

NASA at a crossroads

 Check for updates

The space agency that put humans on the Moon and plans to return them there this decade is mired in a funding crisis that jeopardizes its long-term future. With further political uncertainty on the horizon, NASA officials, scientists and other employees find themselves in an uneasy limbo.

When Donald J. Trump becomes US president again on 20 January, all federal agencies face an uncertain future – including NASA, one of the largest funders of US astronomical research. Major questions include: what will happen to NASA's Artemis programme to send astronauts to the Moon (Fig. 1), which began in the first Trump administration in 2017 but is woefully underfunded and behind schedule? How will the agency be shaped by Trump's relationship with Elon Musk, whose company SpaceX has received billions of dollars in NASA contracts and who has long dreamed of colonizing Mars? And how will the second Trump administration approach the funding of scientific research and what impact will this have on NASA budgets?

Yet even before Trump's election, NASA was facing existential questions about its future. The agency has prioritized short-term success over investing in long-term sustainability, says a major report published in September by an influential advisory group of top scientists, the US National Academies of Sciences, Engineering and Medicine. And that has pushed NASA to the brink of losing its world leadership in science, engineering, and spaceflight.

"This is not a time for business as usual," said Norman Augustine, a former aerospace industry leader who chaired the committee that produced the report. "NASA truly is at a crossroads."

"We are underinvesting in its future," adds Thomas Zurbuchen, a space scientist at ETH Zurich in Switzerland who served as NASA's head of science from 2016 to 2022.

The tensions at NASA come as it tackles some of the biggest challenges it's faced in decades. Those include ramping up the Artemis programme, retiring the International Space Station, planning for ambitious new science projects such as [bringing rock samples back from Mars](#) and building a huge space telescope to search for signs of life on exoplanets. Somehow all these plans have to squeeze into NASA's US\$25-billion annual budget.

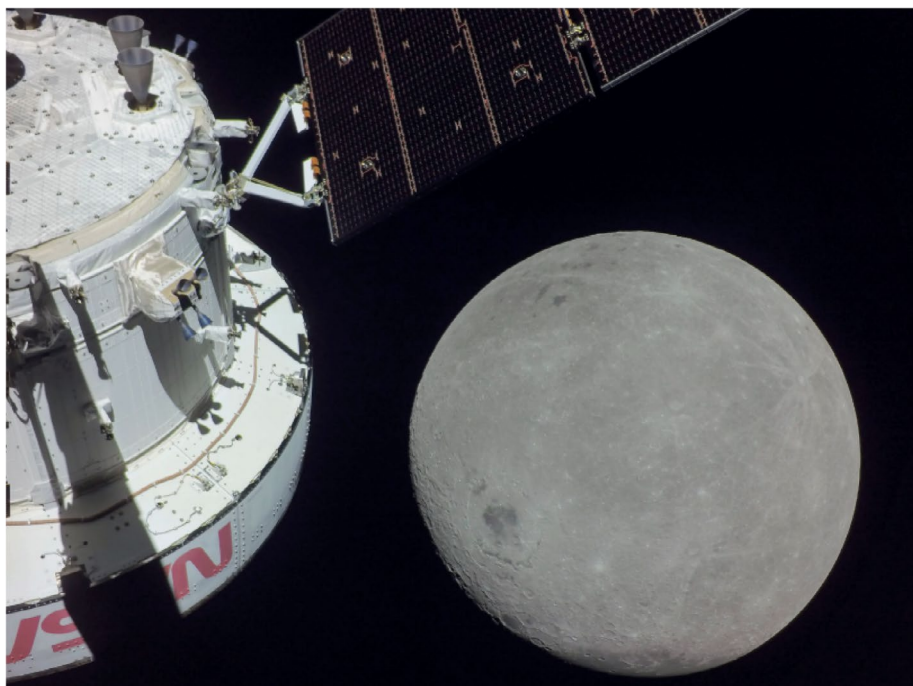


Fig. 1 | NASA's Artemis I mission at the Moon in 2022. Dates for the launches of further components of the ambitious Artemis programme keep slipping.

It's all a lot, even for the world's premiere space agency. That's why Congress asked the National Academies in 2022 to review whether NASA has the facilities, workforce, and technology it needs to meet its long-term goals. The resulting report is perhaps bleaker than the agency might have hoped.

Augustine and his team visited all of NASA's major centres, including the iconic mission control at the Johnson Space Center in Houston, Texas, and the rocketry and planetary-science powerhouse Jet Propulsion Laboratory (JPL) in Pasadena, California. They interviewed hundreds of NASA employees to build up a picture of the agency's in-house capabilities.

That picture isn't pretty. For decades, the report concludes, NASA has consistently underinvested in the people and places it needs to remain a leader in science and technology.

The agency is now stretched thinner than ever to accomplish all the tasks it has on its plate – for instance, every dollar NASA spends on supporting its missions today has to buttress 50% more work than in 2010.

"NASA as an institution is being carried forward by its own inertia and a lot of talent and desire to succeed. But the enabling foundation has become very weak," says Casey Dreier, Chief of Space Policy for The Planetary Society, an advocacy group in Pasadena, California.

