-plus" contracts that left the government responsible for cost overruns. Under the proposed commercial framework, NASA would instead contract with private companies to provide launch and orbital services for a fixed fee. The vendors would develop and fly their own space hardware (albeit under close NASA supervision) and maintain ownership of the related intellectual property. In essence, NASA was proposing hiring privately owned rockets for spaceflight much the way a party of anglers might charter a fishing boat.

This idea wasn't new; the U.S. government had previously relied on commercial launch companies to launch satellites, and the military regularly charters civilian aircraft to transport troops.[47] In 1984, President Ronald Reagan signed the Commercial Space Launch Act, which aimed to enable private space ventures, to encourage federal agencies to use commercial vendors for satellite launches, and to regulate this new industry "only to the extent necessary."[48] His successor, President George H. W. Bush, also backed a modest effort nudging NASA to outsource some of its functions to commercial vendors. Moreover, since the 1980s, a loose coalition of scientists, space buffs, and free-market advocates—the "space pirates," as they became known—had been advocating for the partial privatization of spaceflight.[49]

But NASA's Apollo-era traditions ran deep. The agency had a long-established way of doing things, with powerful divisions in charge of every function. The Marshall Space Flight Center in Huntsville, Alabama (once the unquestioned fiefdom of German rocketry pioneer Werner von Braun), supervised the development of launch systems and space vehicles; rockets and their crews were readied and launched from the Kennedy Space Center at Florida's Cape Canaveral; the Johnson Space Center in Houston handled astronaut training and missions in progress. Unmanned science missions and other research projects were supervised by Pasadena, California's Jet Propulsion Laboratory and several smaller centers. If NASA were to begin relying on privately owned and operated spacecraft, these storied institutions would be partially sidelined. To many NASA veterans—and to the agency's staunchest supporters in Congress—that was hard even to imagine.

Facing both internal and external skepticism, the radical privatization plan took root inside NASA only gradually. In 2006, the agency set up a program to help private partners build the capability to launch cargo into LEO (primarily to ISS)[50] in uncrewed spacecraft. Under the Commercial

Orbital Transportation Services (COTS) program, NASA sought proposals from private companies willing to design cargo vehicles capable of meeting the agency's exacting requirements.[51] At a 2005 conference, NASA administrator Michael Griffin laid out two complementary goals for NASA's commercial space program: first, to "engage the engine of competition," to give NASA more affordable options for routine missions; and second, to incentivize a vibrant American industry by "stimulating commercial enterprise in space."[52] At the time, many thought that Griffin's goals sounded fanciful. In retrospect, both objectives were realized beyond almost anyone's hopes.

Participants in the COTS program were expected to raise their own capital; however, NASA promised to supplement those funds with development grants. These would be issued in increments as participants met a series of development benchmarks. More than 20 companies joined in the competition.[53] Ultimately, just two—SpaceX and Orbital Services (now part of Northrop Grumman)—won contracts to complete and launch their space vehicles. The two companies began delivering cargo to the ISS in 2012 and 2013, respectively.[54] Commercial cargo deliveries to the ISS continue today under an updated version of that program.

In 2024, Phil McAlister, former head of NASA'S Commercial Space Division, suggested that COTS would have faced more opposition had the program's full implications been obvious from the start. "COTS flew under the radar for the first few years," McAlister wrote in an essay posted on LinkedIn.[55] "It was a back-up plan to a back-up plan that most people in the Agency thought would fail anyway." In those years, NASA had several options to deliver cargo to ISS: the shuttle was still flying; Russia's Soyuz spacecraft made regular trips to the station; and NASA's planned Constellation program included a cargo capability as well. If the COTS gamble didn't pay off, it would be no great loss. "Failure was in fact an option for COTS," McAlister writes. But over time, those other cargo options faded: "By 2010, we were referring to the SpaceX Dragon and Orbital Sciences Cygnus systems as NASA's primary means of keeping the ISS resupplied."[56]

Even before the first successful cargo flights, NASA expanded the commercial program to tackle the bigger challenge of building human-rated spacecraft. In 2009—with the shuttle's retirement looming—the Commercial Crew program began soliciting proposals. Unlike COTS, this project would not be able to sneak under the radar. The idea of flying astronauts on private spacecraft set off alarm bells among traditionalists. In pursuing commercial options for spaceflight, the Obama administration was following a policy recommended by Reagan and both Presidents Bush. Nonetheless, congressional pushback was intense. Republican Alabama senator Richard Shelby complained that "the commercial providers that NASA has contracted with cannot even carry trash back from the Space Station much less carry humans to and from space safely."[57] Texas senator Kay Bailey Hutchison worried that NASA's approach "would spell the end of our nation's leadership in space exploration." At the time, astronomer and author Phil Plait noted the irony of watching Republican lawmakers passionately arguing "against privatization."[58]

Democrats also delayed the Obama administration's push for commercial space. Florida senator Bill Nelson, then head of the Senate subcommittee authorizing NASA, threatened to reallocate the $6 billion that NASA had requested for commercial space programs to an as-yet-undefined Mars rocket. "Congress controls the purse strings," he told NASA leaders.[59] (After President Biden nominated Nelson to be NASA administrator, he became a reliable supporter of commercial space.) The lawmakers most hostile to NASA's commercial space plans tended to come from states with major NASA facilities or that were home to aerospace contractors dependent on NASA's traditional model. Concern for the welfare of suppliers also ran deep within NASA itself. Much like the chummy ties between Pentagon officials and defense contractors, many NASA bureaucrats had decades-long relationships with suppliers of space hardware. Some seemed to put the contractors' interests ahead of the space agency's stated goals.

Former NASA deputy administrator Lori Garver told the Manhattan Institute: "We really underestimated how much people did not care what the end-state goal was," i.e., flying astronauts frequently and affordably. Instead, she said, "They really wanted to make sure the money would flow to those contractors. It's human nature."[60] As a longtime "space pirate," Garver had spent much of her career as a civilian advocate for expanding the U.S. presence in space, partly by unleashing the power of free enterprise. In her 2022 memoir, *Escaping Gravity: My Quest to Transform NASA and Launch a New Space Age*, Garver recounts her efforts to win over skeptics both in Congress and inside NASA itself. NASA leaders ultimately made what Garver calls "a Faustian bargain," telling Congress that the agency would continue developing the Apollo-style SLS/Orion project—complete with generous cost-plus contracts—but also request a smaller budget for the Commercial Crew program.[61]

Congress went along with the plan—but, "of course, they didn't give us what they'd promised," according to Garver:[62] "Congress paid lip service while cutting the [Commercial Crew] appropriations budget nearly 40 percent over the first four years."[63] Even as Congress whittled NASA's commercial budget, it appropriated more money to the SLS/Orion project than the agency had requested.

Nonetheless, the Commercial Crew program gradually made headway. In 2011, NASA awarded small development grants to four companies working to develop space vehicles.[64] Three years later, the agency awarded long-term contracts to Boeing and SpaceX that would allow them to complete and test their designs.[65] NASA's goal was to have two vendors qualified to fly astronauts to ISS. At the time, SpaceX was still considered a roguish outsider in the space industry. In contrast, NASA insiders saw Boeing as the easy favorite.[66] After all, Boeing was the world's premier aerospace company and a longtime NASA partner in building space hardware. It was also one of the nation's most politically influential corporations. As a result, Boeing received a $4.2 billion grant, compared with a relatively modest $2.6 billion for SpaceX.[67]

Over the next decade, Boeing struggled to build its new space vehicle, while SpaceX surged ahead. The company flew its first cargo mission to the ISS in 2012, less than a year after the space shuttle retired. By 2020, when SpaceX flew its first crewed mission to the ISS, the company had become NASA's[68] preferred option for flying U.S. astronauts; the agency certainly didn't want to keep putting Americans on Russian Soyuz rockets, and SLS was years from completion. Even critics of Commercial Crew had to admit that, despite Boeing's slow progress, the program had been a stunning success. "There were people at NASA who knew exactly what they were doing," space journalist Eric Berger told MI.[69] Berger has covered NASA for two decades and written two books about SpaceX.

