

Building a better microscope

A bold proposal

NASA, industry weigh the dilemma

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War on wiring

Your smart TV doesn't need data wires, so why do airliners need tons of them? Meet the researchers who don't think they do.

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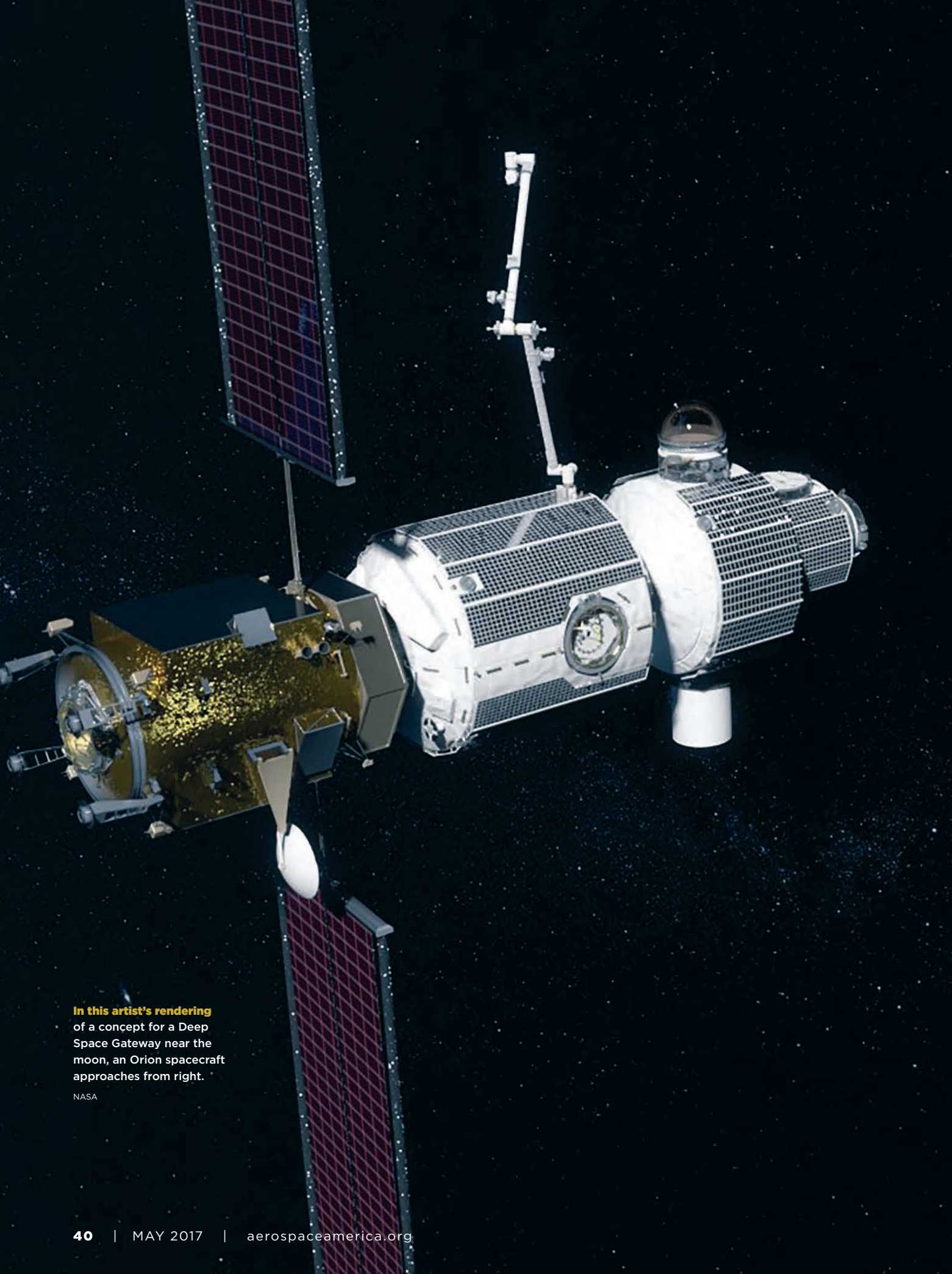
SPECIAL REPORT: DRONES

Sense and avoid; traffic management; market forecast

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Shaping the Future of Aerospace



In this artist's rendering of a concept for a Deep Space Gateway near the moon, an Orion spacecraft approaches from right.

