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Correcting NASA's course

Ron Dantowitz/Clay Center Observatory

While we should expect a hard look at NASA from his administration, President-elect Donald Trump should resist the temptation to overturn the agency's human exploration initiatives. Instead, he should give NASA the tools and resources it needs to open space to explorers and commerce. Former astronaut Tom Jones makes the case for continuity, acceleration and a shift toward cislunar space.

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Come Jan. 20, the Trump administration should resist the urge to discard the human space-flight progress of the past eight years. Instead, it should look hard at NASA's priorities and give NASA a course correction, refocusing the agency on achieving concrete exploration and economic goals in cislunar space, the region between Earth and the moon.

In reviewing NASA's goals and programs, the new administration should assess whether those serve the nation's economic, scientific and national security priorities. It should avoid the mistake of starting over, which the Obama administration made seven years ago when it tossed the Bush-initiated Constellation lunar-return program

◀ **Caption to come**

and bypassed the moon for an underfunded Journey to Mars preparation initiative. Instead, the president and Congress should keep the promising elements of NASA's human space-flight portfolio and use those to establish the U.S. as the leader in exploring and exploiting cislunar space. With a properly funded course correction, within two presidential terms, NASA could be poised to exploit the moon's resources, establish an ability for astronauts to visit there and build a partnership to explore Mars.

Where NASA stands

NASA is slowly moving forward on its Journey to Mars, a technology path that aims to put humans on the red planet in the 2030s. So far, progress has been limited mostly to robotic exploration of Mars. For human exploration, the Obama administration has pushed for development of the Orion Multi-Purpose Crew Vehicle and the Space Launch System rocket but has shown little interest in setting calendar milestones beyond those for testing Orion and SLS. It will be up to future administrations to fund the bulk of the technology needed to get human explorers to Mars. Orion is still five years from flying a crew. After an uncrewed test flight to lunar orbit in late 2018, the only future exploration on the books for Orion is the Asteroid Redirect Mission, or ARM, in which an astronaut crew will be sent to lunar orbit to examine a captured asteroid fragment. ARM faces stiff opposition in Congress and may not survive 2017.

Orion's heavy lift booster, the SLS, has yet to fly. In development as the Ares 5 when the Obama White House took charge in 2009, the SLS was first canceled, then revived by congressional direction. Its first flight is now targeted for late 2018 for the uncrewed Orion flight to and from lunar orbit. After Constellation's cancellation, the White House directed NASA's immediate focus not toward the moon or deep space, but to replacing the shuttle with commercially built transports to launch astronauts to the International Space Station. Those ships, from Boeing and SpaceX, are well behind schedule and won't fly for another two years, forcing NASA to extend its reliance on Russia's Soyuz crew transport. That arrangement, in place since 2011, is vulnerable to the whims of Vladimir Putin. The slow progress of restoring U.S. human launch capability is due at least in part to NASA's budget — $19.3 billion in 2016 — which has lost buying power since 2009.

Defining the goal

The most important element of the course correction is to clearly inform NASA of its goal: Establish this nation as the leading technical, scientific and economic power in cislunar space. Everything else — including Mars — should be secondary. In pursuing

NASA

▼ **The liquid hydrogen tank is part of the core** stage for the Space Launch System. The rocket's first flight is set for late 2018, but NASA would need to accelerate its launch pace to sustain astronauts in cislunar space.

NASA

▲ **The Resource Prospector prototype** searches for a buried sample tube at NASA's Johnson Space Center in Texas in 2015. Intensive robotic exploration of the moon could locate water ice and supply propellant for an astronaut return.

that goal, the administration should follow these general principles:

- Expand and repurpose existing programs; don't wastefully cancel them and start over.
- Provide technology and skills to U.S. companies to help expand their reach into cislunar space, in return contracting for essential, more affordable services.
- Enlist international and commercial partners to provide critical human space-flight elements, e.g., lunar orbit habitats, a lunar lander, propulsion, nuclear power and logistics.
- Provide NASA with the resources it needs; increase NASA's budget by 10 percent immediately and let it pace inflation thereafter.
- Use the capabilities and skills gained in cislunar space to reach Mars. We should take that exciting step when the nation and our partners are ready. Exploiting the resources of the moon and nearby asteroids will get us ready sooner.