NASA's commercial experiment—the "back-up plan to a back-up plan"—ended up keeping the U.S. human spaceflight program alive. SpaceX's ability to safely ferry astronauts to the space station "saved NASA's bacon," Berger told science reporter Walt Hickey. It also vindicated the agency's gamble on the unconventional startup. "It put down a marker to the rest of the space industry that SpaceX was not just this band of unruly jackasses," Berger said. "They were now doing the absolute most important spaceflight missions that the United States government had."[70] Since that 2020 success, SpaceX has become NASA's uniquely indispensable partner in spaceflight, taking on a wide range of missions. SpaceX is also increasingly the go-to vendor for U.S. military launches.[71]

But as NASA's Commercial Crew effort made clear, nurturing companies capable of building and flying their own space hardware is not as simple as issuing grants and setting benchmarks. The program essentially pitted two very different business models against each other: the cautious, increasingly bureaucratic, Boeing versus the scrappy SpaceX, with its tech-startup culture of ruthless innovation. "All the smart money was on Boeing," aerospace consultant and author Rand Simberg told MI in a phone interview.[72] But those were the expectations of a different era and a different contracting model. Under traditional cost-plus contracts, Boeing engineers worked side by side with their NASA counterparts designing hardware and software. As designs evolved, escalating costs got

passed along to NASA and, ultimately, to the taxpayers. In such an environment, managers had little incentive to hit deadlines or prioritize efficiency. Under fixed-price contracts, on the other hand, the manufacturer assumes the financial risks of delays and do-overs.

"Boeing couldn't navigate the fixed-price world," Berger told MI. "Their whole model is based on cost-plus contracts."[73] While SpaceX quickly designed and tested a Crew Dragon variant of its original Dragon capsule, Boeing's effort to build an all-new Starliner crew vehicle struggled from the start. Routinely described in the press as "beleaguered," the Starliner project encountered years-long delays, cost overruns, and alarming technical mishaps.[74] In 2019, the craft's first uncrewed test flight failed to reach proper orbit because of major software flaws. Boeing was forced to launch a second uncrewed test flight at its own enormous expense. Although Starliner successfully delivered cargo to the ISS in 2022, the flight was marred by problems with the thrusters that control the capsule's maneuvers in orbit.[75]

Starliner's first crewed flight, a mission carrying two test-pilot astronauts to the ISS, launched on June 5, 2024. It was supposed to be the final hurdle before the vehicle received final approval from NASA for routine crewed missions to the station. That would finally give NASA two privately owned spacecraft approved to fly its astronauts—while SpaceX would, at long last, have a Commercial Crew competitor. Instead, the Starliner mission turned into a dangerous and an embarrassing debacle for both Boeing and NASA, with five thrusters failing just as the spacecraft began the delicate process of docking with ISS.[76]

For the next several weeks, Starliner astronauts Suni Williams and Butch Wilmore remained stranded at the station while NASA and Boeing debated whether the malfunctioning craft could safely carry them home. Finally, in late August, NASA administrator Bill Nelson made the call: Starliner would fly home without its crew. It was a decision that would have "seemed unthinkable a couple of months earlier," wrote veteran space journalist Jeff Foust.[77] The move also threw a wrench into the station's complex crew-rotation logistics. Rather than add an additional launch solely to bring the astronauts home, NASA instead chose to delay their departure until they could ride home on a scheduled crew rotation flight. Williams and Wilmore were then integrated into the ISS Crew-9 and remained working at the station until that team departed in March 2025.

In late January 2025, Elon Musk said in an X post that Trump had asked SpaceX to bring back the astronauts "as soon as possible. We will do so."[78] This was echoed by a Truth Social post from Trump: "I have just asked Elon Musk and SpaceX to 'go get' the 2 brave astronauts who have been abandoned by the Biden Administration…. Good luck Elon!!!"[79] The exchange left observers scratching their heads. Although their stay at the station had been greatly extended, Williams and Wilmore were usefully engaged as members of the ISS crew and not in need of an emergency rescue. The decision to fly them home in a SpaceX Dragon as part of the crew rotation had been made months earlier. That return to Earth took place as planned. Though it ended with little actual drama, the incident served as a reminder that the Trump White House is inclined to add a strong political valence to questions that once might have been seen as purely technical or logistical issues.

While NASA recently announced it is still "making progress" toward certifying Starliner for human flight, the troubled craft's future remains in doubt.[80] The $1.5 billion write-down that Boeing has already taken on the project does not include the costs involved in Starliner's most recent misadventures. Boeing is estimated to have spent over $5 billion on the Starliner project overall. But its opportunities to earn that money back appear limited. The company's contract with NASA is based on the expectation that Boeing will be able to fly three missions delivering and returning ISS crew members. But Boeing receives the full payment only if NASA certifies the spacecraft and if the company can carry out those missions.

While the aerospace giant struggled in its Commercial Crew efforts, SpaceX continued launching crews and cargo to the ISS like clockwork—with 46 missions to date—and winning lucrative new NASA contracts.[81] The contrast couldn't be starker. "Boeing decisively lost the commercial crew space race, and it proved to be a very costly affair," Berger wrote in *Ars Technica*.[82] Several space analysts told MI that they doubt that Boeing would be a major player in NASA operations after its existing contracts expire. The *Wall Street Journal* reports that Boeing is "exploring the sale of its storied NASA business, including the troubled Starliner space vehicle."[83] In a January 28, 2025, earnings report, Boeing declined to state any future plans for its troubled commercial space program.[84]

Boeing's struggles in the Commercial Crew program show the immense challenges facing aerospace contractors in the unforgiving fixed-price environment. "That fixed-price development world has to stop," Dave Calhoun, then Boeing's CEO, said in 2023. "It doesn't work for us, and it doesn't work for our customers in my not-so-humble opinion."[85] (Calhoun left the company in August 2024.) Boeing isn't alone: Lockheed Martin and Northrop Grumman have also said that they might decline to bid for fixed-price contracts in the future. This is a problem for NASA. If leading space manufacturers struggle (or refuse) to compete in fixed-price programs, the agency will likely struggle to achieve its desire to adopt the commercial model for a wide range of services and missions.

Aside from SpaceX flights to ISS, these experiments in commercial space have had mixed results so far. For example, in 2018, NASA launched the Commercial Lunar Payload Services Initiative (CLPSI), an innovative plan to pay 14 private companies to launch a series of small lunar research probes under fixed-price contracts.[86] Out of four CLPSI missions launched so far, only one has been fully successful. A worrisome 2024 IG report concluded that NASA's schedule for the program was too aggressive and that program managers have placed too many last-minute demands on the relatively inexperienced vendors, making it hard for them to stay on track. These "challenges will continue to hinder NASA's ability to meet the initiative's objectives," the IG said.[87] Clearly, NASA's commercial partnerships require better management, and the agency must be prepared for a sizable percentage of projects to fall short. Nonetheless, NASA's commitment to these public-private partnerships remains strong, and many show promise.

Fortunately, the private space industry is not primarily dependent on NASA contracts. Private investment is pouring into a wide array of space ventures—established companies, as well as startups. Those that prove successful will provide new options in space services for private customers and for NASA and other U.S. government programs.

Like any emerging high-tech field, the space sector is volatile. Some key players, including Richard Branson's Virgin Galactic, have faced financial challenges.[88] But the industry has racked up many successes, only a few of which can be mentioned here. The privately held SpaceX dominates the field in terms of technological innovation, launch cadence, and, analysts presume, profitability. Market analysis firm Payload Research estimates that SpaceX revenues soared to $13.1 billion in 2024, up from $8.7 billion in the previous year.[89] Roughly two-thirds of those earnings are generated by the company's Starlink broadband service, a business whose customer base doubled last year. These robust Starlink revenues belie the common complaint that the company's success is merely the product of corporate welfare. Chris Quilty, co-CEO and president of the research firm Quilty Space, calls the company's growth "nothing short of mind-blowing."[90] Between flights for its own Starlink satellites and those carrying payloads for other customers, SpaceX launched a record 138 missions last year.[91]

Jeff Bezos's Blue Origin, after years of halting progress, is finally entering the orbital launch business in a serious way. Until recently, the company had only flown short, suborbital flights on its reusable, six-passenger New Shepard rocket.[92] But on January 16, 2025, Blue Origin's huge, partially reusable New Glenn rocket successfully completed its long-delayed maiden flight.[93] The rocket is capable of lofting 50-ton payloads to LEO (which puts it roughly between the capacity of SpaceX's workhorse Falcon 9 rocket and its enormous Falcon Heavy). New Glenn is designed to fulfill a wide array of

requirements, including lunar and planetary missions. Blue Origin already has customers lined up for the new rocket, including NASA and the U.S. Space Force. It promises to offer meaningful competition to SpaceX in the large-payload, reusable-booster launch business. In addition, Blue Origin plans to launch a constellation of broadband satellites for its sister company, Amazon.[94]

Blue Origin is also developing a potentially lucrative sideline by selling its BE-4 rocket engine to other rocket companies. The United Launch Alliance has flown two test flights of its new Vulcan Centaur rocket, powered by two BE-4 engines.[95] For two decades, ULA—until recently the country's biggest civilian launch provider—had relied on the dependable, Russian-built RD-180 rocket engines. Those became unavailable following Russia's 2022 invasion of Ukraine. Blue Origin's BE-4 engine therefore not only targets an attractive market niche but also solves an urgent strategic vulnerability for the United States.[96]

Rocket Lab, based in Long Beach, California, is another competitor emerging from SpaceX's shadow. Its small Electron rocket—suitable for launching smaller satellites—has made more than 50 launches. The company's medium-lift, partially reusable Neutron rocket is expected to fly in 2025.[97] "If you don't have a reusable vehicle, I don't think you have a future as a launch company," Rocket Lab CFO Adam Spice said at a recent conference.[98] Other promising companies jostling for a piece of the launch market include Stoke Space, Firefly Aerospace, and Relativity Space.[99] Like Blue Origin, many companies entering the space business also sell various types of hardware and services to the burgeoning sector. Firefly, for example, will provide its Miranda engines to Northrop Grumman for a medium-lift rocket that that company is developing.