NASA

STRATEGIZING ABOUT MARS

BY TOM RISEN | tomr@aiaa.org

Little consensus exists among scientists and policymakers about the best strategy for getting humans into orbit around Mars and someday to the surface. The Trump administration and a re-established U.S. National Space Council are expected to take yet another look at a possible role for the moon in the Mars strategy. **Tom Risen** spoke to NASA's Bill Gerstenmaier, Mars exploration visionary Robert Zubrin and others about their views of the best path ahead.

The far side of the moon never faces Earth but it gets two weeks of sunlight during each of its synchronous rotations. This would give astronauts riding in one of NASA's forthcoming Orion capsules an opportunity to tele robotically pilot rovers on the surface while also proving the performance of equipment including communications, life support and other technology in anticipation of a voyage to Mars orbit. The crew, perhaps in the 2020s, could do all this with little propulsive energy by orbiting around a position 65,000 kilometers from the moon known as a Lagrange point, one of the gravitational sweet spots between planetary orbits, in this case between the gravity of Earth and the moon.

This was one of the visions proposed before the inauguration by then-President-elect Donald Trump's NASA transition team. For some space watchers, a mission like this or a proposal to swing astronauts around the moon in an Orion capsule as early as 2019 would be a stroke of genius. These bold steps could be taken relatively soon while still holding as the ultimate goal a journey to Mars orbit and eventually the surface. Others fear that putting astronauts in an Orion capsule on an untried Space Launch System rocket could be a deadly distraction and that any near-term focus on the moon could squander the funds needed to reach Mars during what they see as a unique window of American public interest in such a mission.

This is the tradeoff that the Trump administration must weigh in the months ahead as it puts its brand on NASA's human exploration strategy.

Conversations about whether the moon or Mars should be the first priority are not new for space policy experts. Similar debates played out fiercely during the George W. Bush and Obama administrations. For now, NASA's long-term goal remains nearly identical to the Obama administration's, which is to have humans depart on a mission to orbit Mars by the early 2030s.

It's fallen to NASA's Bill Gerstenmaier, associate administrator for human exploration and operations, to make peace between the camps.

"It's a false discussion to talk about destinations," says Gerstenmaier. "We are really moving human presence in the solar system." In his view, every mission or contract should be approached with the thought of how it would help NASA build deep space travel capability.

He wants NASA and its contractors to target the equipment that will be required no matter the desti-

nation. Current NASA thinking calls for setting up a Deep Space Gateway in lunar orbit, a spaceport that would be tended by crews who would arrive in Orion capsules and stay for up to 42 days to hone techniques and innovations for the trip to Mars. NASA aims to launch several pieces to assemble the gateway: a propellant bus so it could move to different orbits, followed by a habitat module, an airlock, and one or more logistics modules where astronauts could conduct scientific experiments. When completed, it would be smaller than the International Space Station. Eventually, one of the visiting crews would depart from the gateway toward Mars orbit inside a Deep Space Transport, a spacecraft propelled by chemical engines and solar electric propulsion that could be home to four astronauts for up to 1,000 days. NASA would launch the transport from Earth toward the gateway on a Space Launch System rocket.

Public-private cooperation

One point all seem to agree on is that private companies should play a far greater role in reaching Mars than they did in building and operating the space station. Jack Burns, an astrophysicist at University of Colorado who was a member of the NASA Trump transition team, suggests that companies including Blue Origin and SpaceX could sell cargo launches and other services to NASA. This way, the agency would not have to do these tasks on its own, which would free up resources for NASA to explore Mars or perhaps land humans on the moon again, something that was not in the Obama plan.