Within the decade, NASA should do the following:

- Re-establish humans around and on the moon. Start with intensive, robotic lunar surface exploration. Put a U.S. rover down at the lunar poles by 2020, prospecting for water ice. Demonstrate small-scale extraction of oxygen, hydrogen and useful metals like iron.
- Contract for lunar landing services with private firms competing to reliably deliver robotic payloads to the moon. These commercial missions would begin commercial-scale extraction of water, oxygen and rocket propellant.
- Accelerate the Orion and SLS booster flight schedule. By the early 2020s, fly Orion astronauts to a lunar-orbiting habitat for a monthlong stay. From orbit, control a surface rover on the lunar far side.
- Carry out the Asteroid Redirect Mission, extending our astronauts' lunar orbit expertise to asteroid resource exploitation. Open the asteroid fragment to follow-up commercial prospecting and processing experiments, using the returned asteroid boulder to demonstrate extraction of water from hydrated silicate minerals.
- Extend the ISS partnership to the moon. If lunar resources prove attractive, NASA with its willing partners should develop a lunar lander, planning a return to the moon by the mid-2020s. Astronauts would help establish a propellant plant and conduct scientific exploration. The lunar partnership would build momentum toward reaching Mars together.

On course for deep space

By the mid-2020s, NASA should be poised to return astronauts to the lunar surface, for jobs beyond the skills of robots alone. The same spacecraft elements tested in lunar orbit — habitat, propulsion, energy systems and heavy lift booster — could also be combined in a piloted voyage to a near-Earth asteroid, expanding humanity's reach millions of kilometers from Earth and extending our deep-space endurance to six months or more. By 2030, NASA should contract with commercial ventures for the first return of water and rocket propellant from a near-Earth asteroid. Lunar-generated propellants and/or asteroids will be key in designing an affordable human campaign to reach Mars orbit; visit its two small moons, Phobos and Deimos; and eventually, land on Mars itself.

20 years out

Establishing humans on Mars should remain NASA's "horizon goal," but it should not be a near-term or exclusive NASA priority. Instead, the agency should focus on the technical and economic development of cislunar space. By the mid-2030s, NASA should have laid the groundwork to make the Earth-moon system a thriving economic zone, hosting everything from low Earth orbit tourism to space-based solar power stations to commercial research labs or production facilities, to commercially run propellant tank farms. These activities would help support the ongoing scientific exploration of the moon.

Confidence gained in systems tested at the moon and at near-Earth asteroids would put the U.S. in position by the late 2030s to plan an international expedition toward Mars. Even if NASA still lacked the technology by then for landing a crew on Mars, a NASA-led crew could enter Mars orbit and establish a habitat on Phobos (about 22 kilometers in diameter) or Deimos (about 12 km in diameter). From this close-in outpost, geologists could establish a scientific telepresence on the surface, guiding surface rovers with no appreciable time delay.

Under astronaut control, these robots could search for life and the best site for a human landing. Robots could also assemble the elements of that surface outpost: landing aids, habitat, propellant plant, solar or nuclear energy station, and machines for extracting subsurface ice or water. We would cross the final approximate 9,400 kilometers from Phobos to Mars when technology, budget, risk assessments and international partnerships align.