One problem is the crumbling infrastructure at many NASA facilities; 83% of NASA infrastructure is beyond its design lifetime, the new report found. Zurbuchen remembers seeing hardware that was destined to fly to the Moon but was sitting under a tarp because the roof above it was leaking. But getting Congress



Fig. 2 | Launch of Europa Clipper. The launch of the Europa Clipper mission was a bright spot in NASA's year.

to provide money for infrastructure fixes isn't easy, he notes: "I find it easier to sell the next mission than to sell a building."

Another issue is retaining the highly skilled workforce that NASA needs to succeed. The agency has more than 17,000 employees and around 50,000 contractors. Recruiting and hiring a talented employee can take months under government bureaucracy, and many scientists and engineers are instead choosing higher-paid positions in other technological areas or in the thriving US commercial space industry. Tight budgets also forced two rounds of layoffs this year at JPL. "It's worrisome to think about the future of the community," says Amanda Hendrix, a planetary scientist at the Planetary Science Institute in Tucson, Arizona, who served on the Academies committee.

Augustine and his team offer some solutions to the problems that they identify. Congress,

which holds the purse strings of the US federal government, could decide to give NASA more money to fix its decrepit buildings and retain a talented workforce. But if it doesn't, the agency might need to cut support for missions in the short term in order to fix the longer-term problems.

The report also recommends that NASA embark on a formal long-range planning roadmap to help assess milestones towards its goals. The agency does have a 'Moon to Mars' strategy that lays out specific objectives in robotic and human exploration of space, but it does not detail time steps towards accomplishing these tasks.

In response to the Academies report, NASA administrator Bill Nelson said the agency is already working to bolster its long-term planning efforts. "We will continue to work diligently to address the committee's

recommendations," he said in a statement. Among other things, the agency has kicked off a strategic effort called 'NASA 2040' that aims to elucidate where the agency wants to be in 16 years.

Still, it's incredibly hard for an agency to plan over the long term when it receives funding allocations from Congress once a year. The budgets can vary substantially from year to year, depending on the whims of whoever is in the White House and in Congress, and sometimes the appropriations aren't even finalized until the fiscal year is already well underway. That short-term cycle means that missions can be trapped in financial limbo, unable to plan to make major progress without knowing how much money they will have to spend in a given year.

This can cut especially hard in NASA's \$7-billion science directorate, which supports

scientists both inside and outside of the agency. There are some bright spots: In the past few years NASA has managed to eke out progress on some major science missions, such as launching the \$5-billion Clipper mission to Jupiter's moon Europa in October (Fig. 2). Other big science projects that are moving forward in the near term include the Nancy Grace Roman Space Telescope, slated for a 2027 launch, and the Dragonfly mission to Saturn's moon Titan that should launch in 2028.

But other science efforts are struggling. Plans for Mars Sample Return, one of NASA's biggest ambitions at the moment, are on hold as the agency tries to figure out a way to bring rocks collected by its Perseverance rover to Earth for less than the initial estimate of up to \$11 billion. In July the agency also cancelled its VIPER Moon rover, triggering outrage among planetary scientists who said its ability to search for ice on the lunar surface was a crucial science goal as well as a foundational technology for future human exploration. VIPER, which is already built and ready to fly to the Moon, will either be dismantled or taken over by another, as-yet-to-be determined partner.

Meanwhile, the fate of the Chandra X-ray telescope, a 25-year-old powerhouse of discovery, remains very much up in the air. NASA had proposed slashing the amount it spends

on Chandra, to a degree that would have essentially shuttered the observatory. Following outcry from astronomers, some members of Congress have pushed back on that suggestion, saying its scientific return remains high. The venerable Hubble Space Telescope also faces potential cuts.

NASA now says it will wait for Congress to weigh in with final budget numbers, likely early next year, before deciding what to do about the missions. "We have suspended any key decisions on both Hubble and Chandra," Mark Clampin, NASA's head of astrophysics, said at a 7 November NASA advisory committee meeting.

And that continues to leave scientists in limbo. In the meantime, policy experts recommend that researchers educate themselves and get involved in the intricacies of US science policy – especially by working through professional societies such as the American Astronomical Society or the American Geophysical Union. Meeting with members of Congress and explaining the value of science, Dreier says, can have tangible impacts in what research ultimately gets funded: "Science has been a shining example of what has worked best about NASA."

Hendrix, too, is qualifiedly optimistic. "I do think that we will look back on this time and think, that was bad but we got through it,"

she says. But "there are a lot of big things in the queue right now that we might need to temper."

With a new Trump administration about to take charge in Washington, it's anyone's guess where NASA might go in the near future. The first Trump term saw many efforts to slash certain projects within the agency, such as earth science and STEM education, while bolstering human spaceflight. In the next Trump term, projects as fundamental as Mars Sample Return could be drastically revised if, for instance, Musk talks NASA into sending astronauts to Mars aboard SpaceX's Starship vehicle – making a robotic sample return unnecessary. And if the incoming administration follows through on promises to slash federal bureaucracy, it's possible that some of NASA's ten centres could be eliminated completely – removing some of the need to update the agency's infrastructure or workforce, as there might not be much left to update.

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