Some in the industry are eager for this larger role. United Launch Alliance, the joint venture of Boeing and Lockheed Martin that makes the Atlas and Delta rockets, in February hosted a workshop



Deep space strategy

Lagrange points are positions in the orbits of two large celestial bodies, such as the Earth and moon, where a smaller object can stay in a stable orbit while expending little fuel. The Trump administration is reviewing a proposal from its pre-inauguration NASA transition team to place an Orion capsule at Lunar Lagrange point 2, or LL2, where astronauts could stay in contact with Earth while remotely piloting rovers on the moon's surface. Space contractors have also discussed LL1 as a potential location for commercial projects like deep space manufacturing.

Source: NASA and Aerospace America research

to discuss potential commercial projects and infrastructure development in what ULA calls a CisLunar Marketplace. Representatives from universities, NASA and space contractors discussed potential projects, including solar energy collection, lunar prospecting and deep space manufacturing, says Burns, who attended. [Read more: "Toward a Cis-lunar Marketplace," Page 18]

Burns says work like this closer to Earth will be critical. "The American public is not going to wait 20 years to develop a pathway to Mars, their interest is going to wane," he cautions. "Developing space infrastructure around the moon gets us something tangible to show people we are on that track. The economics have changed in the last decade, so NASA doesn't have to do this all on its own."

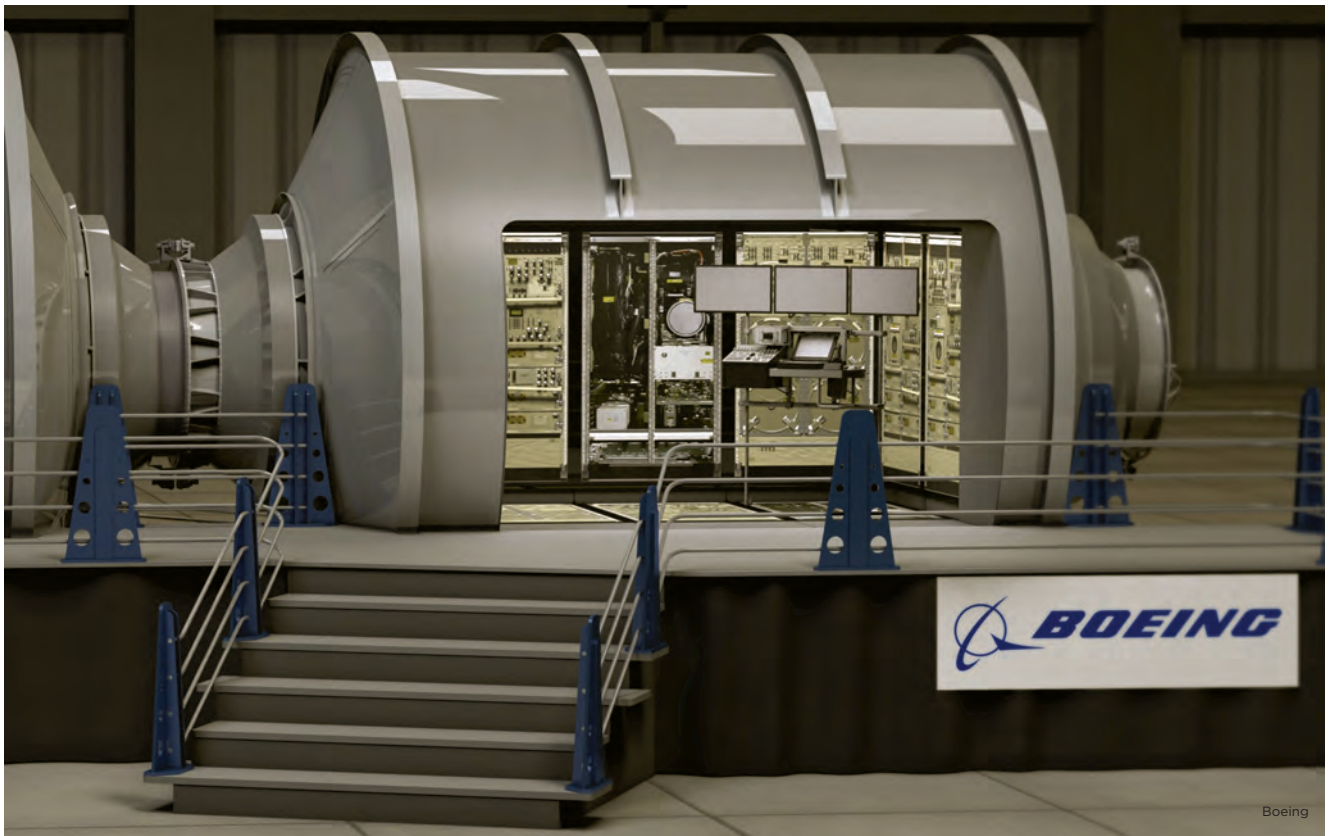
In 2013, Burns and his University of Colorado team set up a lunar surface obstacle course at NASA's Ames Research Center in California. Astronauts aboard the space station controlled a rover on the course to simulate steering it from lunar orbit.