U.S. firms overwhelmingly dominate the commercial launch business. Europe's Arianespace, the company that pioneered the civilian launch business in the 1980s, now struggles to compete in the era of reusable rockets.[100] The market for launches and other space services, however, remains global in scope and is growing at a blistering pace. A 2024 report issued by the World Economic Forum and McKinsey & Company estimates that "the global space economy will be worth $1.8 trillion by 2035 (accounting for inflation), up from $630 billion in 2023."[101]

The burgeoning space economy presents a precious opportunity for our domestic economy. It also provides NASA and other U.S. agencies with technological options that would have been unimaginable just a decade ago. The Trump administration appears determined to take advantage of this window of opportunity. Fortunately, the White House also inherits a uniquely positive political environment for space innovation (assuming that the administration can avoid alienating Democratic lawmakers who have been part of the pro-space coalition since the Obama years). As Garver documents in *Escaping Gravity*, the Obama administration helped solidify support for both NASA's commercial space efforts and efforts to return to the moon.

When the first Trump administration came into office in 2017, it built on that progress. The White House reactivated the National Space Council, a high-level advisory board established during the George H. W. Bush administration (and dismantled under President Clinton), and put Vice President Mike Pence—a self-described "lifelong NASA fan"—in charge.[102] The president also named Congressman Jim Bridenstine, a strong commercial space advocate, as NASA administrator.[103] The White House issued numerous policy directives aimed at boosting commercial space, mitigating orbital debris, launching the Artemis program, and pursuing other goals.[104] A 2020 Trump executive order stated: "The U.S. vision for space is one in which there is a sustainable human and robotic presence across the solar system, and where there is an expanding sphere of commercial, non-governmental activities, with increasing numbers of Americans living and working in space."[105] That remains an excellent set of goals for America's civilian space efforts.

At the same time, space was becoming an increasingly dangerous domain as both China and Russia pursued anti-satellite weapons and other hostile capabilities.[106] In 2019, Trump successfully urged Congress to consolidate the country's space-based warfighting efforts under a new U.S. Space Force.[107]

"While the United States would prefer that the space domain remain free of conflict, we will prepare to meet and overcome any challenges that arise," the White House said.[108] The creation of the Space Force gave the U.S. a more focused approach to space defense. It also freed NASA from the need to take military requirements into account when designing space hardware and missions.

When President Biden took office in 2021, his team largely stayed the course with Trump's initiatives, including Artemis, the National Space Council, and the Space Force.[109] Below the surface, however, NASA's momentum flagged in some key areas. As noted above, the agency burdened its staff and contractors with a host of distracting DEI requirements during the Biden years.

There were also harmful changes in NASA's management of its vital commercial programs. Under the Biden administration, the agency moved away from "the guiding principles that led to success with the early cargo and crew programs," Berger stated.[110] Unlike cost-plus contracts—which allow NASA to make myriad demands or changes—fixed-price contracts work only if the agency sets a limited number of clear requirements up front and then allows the contractor to work out the details. But in the Biden years, NASA managers began backsliding from that relatively hands-off approach, *Ars Technica* noted: "NASA is adding requirements, changing them, and burdening contractors with thousands of requirements rather than hundreds."[111] Not surprisingly, many contractors—and not only legacy manufacturers like Boeing—are struggling to deliver on their fixed-price commitments.

In short, Trump's administration will face much bigger challenges this time around. China is ramping up its effort to beat the U.S. back to the moon. Meanwhile, NASA's failure to contain the costs—and meet the goals—of its Artemis program could doom U.S. ambitions in space exploration for a generation. Important decisions about whether to continue the SLS/Orion program cannot be put off. Even NASA's generally successful commercial space program needs a course correction. At the same time, while America's private space companies have made huge strides, they are increasingly bumping up against outdated regulations. The U.S. needs to overhaul its space policy—to build on its successes and to rectify its failures—and it needs to begin today.

Part 3: A Golden Window for Space-Policy Reform

The stars are aligning for the Trump administration to reinvigorate NASA while also clearing a path for America's fast-growing private space sector. Space policy has long been one of the few arenas in which Democrats and Republicans often find agreement. The battles fought by Garver, Bridenstine, and other commercial space advocates have largely been won. On Capitol Hill, the fiercest opponents of NASA's Commercial Crew program have mostly retired or moderated their views. And there is broad support for the Artemis program (or, at least, its general goals).

With control of both houses of Congress, Republicans are in a strong position to enact new legislation advancing the White House's space initiatives, ideally with bipartisan support. In January, Texas senator Ted Cruz was named chairman of the Senate Committee on Commerce, Science, and Transportation; and Congressman Brian Babin (also of Texas) became chairman of the House Science, Space, and Technology Committee.[112] Both men are strong advocates for NASA and the private space industry (although their state also benefits from NASA's SLS/Orion program,

which could make them reluctant to back rapid changes). Trump's nomination of private astronaut and entrepreneur Jared Isaacman as NASA administrator bodes well for agency leadership that fights bureaucratic bloat and focuses on mission success.[113] A total of 28 former NASA astronauts signed a letter supporting Isaacman's nomination, saying that he "will bring a renewed energy and sense of purpose to NASA."[114]

Of course, as the early months of the second Trump administration confirm, the president and his team rarely shy away from political drama. Space advocates are of two minds: many hope that the administration will enact difficult, sweeping reforms while also worrying that too much Sturm und Drang will alienate needed allies. Elon Musk's potential influence is the biggest wildcard. The entrepreneur has already helped shake up numerous federal agencies. His influence on space policy could be even more dramatic. "I do think the change that he is going to bring to this administration will be like nothing we have seen before," Garver predicted at the Beyond Earth Symposium in November.[115] Musk is the most important rocketry pioneer since the USSR's "Chief Designer" Sergei Korolev or German-wunderkind-turned-NASA-technocrat Werner von Braun. Any country would be lucky to have Musk's help in guiding a space program. But pitfalls abound.

Today, SpaceX is NASA's most effective commercial partner by leaps and bounds. For some services, such as the upcoming contract to de-orbit ISS, it is the only realistic supplier. A disinterested advocate for NASA efficiency could argue for even greater collaboration with Musk's company (at least until Blue Origin and other competitors prove their capabilities). But if Musk himself makes that argument, he invites conflict-of-interest accusations. Moreover, his outspoken political involvement is provoking a strong counterreaction on the left; anti-Musk partisans are already framing NASA's commercial space ventures as merely schemes to enrich his company.

A widespread backlash to Musk's involvement in NASA policy could shatter today's bipartisan consensus in favor of the agency's commercial programs. Indeed, pundits on the left have long criticized his companies and their relationships with the federal government. In a broadcast just before the presidential election, MSNBC anchor Rachel Maddow stated: "The Defense Department and NASA are going to need a new arrangement for all their rockets and all the multibillion-dollar contracts Elon Musk's companies have with the U.S. government."[116] Steve Feldstein suggested in *The Atlantic* that the U.S. government should nationalize SpaceX's Starlink division, "taking effective control over the company's operations and removing Musk as its head."[117] More recently, the anti-Musk movement has taken on an extreme and violent edge, as can be seen in the nationwide attacks on Tesla vehicles and dealerships.[118]

Trump administration officials might be inclined to laugh off sniping from the Maddow wing of the commentariat. And they certainly shouldn't let arsonists dictate White House policy. But they should worry about driving away the mainstream Democrats—not to mention Republicans from space-industry-heavy states—who supported Artemis and other space-policy innovations during Trump's first term. Successful NASA programs need to maintain momentum and support across years and decades. No administration can count on full control of Congress through an entire term; backing from pro-space Democratic lawmakers will likely prove vital in coming legislative battles. And, in years to come, one can easily imagine future Democratic administrations spitefully dismantling NASA programs that they believe to be Musk fiefdoms. So far, neither the president nor Musk has shown much inclination to win over skeptics or calm frazzled nerves in a federal agency facing major cutbacks. But in an ideal world, the administration would walk a fine line, tapping into Musk's enormous expertise without creating the impression that it is handing the keys to the U.S. space program over to the president's wealthiest supporter.