Advantages of changing course

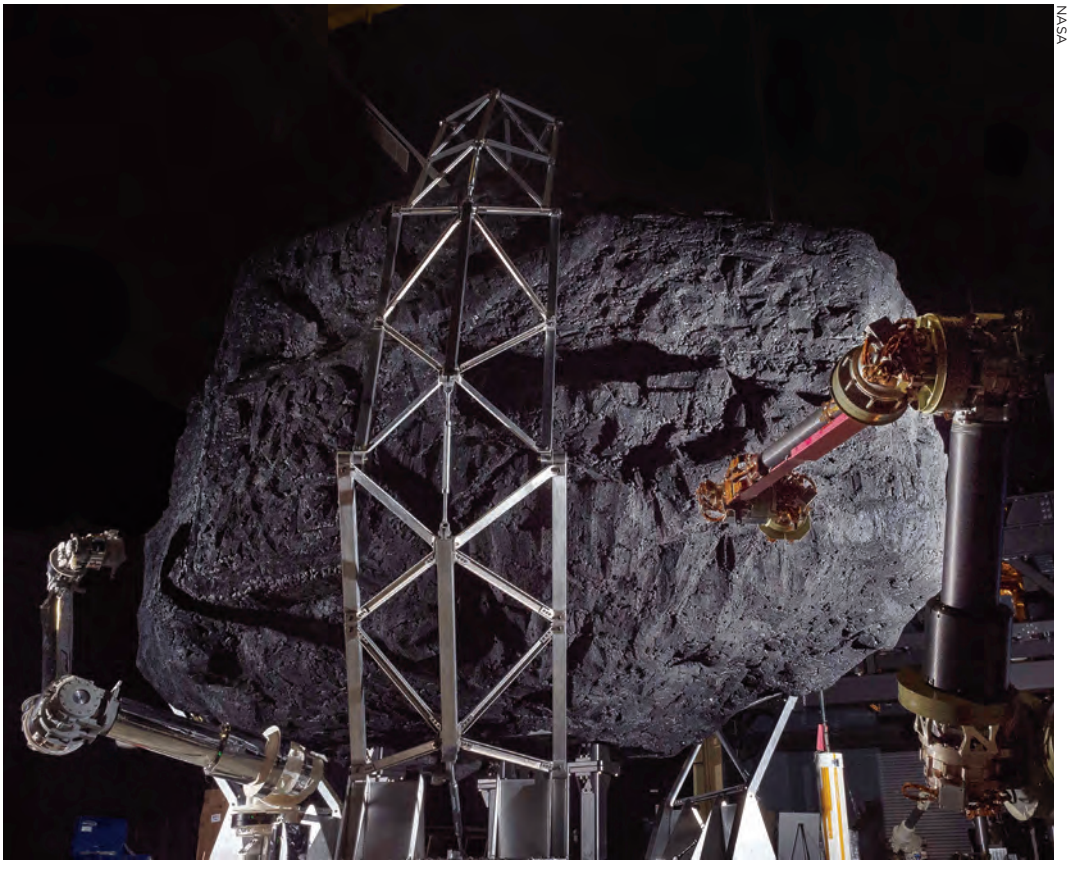
Within two presidential terms, a NASA focus on cislunar space would produce highly visible progress, namely the following:

- Commercial robots busily exploiting the moon, extracting water and metals from the lunar regolith;
- Astronauts regularly visiting a lunar orbit habitat, tele-operating robots and readying for a return to the moon's surface;
- An international lunar exploration consortium for science and resource production, an achievement readily adapted for reaching Mars;
- Private companies under NASA contract shipping supplies to the lunar orbit outpost and extracting tons of oxygen and rocket fuel from the moon;
- And astronauts training for their first deep-space encounter with a resource-rich asteroid.

By contrast, under current NASA direction and projected budgets, the U.S. couldn't achieve a human mission to the moon — even if it decided to join its ISS partners in the effort — let alone Mars. By 2025, for example, NASA astronauts will have flown Orion perhaps twice, repeating what America first accomplished on 1968's Apollo 8 mission. ARM is unlikely to make the new Congress's list of space priorities. And on our current course, by 2025, the ISS will be just a few years from a fiery re-entry into the Pacific, leaving China with the only space station in low Earth orbit. Soon after, these learners in space and up-and-comers will stamp their footprints on the moon.

Executing this course correction — preserving and accelerating NASA's promising programs — would restore bipartisan support to the agency, so lacking for eight long years. The U.S. will use cislunar space to train for Mars while tapping the economic potential of the Earth-moon system. Near-term success would bring renewed confidence in NASA's abilities and its hopes for leading a partnership to the asteroids and Mars.

In 1801, President Thomas Jefferson delivered his first inaugural address and predicted a "rising nation, spread over a wide and fruitful land … advancing rapidly to destinies beyond the reach of mortal eye." Today, that frontier is not the West, but space and its resources. A wise course change for NASA's exploration plans would invigorate our nation's fortunes once again. ★



NASA

An Asteroid Redirect Mission robotic prototype is tested with a mock asteroid boulder at NASA's Goddard Space Flight Center in Maryland. The robotic portion of ARM is targeted for launch in 2021, but the mission's fate is in the hands of the new Congress.