Prudence

NASA expects to complete a study before June about whether to add a crew of two on Exploration Mission-1, which would be the first launch of a Space Launch System rocket. The current plan calls for launching an Orion loaded with instruments rather than a crew for a three-week round-trip mission that would include orbiting the moon for several days. The Trump administration and Acting NASA Administrator Robert Lightfoot asked NASA in February to look at the feasibility of a crew option.

Considerations include whether an initial flight without a crew could encourage more rigorous testing to include precision maneuvers, deep space navigation and heat shield tests. On the downside, in addition to the risks of putting a crew on the first launch of a new kind of rocket, crew safety preparations would push the launch to mid-2019.

As risky as it might sound, the crew option does have supporters. One of them is former astronaut Leroy Chiao, who commanded the space station in



▲ This is an artist's rendering of a ground prototype that Boeing is developing as part of NASA's program to test deep space habitats.

2004 and 2005, and is a member of the Human Exploration and Operations Committee of the NASA Advisory Council. He argues that the initial flight of the capsule and rocket around the moon would have little technical benefit besides a test run, so he advocates including a crew, if funding allows.

"It would have a much bigger impact on public opinion if we launched EM-1 with a crew on board because it would be the first time humans leave Earth's orbit since 1972," Chiao says.

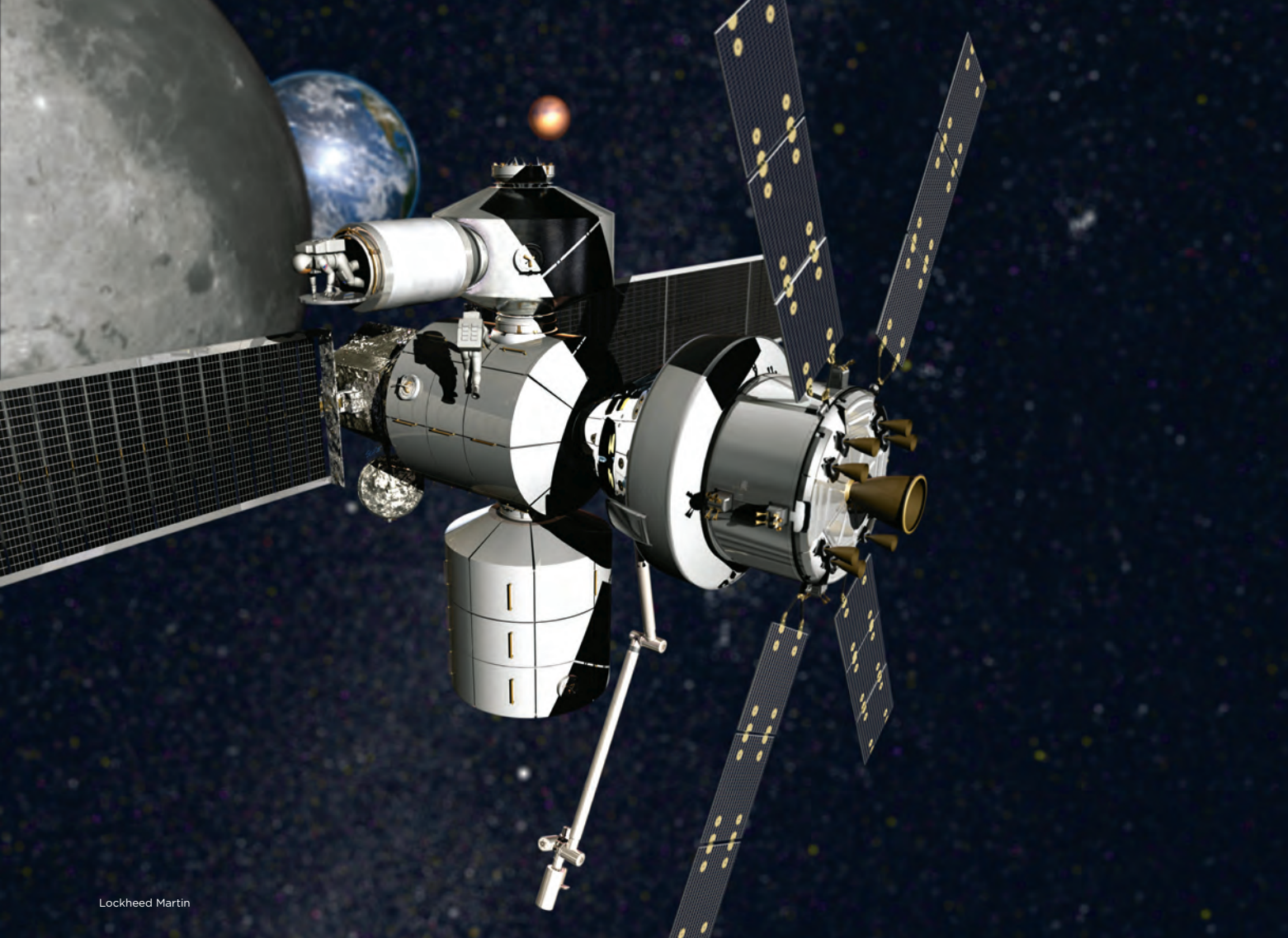
If NASA's timetable remains unchanged and humans are not sent on the first flight of the Space Launch System, astronauts will be launched on Exploration Mission-2 by 2023 to orbit the moon. After EM-2, NASA wants to launch an SLS and Orion with a crew and cargo to lunar orbit each year to begin building the gateway.

Prudence also figures into the broader discussion of a possible role for the moon on the way to Mars, a staggering 225 million kilometers away. If something went wrong with equipment that far from Earth, astronauts would be in a tough spot during the up-to-eight-month journey home. By contrast, if the Trump administration elected to land astronauts on the moon again, astronauts could return in three to five days in an emergency. At the moon, humans could test their on-site, or in-situ, resource utilization skills with less risk than trying them for the first time on Mars.