To the contrary, the first step in reinvigorating U.S. efforts in space should be to reaffirm that robust public and private ventures in space will yield benefits for *all* Americans. While NASA's budget is a tiny share of total federal spending (less than 0.4%), space programs are highly visible, making them prone to complaints from voters who believe that the money could be better spent

"down here." As the Trump administration begins reforming U.S. space policy, it should explain to the public how America's success in space will contribute to prosperity while enhancing this country's prestige and security.

The American people should also understand that the private space industry is beginning a revolutionary transformation. Just as the computer revolution was driven by reductions in computing costs, the space boom will be spurred by plunging launch costs. So far, these reductions have been led by SpaceX, which—by landing and repeatedly reusing valuable rocket boosters—has reduced the cost of putting cargo into orbit by a factor of 11, compared with average costs during 1970–2010.[119] Now, with its experimental Starship having completed eight test flights, the company is pioneering a new generation of huge, fully reusable spacecraft.[120] Once in service, Starship will slash costs even more radically. "Being able to put mass in orbit cheaply solves so many problems," space analyst Rand Simberg told MI.[121] "If mass is cheap, we can do things we've dreamed of for 50 years." Ultralow launch costs will spark a boom in off-planet industries: communications, tourism, manufacturing, medicine, solar energy, asteroid mining, and more. And these, in turn, will shower economic benefits on the United States.

NASA's crewed space missions also benefit the nation. During the Cold War, the Apollo program's success showed the superiority of a free and democratic system, compared with the repressive—though technologically capable—Soviet regime. A similar struggle looms today, as China locks down freedoms at home, allies with America's enemies, and seeks dominance in space. Most of the world still finds the American model more attractive, as the success of the Artemis Accords demonstrates.[122] Established during Trump's first term, that diplomatic framework lays down basic ground rules "to increase the safety of operations, reduce uncertainty, and promote sustainable and beneficial use of space for all humankind."[123] The Artemis Accords help ensure the safety of U.S. operations and preserve our right to extract resources and travel freely in space. They also enhance this country's soft power, as more than 50 nations have signed the agreement, and many of those seek to partner with us in space exploration.

The U.S. can lead the world in space exploration and commercial development. But first, the administration faces major decisions that have been left unresolved for too long. Here are the four key priorities that the White House, Congress, and NASA should pursue immediately:

1. Lift the Regulatory Burden on Private Space

For years, private spaceflight has been almost an afterthought in U.S. regulatory policy—which proved a quiet blessing for space startups. While the U.S. Commerce Department, the Department of Transportation (particularly its Federal Aviation Administration), and other agencies regulate various aspects of spaceflight, private ventures have had the freedom to build, test, and launch space vehicles with relative freedom. SpaceX, Blue Origin, and Virgin Galactic have even been permitted to carry paying customers into space with surprisingly moderate oversight. This regulatory light touch is a key reason that the U.S. leads the world in private space innovation.

Unfortunately, growth of the U.S. launch industry is hitting a roadblock: the Federal Aviation Administration (FAA) Office of Commercial Space Transportation, known (for obscure bureaucratic reasons) as AST. AST must approve any civilian spaceflight launching through or reentering U.S. airspace. In some cases, that understaffed department can take months or longer to approve launches. As a result, "the United States faces regulatory paralysis that will stifle the abundant innovation and capability that the private sector is bringing to market," William Gerstenmaier told Congress in 2023.[124] Over a four-decade career at NASA, Gerstenmaier helped oversee the agency's human spaceflight efforts; today, he is SpaceX's vice president of build & flight reliability. FAA needs to face "the very real prospect that it is slowing rather than enabling U.S. progress in spaceflight capability," he testified.

In 2018, the Trump administration asked AST to simplify its policies for launch approval.[125] As so often happens when federal agencies attempt reform, the new rules, known as Part 450, ballooned—in this case, to 53 pages of dense requirements. In September 2024, the House Science Committee held hearings on the new regime. The upshot, reported *SpaceNews* journalist Jeff Foust, "is that Part 450, intended to streamline launch/reentry licensing, is instead hampering it, threatening U.S. leadership in commercial launch."[126] Musk put the point more dramatically on X. Responding to a post about China's aggressive lunar program, he wrote: "Meanwhile, back in America, the FAA is smothering the national space program in kafkaesque paperwork!"[127]

In contrast to the older regulatory regime, which focused mostly on protecting people on the ground from launch mishaps, Part 450 added numerous poorly defined performance-based requirements. For fast-moving startups, whose designs evolve from one launch to the next, the new rules result in "an endless back-and-forth process," Dave Cavossa, president of the Commercial Spaceflight Federation told the committee.[128] It took SpaceX nearly three years to obtain clearance for its first Starship launch, for example.[129] In a statement, SpaceX lamented these sorts of delays: "[W]e continue to be stuck in a reality where it takes longer to do the government paperwork to license a rocket launch that it does to design and build the actual hardware. This … threatens America's leadership in space."[130] At an earlier conference, SpaceX president and CEO Gwynne Shotwell noted that even well-tested space hardware is subject to unpredictable delays. "I launch Falcon every two or two and a half days, and the regs just weren't built to keep up with that."[131] Even routine launches require extensive paperwork. Private launch companies also need the ability to set schedules longer in advance and greater flexibility to test new designs.

Since that September hearing, FAA has granted SpaceX approval to increase the pace of Starship flights, from the current five to 25 launches per year. The agency also signaled that it is likely to approve big increases in the size and power of the experimental craft.[132] In November, FAA announced a new rulemaking committee to reexamine the controversial Part 450 changes. The agency is seeking to update the rules "to foster more clarity, flexibility, efficiency and innovation," according to an FAA staffer.[133]

These changes are welcome but are only a start. The new administration should direct FAA to roll back the Part 450 rules and establish a simplified regime with two main goals: enable frequent launches and rapid design iteration for Starship and other experimental spacecraft; and accommodate the rapid launch cadences made possible by reusable launch systems like SpaceX's Falcon 9 and Rocket Lab's Electron.[134]

Lawmakers and regulators must accept that the commercial launch business is not remotely comparable with civilian aviation. This is not a transportation system flying millions of people a year; it is an industry in its infancy that requires freedom to grow. FAA has no mandate to set performance or safety parameters for commercial spacecraft, aside from simple measures to protect people, infrastructure, and environments on the ground. When a launch mishap harms uninvolved parties—as in early 2025, when two consecutive Starship test flights ended in explosions that scattered debris across the Caribbean—timely FAA investigations are warranted.[135] But unless something goes very amiss in the development of private launch technology, those cases should be rare exceptions.

For the foreseeable future, people who fly on private spacecraft—including paying customers—will understand that they are part of a high-risk enterprise. The best way to make these technologies safer and more reliable is to allow them to fly as often as possible. At a recent conference, Shotwell eloquently expressed the risks of overregulation. She noted that China, with its aggressive, state-funded rocket program, doesn't let regulations hinder its rapid progress. But elsewhere, government micromanagement "is slowing technology down. It's not helping; it's slowing. All we ask is, regulate industries, make them safe, make them right, make them fair, but you have to go faster."[136]

2. Retire SLS to Save Artemis

To ensure the future of spaceflight, NASA must stop building rockets. That counterintuitive notion is borne out by the agency's post-Apollo history. For the past 50 years, NASA has been held back by its attempts to develop human spaceflight systems that cost too much and fly too little. Today, the private sector can build rockets faster, cheaper, and better.

Too often in the past, NASA has focused on building and maintaining expensive launch platforms at the expense of its core goal: flying missions efficiently and frequently. The space shuttle, for example, was a bold attempt to create a reusable space vehicle but was designed for such a wide range of scenarios that it proved wildly inefficient for most of them. Over 30 years, it launched only 135 times, fewer than five flights per year. The post-shuttle Constellation system and the SLS rocket that replaced it were built without any clear description of what vital mission they would enable. NASA and the agency's overseers in Congress simply assumed that the U.S. needed "Apollo on steroids."

Congress often demands this cart-before-the-horse approach. In the waning days of the shuttle program, influential members of Congress wanted to protect shuttle-related contractors and NASA operations in their states and districts. In the name of "skills retention," Congress pushed NASA to repurpose shuttle components and facilities for the Constellation rocket and, later, SLS. That is why the SLS rocket uses rocket engines and solid fuel boosters originally designed for the shuttle. Absurdly, when the Artemis II mission flies four astronauts around the moon roughly a year from now, it will be powered by engines designed before any of those astronauts were born.