For some, the moon is an exciting place once again now that scientists are confident it holds water ice in the shade of at least some of its craters and might also have water beneath its surface. In 2009, NASA intentionally directed the Lunar Crater Observation and Sensing Satellite and a rocket stage to crash into a lunar crater. Scientists reported detecting water in the resulting plume. If NASA were to send astronauts to the surface, they and their robotic helpers could conduct a survey to identify a suitable location for a lunar base. A mining operation could be set up to create drinking water or rocket propellants, providing a supply line outside of Earth's orbit to support space travel.

The drawback to including the moon in the Mars plan would be that establishing a human presence on the surface would take years. The European Space Agency has expressed interest in building a lunar lander, but so far not NASA. Gerstenmaier says landing on the moon is "not necessary" for the journey to Mars despite the long-term potential of a base on the surface. An ideal lander would be reusable, but the difference in gravity between Mars and the moon would make it difficult to build one capable of safely landing on both worlds. It also would take time to design and build a durable lodging for astronauts with amenities like oxygen filters and heat on the airless moon.

"I would rather build the Deep Space Transport than go back to the surface of the moon," Gerstenmaier says.



Lockheed Martin

The Deep Space Transport, which NASA would launch from Earth in several pieces and dock with the gateway, would carry food, sanitation, exercise and science gear for a trip to Mars and back that could last up to three years. The transport, which could be reused for three missions to Mars, will likely include a combination of chemical propulsion and solar electric propulsion. Once completed in 2029, a crew of four astronauts would fly a test mission on the transport for up to 400 days near the moon.

To Mars or bust?

SpaceX CEO Elon Musk is among those who are impatient for a bigger commitment to travel to Mars, and he expressed his frustration in a Twitter post about Trump's proposed 2018 budget that would not increase NASA funding. "Perhaps there will be some future bill that makes a difference for Mars, but this is not it," Musk wrote.

Critics say the underlying problem with NASA's exploration strategy is that the agency has ordered construction of specific technologies, including Orion, and now it is trying to decide how to use them.

Better, they say, would be to decide on a detailed exploration plan and develop the equipment needed for it. One of the critics is Robert Zubrin, president of the Mars Society, a nonprofit dedicated to furthering the exploration of the red planet.

"We do not need a lunar orbit base camp for any purpose other than to spend money on a lunar orbit base camp," Zubrin argues. "There is some interest in a return to the moon. I think this could work if the program was a parallel moon-Mars program."

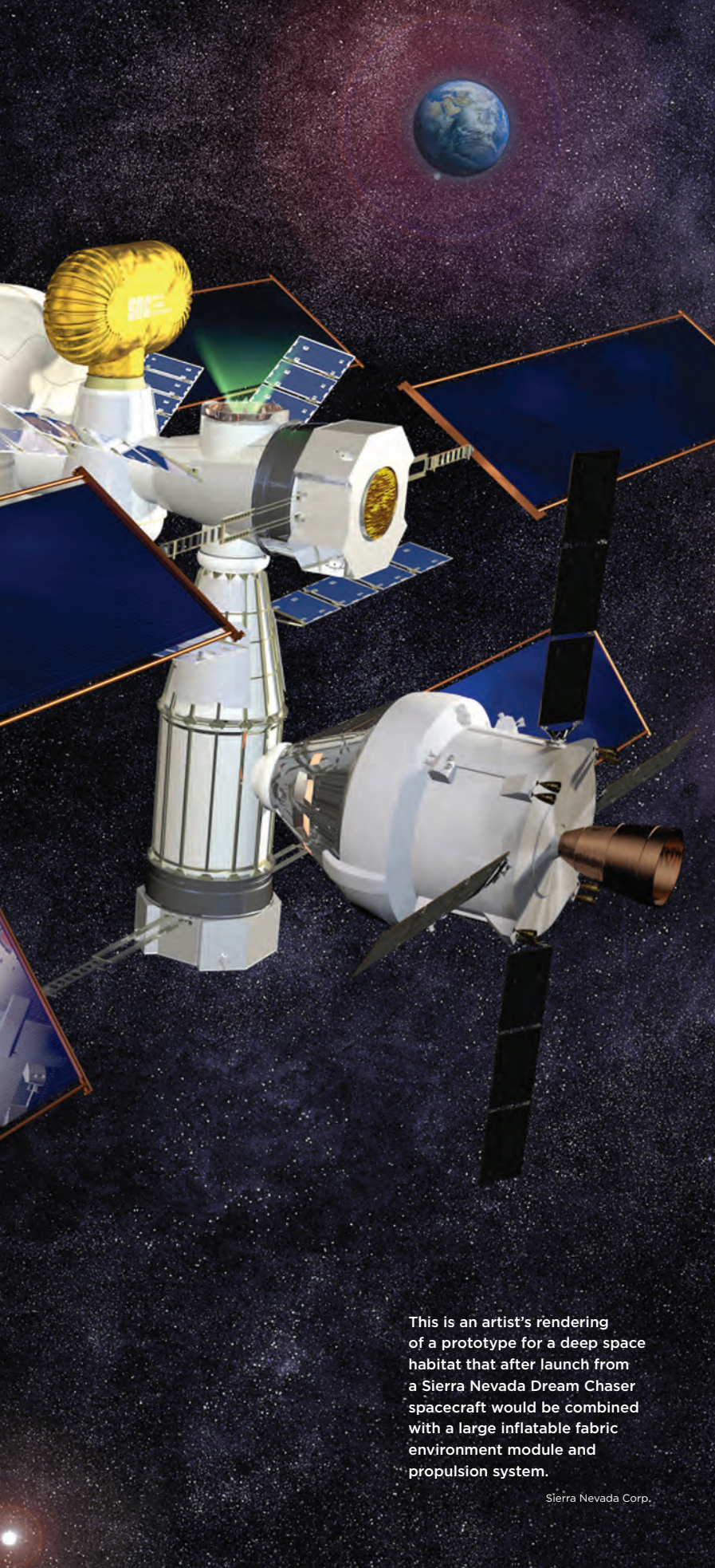
Returning humans to the moon's surface by 2020 as a proving ground for Mars was the goal of the Constellation program started in 2005 by the George W. Bush administration. Unlike the Space Launch System rockets that would launch crews and equipment into space, in the Constellation program NASA envisioned an Ares rocket that would launch only the Orion capsule. President Barack Obama in 2010 canceled Constellation, stating in his proposed budget for 2011 that the program was too costly, "behind schedule, and lacking in innovation." NASA was told to continue work on Orion and scrap Ares to begin work on the Space Launch System.