In a sense, carrying astronauts has never really been the new rocket's main purpose. "SLS, which is known in space circles as the 'Senate Launch System,' has always been a jobs program for connected states," University of Tennessee law professor (and longtime space advocate) Glenn Reynolds told MI.[137] As with the space shuttle a generation earlier, the SLS program's inefficient design and enormous costs are, in the topsy-turvy calculus of politics, advantages rather than detriments. As a result, SLS is a towering monument to obsolete ideas: an expendable system in the age of reusable rockets and a vehicle for the space missions of the future, built with 50-year-old technology. It is a dreadnought in an age of aircraft carriers. Of course, the blame lies not only with NASA but also with Congress's parochial meddling in technical design decisions. Any federal program that showers so much money on so many states and businesses for so long becomes almost impossible to reform.

The SLS still has strong support in Congress, especially among lawmakers from Gulf Coast states, where much of the program is based. However, space experts are increasingly calling for the SLS to be retired—if not immediately, then over the next several years. "We need an off-ramp for reliance on the SLS," Scott Pace, director of the Space Policy Institute at George Washington University, told the House of Representatives Subcommittee on Space and Aeronautics in February: "The United States should seek to use commercial providers for heavy-lift capabilities that can sustain multiple crew and cargo missions each year to the Moon" and SLS should be phased out as soon as "one or more sources of private heavy-lift are demonstrated."[138] This is significant coming from Pace, a physicist who served as executive secretary of the National Space Council during Trump's first term, advised several Republican administrations, and, until this year, has been a strong supporter of the SLS program.

In his April confirmation hearing, Jared Isaacman, the White House's nominee to be NASA administrator, offered a similar assessment. Issacman vowed to address the issues at the agency "that are causing everything to take longer than it should and cost more than it should." Clearly, the SLS program is high on that list. "I don't think [the SLS] is the long-term way to get to and from the moon and Mars with great frequency," he testified, without offering specifics as to how the rocket might be replaced.[139]

Fortunately, while SLS may be a white elephant, the lunar mission that it is intended to enable is no longer just a pretext for building an enormous rocket. Over the years, NASA has fleshed out a meaningful plan for a return to the moon that will pave the way for an eventual Mars expedition. Aided by the revived National Space Council, the first Trump administration developed a compelling agenda to achieve this, codified in Space Policy Directive 1 on December 11, 2017.[140] Broadly, the plan aims to "enable human expansion across the solar system." More specifically, the Artemis plan calls first for a series of robotic explorations of the moon's South Pole area. That region has deep craters that scientists believe contain pockets of water ice (valuable for life support and for making oxygen and fuel) and high points that enjoy continuous exposure to sunlight (unlike most of the moon, which experiences alternating 14-day periods of sunlight and frigid darkness)—which together make the area promising for long-term inhabitation. Artemis calls for an initial weeklong visit by two astronauts, followed by construction of permanent facilities. "When we go to the Moon with Artemis, we are going to stay," NASA officials said in an overview document.[141] NASA hopes to apply the lessons learned in these lunar ventures to later expeditions to Mars.

In contrast to the Apollo era, the Artemis plan embraces the use of commercial contractors to carry out crucial functions. For example, NASA has contracted with SpaceX and Blue Origin to design and fly two versions of the Human Landing System (HLS) that will carry humans from lunar orbit to the moon's surface.[142] The plan also invites meaningful contributions from America's international partners, which NASA has done since the days of the space shuttle. But this effort is more than diplomatic; today's partners, including the European Space Agency, Japan, and the United Arab Emirates, bring significant technological capabilities—along with a willingness to help fund these expensive missions.[143]

Long before the Artemis plan was codified, space advocates and NASA insiders debated whether to prioritize a return to the moon or dedicate resources entirely toward a Mars mission. During Trump's first administration, space-policy leaders reached a consensus to first build up expertise in the more accessible lunar environment. In his second-term inaugural address, however, Trump put a faster push toward Mars back on the table, calling a landing on the red planet part of America's "manifest destiny."

No doubt Musk is having an influence on the president's thinking. The entrepreneur has long argued that colonizing Mars was an urgent priority for the future of humanity. We're "going straight to Mars," Musk posted on X in early January. "The Moon is a distraction."[144] For over a decade, the entrepreneur has said that he wants "to die on Mars (just not on impact)."[145] That focus on the red planet is reflected in the design of the SpaceX's next-generation Starship. A considerably smaller spacecraft would have sufficed for foreseeable lunar and LEO missions. But Musk pushed his company to build a ship big enough to conduct a Mars mission in the relative near term.

The *Wall Street Journal* recently reported that Musk is "working to recast [NASA] programs, reallocate federal spending and install loyalists to aid his decades-long goal of sending people to Mars." But it doesn't seem that the entrepreneur has entirely won over the president. "There's a lot of interest in going to Mars," Trump said in a March 9, 2025, interview on Fox News. "Is it number one on my hit list? No. Not really. But … it would be a great thing if we could do it."[146]

If the administration were to propose leapfrogging the moon in favor of Mars, the plan would face serious opposition in Congress, including from Republicans. "To bypass the moon would be a mistake," Babin told *Politico*.[147] Such a move would also invite the kind of partisan pile-on described at the beginning of Part 3 of this report. In the past, Musk has said that SpaceX would fund the colonization effort using revenue from its Starlink division.[148] If the White House suddenly announced that it was redirecting billions in lunar funding toward a Mars program, Musk's critics would have an irresistible talking point: Why are American taxpayers funding a billionaire's passion project?

Moreover, while sending Americans to Mars is a worthy and achievable goal, there are good reasons to spend time on the moon before sending humans to the more distant body. The moon requires a three-day trip, as opposed to a multiyear round-trip for a Mars visit. As the U.S. develops the technology, skills, and psychological preparation for extended life on another space body, it makes sense to start at the more accessible location. Sticking with some version of NASA's moon plan also makes strategic sense, given China's aggressive posture. "If we do not beat the Chinese to the moon, they are going to write the rules of the road up there," Babin said.[149] Isaacman relieved many in Congress when he stressed the importance returning to the moon before China establishes a foothold there. At the same time, the nominee's statement that the agency will "prioritize" Mars efforts left open the possibility that the administration will try to scale back lunar programs after the initial landing, and begin shifting resources to a red planet push.

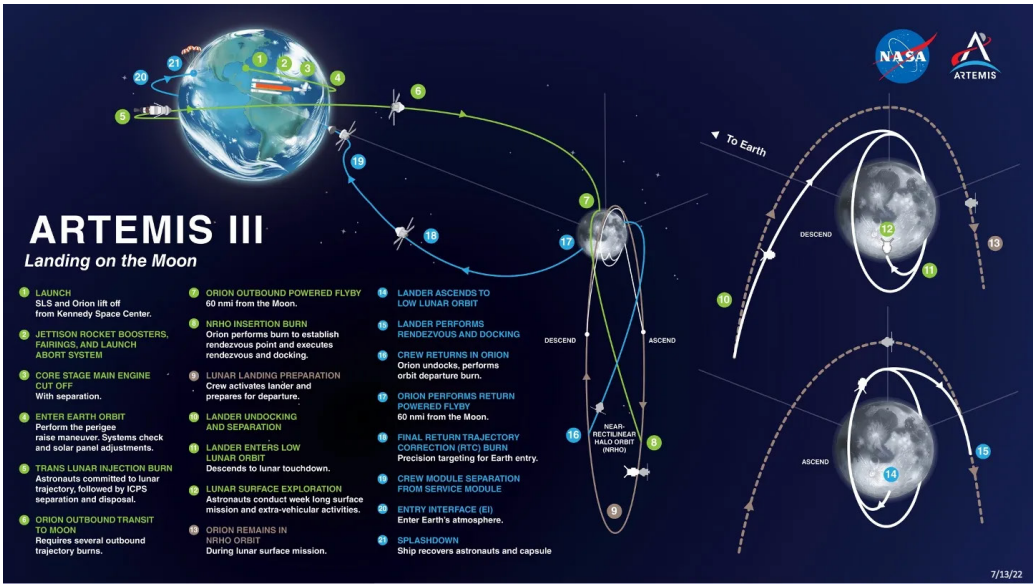
The Artemis program faces enormous challenges no matter how ambitious NASA's lunar plans turn out to be. Above all, it lacks an adequate technological foundation: the SLS rocket doesn't have the capacity to deliver astronauts and hardware to the moon on the current schedule or within reasonable budget constraints. The Trump administration thus faces a decision that it had avoided in its first term: Should the U.S. stay committed to SLS/Orion and accept a slow and massively expensive moon program? Should it scrap the troubled rocket immediately and start anew, using commercial vendors to carry out the program? Or is there a compromise approach?