▲ Lockheed Martin plans to refurbish a multipurpose logistics module, seen in an artist's rendering, into a habitat prototype under NASA's Next Space Technologies for Exploration Partnerships, or NextSTEP.

A satellite with large blue solar panels is shown in space. In the background, the cratered surface of the Moon is visible against the blackness of space. The satellite has a white cylindrical body with 'SNC' and 'SINERGA NEVADA CORPORATION' printed on it. An astronaut is visible on the satellite's exterior.

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— JACK BURNS, FORMERLY OF THE
TRUMP TRANSITION TEAM.



This is an artist's rendering of a prototype for a deep space habitat that after launch from a Sierra Nevada Dream Chaser spacecraft would be combined with a large inflatable fabric environment module and propulsion system.

Sierra Nevada Corp.

Constellation is not the only example of how new presidencies can change space priorities. The Asteroid Redirect Mission could become the latest program to meet the chopping block. Trump's proposed 2018 budget would cut NASA's plan to move part of an asteroid closer to Earth so astronauts could study it. The plan has failed to gain broad enthusiasm among congressional Republicans and Democrats, some of whom have cited it as an example of a mission that distracts from the goal of reaching Mars.

Cutting red tape

The Trump administration thinks it can free up funds for Mars by improving the space bureaucracy's efficiency. That will be one role for Vice President Mike Pence and the National Space Council that he will chair. This executive branch board, created in 1958, has been defunct since 1993. The council had successes, including brainstorming the Kennedy administration's plan to send humans to the moon. Presidents eventually came to ignore it as another level of bureaucracy.

The Trump administration says things will be different under Pence. "The administration looks forward in the months ahead to further detailing the President's goals for the National Space Council, NASA and the private sector interests that are engaging in commercial spaceflight and expanding our understanding of the universe," says an email from Marc Lotter, press secretary for Pence.

Rep. Jim Bridenstine, R-Okla., considered the front-runner to be NASA's next administrator, discussed the council during a speech at the Washington Space Business Roundtable luncheon in March. He praised the council as a chance to make U.S. space business more competitive by streamlining contracting, and he cited China's ambition to send robotic rovers to the far side of the moon.

"You think of all the different stovepipes that exist already," Bridenstine said of federal space operations. "You can't figure out who is in charge of anything."

Gerstenmaier says the council would need to influence the budget process and policymaking of Congress and contractors to be significantly effective in assisting with NASA's deep space missions.

"We have enough people giving us guidance," Gerstenmaier says.

Political will for space travel is hard to maintain even during the best of times, so Gerstenmaier says inspiring people is not a sufficient reason to do a mission. Politicians during the 1960s debated ending the Apollo program before the first moon landing happened with Apollo 11, for instance, despite public interest in the space race with the Soviet Union.

Gerstenmaier often hears people say, "If we just had a compelling vision, this would all be sold." He disagrees: "I don't think that's the case." ★