To answer that question, it helps to understand the current Artemis lunar plan.[150] NASA launched the first Artemis mission in 2022, using an SLS rocket to send an unmanned Orion capsule looping around the moon before returning to Earth (that mission revealed weaknesses in Orion's heat shield; the program schedule slipped further as NASA worked on the problem).[151] The Artemis II mission (recently pushed from late 2025 to April 2026) will send four astronauts around the moon before returning home.

Artemis III (pushed to a still-optimistic 2027)[152] involves several steps (shown in **Figure 2**): NASA has contracted with SpaceX to use Starship's upper stage as the mission's HLS lunar landing vehicle. As noted above, NASA also has a contract with Blue Origin to build a smaller, purpose-built HLS. To get its lunar Starship into orbit around the moon, SpaceX will first launch a fuel depot into LEO and then send several tankers to fill it with fuel. A modified, uncrewed Starship will follow into orbit, refuel at the depot, and then perform an engine burn to enter a parking orbit around the moon. Finally, an SLS rocket will launch an Orion capsule with four crew members into lunar orbit. Orion will dock with Starship; two crew members will transfer to the SpaceX ship, which will carry them to the lunar surface. Six days later, Starship will carry the astronauts back into lunar orbit, where they will reboard Orion and begin the journey home.

Figure 2

Artemis III



Source: Courtesy of NASA. This mission plan for the Artemis moon landing leaves the details of the lunar landing vehicle unspecified.

Later-planned Artemis missions grow even more complex. As currently envisioned, they will require building a second iteration of the SLS, known as **Block 1B**, which will include a more powerful upper stage and a larger payload compartment, both of which are needed to deliver heavy cargo to the moon. These missions will help construct the Lunar Gateway, a small space station that will remain in lunar orbit and serve as a way station for crews coming and going to the lunar surface, helping to support a permanent presence at the South Pole.

These Artemis plans sound exciting. And a number of foreign partners have signed on to help build the Gateway and participate in other aspects of the program. Unfortunately, virtually no experts believe that NASA will be able to launch Artemis missions on anything close to the necessary timetable. After all, NASA has been missing targets for returning to moon for over a decade. After years of delay, SLS/**Orion** remains at least a year away from being able to fly the crewed Artemis II mission. And few other components of the program are on track for a timely follow-up. Crucially, the **Block 1B** upgrade, the larger tower required to launch the bulked-up rocket, and the Lunar Gateway space station all remain far behind schedule.

Given those concerns, it seems that the simplest approach would be to cancel SLS/**Orion** today. But there's a problem: "At this time, we don't have a crew system other than **Orion**," space consultant John Mankins, who spent 25 years at NASA and the Jet Propulsion Laboratory, told MI.[153] "Right now, if you get rid of SLS/**Orion**, you get rid of human spaceflight beyond LEO," he added. The current Artemis mission plan requires a space vehicle returning from the moon to reenter Earth's atmosphere at a blistering 25,000 miles per hour.[154] Today, **Orion** is the only crewed space vehicle that has demonstrated the ability to survive that challenging reentry.[155] "Getting to the moon is easy," notes analyst Rand Simberg. "It's getting back that's hard."[156] Scrapping SLS/**Orion** today would require "either developing another system or waiting another decade getting to the moon," Mankins believes.

Some experts, including Simberg, want to retire the SLS rocket immediately. They argue that Orion could be launched on other, existing rockets and that the entire SLS/Orion package could be replaced by the SpaceX Starship or some combination of existing or emerging technologies. Starship—with its enormous payload capacity and complete reusability—is the obvious front runner in these discussions. SpaceX's Starship is certainly revolutionary—a 747 in an era of DC-3s. But it remains an experimental vehicle in a very early stage of development. On January 15, 2025, the newly upgraded Block 2 version of Starship exploded roughly eight minutes into its flight.[157] Seven weeks later, another Starship test also ended in a fireball.[158] Those incidents reminded space watchers that Starship still has an arduous development path before it is likely to be approved for launching U.S. astronauts. NASA analysts believe that those back-to-back failures will likely "cement the path forward for Artemis II and Artemis III to fly as planned, with crews flying on the Space Launch System, rocket and the Orion spacecraft," as Eric Berger wrote in March. [159]

At the same time, the two-month gap between these two failed flights drives home the difference between how NASA and SpaceX approach hardware development. Almost four years will have elapsed between NASA's first flight of SLS and its planned second launch. SpaceX has conducted eight Starship test flights in less than half that time. SpaceX embraces a model of rapid testing and constant revisions in vehicle designs; the company expects that some test flights will end in what Musk likes to call "rapid unscheduled disassembly" while still producing useful data. In the long run, SpaceX's rapid-iteration model should result in a safer, more reliable vehicle. "Most people will forget about those two Starship failures after a couple of Starship successes," Simberg believes. NASA, by contrast, has spent two decades building a rocket whose key components were designed in the era of rotary phones. The U.S. will never develop extensive lunar settlements, much less put boots on Mars, relying on the glacial SLS/Orion approach. The long-term future of NASA's manned space program now depends on SpaceX, Blue Origin, ULA, and other private space companies continuing to increase the pace and drive down the costs of spaceflight.

In the short term, however, the SLS/Orion platform appears to be the quickest way to get U.S. astronauts back to the moon. After all, as space journalist Stephen Clark notes, "The rockets most often mentioned as stand-ins for the Space Launch System—SpaceX's Starship and Blue Origin's New Glenn—aren't likely to be cleared for crew missions for at least several years."[160] In contrast, all the components for the Artemis II SLS/Orion mission—which will carry astronauts around the moon for the first time since the end of the Apollo program—are now being stacked at the Kennedy Space Center in Florida.[161]

Assuming he is confirmed, NASA administrator Isaacman will face a tough set of challenges. He will need to push for the soonest possible moon landing while simultaneously laying both the technological and political groundwork to retire the SLS. Isaacman's first order of business should be to announce that NASA is seeking the earliest possible exit from the SLS program. The timeline for that retirement will depend on how rapidly alternate heavy-lift launch systems, including Starship, New Glenn, and ULA's Vulcan rocket, can achieve high flight rates. The best current target appears to be after Artemis III, the first crewed lunar landing. (In his confirmation hearing, Isaacman appeared to endorse using the SLS through the Artemis III mission.)[162]

Under this plan, the Artemis II and III missions should proceed as planned, using SLS and Orion. The crewed flight around the moon will set the stage for the next task: landing astronauts on the lunar surface. Isaacman will also have to admit that Artemis III is not going to launch in 2027, as currently planned. As noted above, holdups in launch approvals delayed SpaceX's first flight tests of Starship, which NASA plans to use as the lunar lander. SpaceX will need more time to complete a Starship lunar variant, put a fuel depot in Earth orbit, and demonstrate that it can transfer fuel in space. A November 2023 Government Accountability Office (GAO) report noted that SpaceX had "made limited progress maturing the technologies needed to support this aspect of its plan."

The space suits needed for exploring the lunar surface are also likely to be delayed, GAO noted.[163] Instead of publicly insisting on an unattainable timetable, NASA should designate a realistic date to put American boots on the moon again.

Of course, the plan to retire the SLS after Artemis III will need to begin long before that first crewed landing occurs. (And if NASA and its private partners can develop a faster plan to land astronauts on the moon without the SLS, the agency should pursue it.) Ending the SLS will, in turn, give NASA the opportunity to streamline the entire Artemis program. To recap, Artemis II involves using existing technology, the current version of SLS and the Orion capsule. Artemis III adds Starship as a lunar landing vehicle and an as-yet-untested orbiting fuel depot to the mix. Given SpaceX's typically rapid pace of innovation, it is not unreasonable to expect those components to be ready by 2028. But Artemis IV and beyond require building the entire Lunar Gateway space station, upgrading SLS with the more powerful Block 1B upper stage, and finishing the bigger, $2.7 billion launch tower that SLS Block 1B will require. All those projects should be on the chopping block.

The first step will be to cancel the Lunar Gateway. The Gateway was originally conceived as the crucial way station between Orion and the lunar lander. But in 2021, NASA selected the SpaceX Starship to serve as HLS; in this plan, Orion will dock directly to the Starship craft. If Orion can dock directly with the Starship landing vehicle, there is no need for an intermediate habitat. Moreover, building the Gateway would require a series of missions, diverting resources away from the moon itself. As space analyst Mark Whittington pointed out in 2022, during that period, expeditions to the lunar surface would "slow to crawl for several years."[164] Canceling the Gateway would not only facilitate more rapid development of a lunar base; it would also allow further downstream savings. Even if NASA is (for political or other reasons) forced to use SLS for one or more missions after Artemis III, the program would be much cheaper without the Gateway. *Ars Technica*'s Eric Berger notes that if NASA doesn't need the Gateway, it can also cancel the expensive Block 1B enhanced upper stage for SLS. The main purpose of that upgrade is to handle the heavy Gateway components.[165] Finally, if NASA doesn't need the Block 1B upper stage, it can also stop building the $2.7 billion expanded launch tower.

NASA will also need a plan to test and select the launch systems and vehicles needed to get astronauts and cargo into lunar orbit and home again. The simplest approach would be to rely on Starship for everything. Space analyst Gerald Black estimates that using Starship for all phases of the lunar mission would be roughly 10 times less expensive than the current Artemis plan to use the SLS/Orion in tandem with the Starship lunar lander.[166] But other pathways could be developed in parallel with the all-Starship approach. For example, the existing Orion capsule could be launched atop another heavy-lift rocket, such as the Blue Origin's New Glenn or the ULA Vulcan, each of which has flown a single test flight and will need further testing before being certified for human launches. Orion could also launch atop a SpaceX Falcon Heavy, possibly using a ULA Vulcan rocket as the second stage to provide the extra boost to the moon.[167] The SpaceX *Crew* Dragon is another potential candidate for the lunar journey.

NASA doesn't need a single solution; in fact, two or three might be best. Scott Pace recommends "dissimilar redundancy" for lunar landing and crew launch.[168] NASA has done this by contracting with both SpaceX and Blue Origin to develop lunar landing vehicles. Dissimilar redundancy means that if a major design flaw grounds one type of vehicle, a technologically different system remains available. Of course, working with multiple vendors also reduces the political pushback that would likely result from relying so heavily on SpaceX alone. In the end, almost any combination of commercial vendors will help NASA build a presence on the moon for a small fraction of what the current plan would cost. The money saved will allow a more rapid buildup of lunar infrastructure and, if the White House so chooses, allow an earlier pivot to Mars.

Still, retiring SLS and streamlining the Artemis program will entail both financial and political costs. Contractors including Boeing, Bechtel, and SpaceX have large contracts to build or supply Gateway and other components of the later Artemis systems. Several international partners are already signed up to build parts of the Lunar Gateway. Many workers at NASA's Johnson Space Center and Marshall Space Flight Center would have to be reassigned or let go. Each of these constituencies will fight to keep SLS flying. The White House will undoubtedly have to apply political muscle to get influential Republicans on board with a plan that reduces NASA dollars flowing to their states. But for the nation as a whole, the short-term pain of these changes will be minor, compared with the long-term humiliation of spending over $100 billion on the SLS-based version of Artemis—and failing to achieve most of the program's goals.

These reforms to the Artemis program are decades overdue. For too long, NASA has focused on building big, expensive rockets and space vehicles, while giving too little attention to the missions that these vehicles are supposed to accomplish. It's little wonder that NASA astronauts haven't ventured beyond LEO since 1972. Once the SLS is dead, and commercial partners can routinely carry astronauts to the moon and beyond, NASA should be permanently out of the launch business. Only then will it finally be able to focus on its greater mission.

3. Repair, Then Expand, NASA's Commercial Programs

NASA deserves enormous credit for its two-decade effort to utilize commercial contractors with fixed-price contracts. But, as noted above, the program has hit significant turbulence, including Boeing's Starliner debacle, the reluctance of some large contractors (including Boeing) to accept fixed-price contracts, and several smaller contractors walking away from commercial projects that became too difficult to manage. Given that almost all recent contracts in the Artemis lunar program were awarded on a fixed-price basis, this could be a major problem for NASA.

The solution is not simply to revert to NASA's traditional cost-plus approach. After all, some of the most problematic projects in the Artemis program, such as the Lunar Gateway and the SLS Block 1B upgrade, are being built mostly under cost-plus contracts. An August 2024 IG report, for example, found a "degraded state of quality control"—including faulty welds—at a Boeing plant building Block 1B hardware.[169] While there may be some projects that require cost-plus contracts, the tortuous history of SLS development shows that the model is typically a recipe for delays and cost overruns.

Likely incoming NASA administrator Isaacman must assemble a team dedicated to reviving the principles that generally paid off for the COTS and Commercial Crew programs. NASA's former COTS and Commercial Crew manager Alan Lindenmoyer recently described how those programs worked: "[W]e wanted to be able to use what was available in the public market for government use, with minimum modifications." At the time, of course, there were no private spacecraft capable of supplying the ISS. So NASA helped SpaceX and other early COTS participants start developing ISS-compatible space vehicles by providing both seed money and a clear description of what the spacecraft needed to do. And, unlike in a traditional cost-plus development project, those parameters had to be limited and not constantly changing. "It was fundamental to have well-developed, lean set of requirements," Lindenmoyer said.[170]

The Commercial Crew program also took a relatively hands-off approach. It worked beautifully with SpaceX but not so well with Boeing, a company more at home in the cost-plus world. But even with that failure, NASA can now count on clockwork cargo and crew-rotation missions to ISS. In a sense, the agency now enjoys access to the kind of off-the-shelf hardware that Lindenmoyer envisioned at the start of the COTS program. SpaceX uses the same rockets to launch NASA cargo and crews, satellites for Starlink and other customers, and military hardware for the U.S. Space Force. Common platforms bring down costs for all customers. An internal NASA study showed that it would have cost the agency four to six times as much to develop this launch capacity on its own.[171]

But fixed-price contracts require managerial restraint from NASA, an organization famous for aggressively hands-on relationships with contractors. Discipline appears to have slipped in the Biden era. Some of NASA's key Commercial Crew managers moved on or were nudged aside; NASA engineers grew more involved and demanding. Faced with too many new and changing requirements, some contractors—including space-suit developer Collins Aerospace—have walked away.[172] A source at one commercial space company working on a fixed-price contract told *Ars Technica*, "It certainly feels like a lot of people are treating us like we're a cost-plus contractor."[173]

NASA must resist backsliding on the commercial model. It needs to give its fixed-price vendors room to work out their own solutions to problems—and sometimes to fail. This doesn't mean that NASA should tolerate slapdash designs for human-rated spacecraft. But the agency must be willing to issue multiple contracts to different firms, make the terms generous enough so that successful competitors can make a profit, and then be prepared for some of them to fail or to drop out.

That may not be easy for an agency where "failure is not an option" (a phrase attributed to legendary flight director Gene Kranz in the film *Apollo 13*).[174] NASA's traditional approach to developing space hardware has been to put all available resources into a single too-big-to-fail platform. Apollo's Saturn V rocket and lunar module had to work flawlessly on their first flights. Recent science missions, such as the *Perseverance* Mars rover and the James Webb Space Telescopes—multibillion-dollar investments—had to work perfectly the first time. Had they failed, it might have been decades before NASA could try again. The same goes for SLS. One can understand how NASA engineers, accustomed to working on such high-stakes projects, might become fanatical micromanagers. NASA administrator nominee Isaacman, with his entrepreneurial, private-sector background, brings a good skill set to reverse this managerial drift.[175]

The growing world of commercial space, on which NASA will have to depend, will operate by very different rules. Private companies, testing uncrewed rocket systems that were quickly built, can afford to fail, adjust, and try again. As American Enterprise Institute futurist James Pethokoukis writes: "SpaceX's approach to rocket development differs fundamentally from NASA's. Instead of extensive ground testing and a cautious pace to minimize launch failures—which can lead to longer development timelines and higher costs—SpaceX embraces rapid iteration and learning from failure."[176] In 2023, SpaceX vice president William Gerstenmaier tried to explain this to Congress: "We were permitted to learn through flight…. We implemented learnings quickly, returned to flight quickly, and learned more."[177]

Phil McAlister and other visionaries who started NASA's COTS program understood that they were breaking with tradition to embrace this kind of high-risk approach: "Failure was in fact an option for COTS," he writes.[178] NASA's next generation of leaders will need a similar spirit.

Wherever possible, NASA should offer multiple, smaller contracts rather than putting all its hopes in one or two can't-fail projects. Instead of a single $3 billion Mars rover like *Perseverance*, NASA could fund a dozen small ones deployed around the planet. If two or three don't survive, it's not the end of the mission. There are several proposals to develop such "robotic swarms."[179] The lesson from COTS and Commercial Crew is clear: Private companies can deliver new hardware and services for a small fraction of what NASA would spend developing the same capability. Though some contractors will inevitably fail, the agency—and taxpayers—come out ahead.

4. Restructure NASA for an Entrepreneurial Era

Ironically, as America's presence in space increases, NASA's role will become harder to define. The days of Apollo and the space shuttle are long past, and the ISS is nearing retirement. NASA will have a very different role in the coming decades of space exploration and settlement—no longer the solitary player but part of a growing community of space pioneers. Moreover, once freed from

the need to build and manage expensive space vehicles, the agency will have more resources to devote to genuine exploration and research. NASA should be restructured to focus on what it does best: basic R&D, mission planning and management, and space science.

Restructuring will mean painful changes at NASA. These will include closing or consolidating some of the agency's roughly 20 research and management centers that are spread around the country (partly for political reasons). The enormous staff dedicated to managing SLS and Orion will need to be trimmed. NASA has already made cuts in some departments, with more layoffs expected. In April, the White House Office of Management and Budget (OMB) circulated a draft proposal that would cut NASA's overall budget roughly 20% and slash funding for the agency's Science Mission Directorate nearly in half. Such cuts would require canceling some planned robotic programs and reduce support for ongoing science missions. The recommendation undercuts NASA administrator nominee Isaacman's promise to be an "advocate for science" in his Senate testimony. Musk called the proposed cuts "troubling."[180]

That said, like every other federal agency, NASA will need to become leaner and more productive. "NASA is no longer the trim, efficient government agency it was in the 1960s," notes space historian Robert Zimmerman. Budgets for the James Webb Space Telescope and other programs have ballooned egregiously in recent decades; NASA needs a new approach. There are "ample and rational reasons to consider major budget cuts to most NASA programs," Zubrin concludes.[181] But, while judicious cuts to runaway programs are called for, ham-fisted reductions could threaten U.S. leadership in space science. So far, the Trump White House has shown little inclination to make such fine distinctions in its budget planning.

Isaacman will need all his private-sector skills to manage the coming changes at NASA. On one hand, he will have to battle with the White House to bring more precision to the budget process. He will also need to help NASA staff navigate through a period of painful transition. Finally, the incoming administrator will be forced to weather the political blowback that will inevitably come as NASA reduces its footprint in influential states and districts. But if Isaacman can successfully steer NASA through this necessary reinvention, the upsides for the agency—and for the U.S.—are enormous.

As analyst Casey Handmer notes, "NASA is in the midst of the biggest opportunity since its founding in 1958."[182] A quantum leap in space accessibility is fast approaching. The SpaceX Starship is getting closer to commercial service, and SpaceX competitors Blue Origin, Rocket Lab, and others are—if not exactly catching up with that extraordinary company—at least closer to being peer competitors in launching heavy- and medium-lift payloads on reusable rockets. The days of "cheap mass" anticipated by Simberg are arriving. "I think SpaceX will eventually be able to get launch prices down to $10–$20 a pound," he predicts. "At those kinds of rates, the possibilities are endless."[183]

The era of cheap mass will also let NASA take on a range of missions that would have been unimaginable just a few years ago. Since the dawn of spaceflight, NASA engineers have been held back by what Handmer calls "absurdly harsh mass constraints, since launch costs to LEO are as high as $10,000/kg and single launches cost hundreds of millions."[184] When every gram is precious, engineers must design satellites, space telescopes, or planetary rovers out of super-lightweight materials with exotic, one-off components. Designing a single space probe might take hundreds of engineer-years. But when mass is cheap, space hardware can be built quickly out of ordinary materials and off-the-shelf components. And, instead of launching a single Swiss-watch probe or rover, NASA can deploy swarms of simple, ruggedly made units. In that world, notes Handmer, "we could have every NASA center churning out world-building machines by the truckload, building critical infrastructure that forms the backbone of humanity's leap to a multiplanetary civilization."[185]

NASA will not be alone in this effort. In fact, it won't always be leading the biggest leaps in space exploration. As John Mankins notes, "Some of the biggest innovations have been coming from the private sector recently."[186] Accepting that reality will be a challenge for many long-term NASA employees. Nor will NASA astronauts be the only ones venturing to the moon, the asteroids, and Mars. Private companies, resource prospectors—and even space tourists—will be eager to make these dangerous journeys. NASA should help these ventures where it can and harvest the knowledge that they bring. At the same time, NASA must curtail its failure-is-not-an-option mentality. As Simberg argued in his 2013 book *Safe Is Not an Option*, spaceflight has always entailed huge risks and attracted a select few willing to face that peril. U.S. policymakers and NASA leaders must recognize that rapid progress in space requires dangerous missions, whether led by NASA astronauts or private explorers. And the U.S. public must accept that not every explorer will make it home.

No one understands this better than incoming NASA administrator Jared Isaacman, who funded and commanded two missions in the SpaceX Crew Dragon vehicle. The second of those, Polaris Dawn in September 2024, reached an apogee of 870 miles, the highest altitude achieved by any Earth-orbiting crewed spacecraft in history. On that mission, Isaacman and SpaceX's lead space operations manager Sarah Gillis also performed the first commercial space walk, depressurizing the cabin and then venturing out of the hatch for over an hour. The mission was not mere space tourism; it was genuine exploration that expanded the orbital range of the Dragon spacecraft and demonstrated the effectiveness of the new SpaceX EVA space suit.[187]

The future of spaceflight will often feature commercial astronauts pushing the frontiers of discovery. Indeed, the first boots on Mars may well be worn by a civilian explorer rather than a NASA astronaut. The agency's leaders need to prepare for a world where NASA space vehicles and personnel are not alone at the vanguard. But if NASA isn't building rockets and singlehandedly exploring the heavens, what is its reason for being?

NASA should go back to basics. It should focus on the tasks that commercial vendors cannot easily do, including basic research into space technology and new propulsion systems. (In his confirmation hearing, Isaacman stressed the need to study nuclear propulsion, the kind of R&D that would be difficult for private companies to undertake, but which could prove crucial to deep-space travel.)[188] It should continue studying ways to keep astronauts healthy in zero gravity, protected from radiation, and psychologically fit on long space voyages. NASA's crewed missions should rely as much as possible on launch and other services provided by commercial vendors. But when NASA sends its astronauts to environments where private space companies cannot yet venture, it should structure those excursions as proof-of-concept missions. As Glenn Reynolds puts it: "NASA should not be in competition with private companies. … It should only do directly those things—like deep space probes—that private companies can't do yet, and it should yield territory as those companies progress."[189]

Some at NASA might balk at sharing the glory of exploration with profit-motivated companies, some of which might be carrying space tourists as passengers. But others at the agency are excited at the prospect of being part of a revived American presence in orbit, on the moon and beyond—one that both harnesses and enables the private space industry. In a 2022 response to recommendations from the NASA Advisory Council, an unnamed writer at the agency sketched out a compelling vision of a future outpost on the moon that would combine NASA staff and infrastructure with thriving commercial enterprises:

> We believe that public-private partnerships and service-based models will drive down access costs while simultaneously increasing public interest and generating demand in future markets like prospecting, academic research, tourism, supply chain, and logistics. As these markets develop, NASA will become one of many customers for lunar access and will be able to conduct long-term research on the Moon while focusing development funds on the capabilities needed to send humans to Mars.[190]

NASA seems to be describing a kind of lunar Mos Eisley spaceport (though hopefully not a "wretched hive of scum and villainy").[191] In this scenario, NASA's pioneering exploration would open lunar terrain for private space ventures, which, in turn, could provide valuable services for the agency. A lunar entrepreneur might mine ice and then sell water, oxygen, and hydrogen fuel to a NASA compound. A space tourism operator might build structures that could house paying guests but double as accommodations for astronauts or visiting scientists. This diverse lunar ecosystem would build experience for even more ambitious outposts on Mars. NASA would catalyze these synergistic activities without directly operating all of them, leaving the agency with more resources to focus on the next big challenge. Isaacman seemed to envision this kind of synergy in his Senate testimony. "By working alongside international partners and industry, we can unlock the true economic benefits of space and deliver meaningful benefits to the American people," he said.[192]

No other country in the world can match what the U.S. will accomplish in space if it combines the best of what NASA can offer with the genius of private enterprise. The new administration has a golden opportunity to make that uniquely American formula work.

About the Author

James B. Meigs is a senior fellow of the Manhattan Institute and a contributing editor of *City Journal*. He is the former editor of *Popular Mechanics*, where he helped reposition that century-old brand to become a major voice on technological issues of the day. He also writes the Tech Commentary column for *Commentary* magazine. His coverage of energy, environmental policy, culture, and other topics has appeared in the *Wall Street Journal*, Slate, the *New York Post*, and other publications. He holds a B.A. in philosophy from Dartmouth College.

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