



Outgoing NASA Team Leaves Its Successors With Robust Options for Space Exploration

By Rudy deLeon, Peter Juul, and Stefanie Merchant February 9, 2017

Today, a new generation of Americans looks to space and wonders where America will go next. Over the past eight years, NASA has laid the foundation for renewed American space exploration leadership under Charles Bolden, who stepped down as the agency's administrator on January 20.¹ Although the space shuttle fleet has been retired, NASA has begun to field new capabilities that will take Americans back to Earth orbit, the moon, and beyond.

Bolden leaves his successor at NASA a full range of capabilities and policy options. America's space agency has also reached out to private-sector entrepreneurs to develop commercial space capabilities to ferry astronauts to and from the International Space Station. And along with investing in the future of human space exploration, the United States has maintained a robust robotic space exploration program as well.

Indeed, America is better positioned today to embark on a big and bold program of human and robotic exploration than at any time since the end of the Apollo program. Despite tight budgets, NASA has invested in key building blocks—such as the Space Launch System, or SLS, and the Orion crew vehicle—that will come online during the current presidential administration. But these investments will only pay off if America sticks to the plan that NASA, Congress, and the Obama administration had collectively put together.

This hard-forged consensus will unravel, however, if the Trump administration changes course by initiating another high-level review of space exploration policy. Instead of commissioning another blue-ribbon panel, the current administration's NASA team should build on the progress made under Bolden. There is no need for the new NASA team to throw away eight years of hard work and investment just as America develops the capabilities necessary to send astronauts where they have never gone before.

America's space program at the end of the Obama years

NASA is ready for an ambitious, next generation program of space exploration. Even as the United States prepares to once again launch astronauts into orbit from the Kennedy Space Center in Florida, American astronauts—two as of January 2017—still remain on the International Space Station.² Astronaut Scott Kelly's year on board the station, which ended when he returned to Earth in March 2016, will help NASA better understand the physiological and psychological stresses of long-term spaceflight. Moreover, the Hubble Space Telescope continues to beam down breathtaking images of the cosmos after a quarter-century—and four repair missions—in orbit. Finally, 10 robotic explorers plumb the depths of the solar system, from Mars to Pluto and beyond.

These accomplishments are impressive, but NASA has not rested on its laurels over the past eight years. Despite a difficult transition period and tight budgets below those of previous decades when adjusted for inflation, NASA has made significant progress toward human exploration missions beyond the moon. Building on the solid bedrock of President Barack Obama's 2010 National Space Policy directive, Congress' NASA Authorization Act of 2010, and NASA's own 2015 Journey to Mars report, the space agency has made investments in new capabilities such as the Space Launch System, the Orion crew vehicle, and the Commercial Crew Program. With support and encouragement from NASA, new space entrepreneurs such as SpaceX, Bigelow Aerospace, and Blue Origin will soon bring their own capabilities and systems to the aerospace market. These investments will bear fruit in the coming years—but only if the Trump administration sticks to existing plans.

Progress toward Mars

In recent years, and with the solid support of Congress, NASA has made slow but steady progress on the two main components of any human exploration beyond the moon: the Space Launch System rocket and the Orion crew vehicle. Already, Orion has had a successful uncrewed test flight—Exploration Flight Test-1—in December 2014.³ Work is well underway on the next Orion vehicle, slated to be on the first SLS launch in late 2018. In another uncrewed flight dubbed Exploration Mission-1, or EM-1, Orion will spend six days in lunar orbit to test capabilities critical to future missions with astronauts.⁴

Development of the SLS rocket that will send Orion on EM-1 has also proceeded apace. Testing is well under way on key SLS components such as the solid rocket boosters and the RS-25 engines that will power the rocket.⁵ Moreover, NASA's

TABLE 1
NASA robotic exploration missions currently in progress

Mission name	Launch year	Destination
Cassini	1997	Saturn
Mars Odyssey	2001	Mars
Opportunity rover	2003	Mars
Mars Reconnaissance Orbiter	2005	Mars
New Horizons	2006	Pluto and Kuiper Belt
Dawn	2007	Asteroid Vesta and dwarf planet Ceres
Juno	2011	Jupiter
Curiosity rover	2011	Mars
Mars Atmosphere and Volatile Evolution, or MAVEN	2013	Mars
OSIRIS-REx	2016	Asteroid Bennu

Source: NASA.

Marshall Space Flight Center in Alabama has finished construction of the test stand for the largest SLS fuel tank.⁶ If all goes well, an SLS rocket will launch for the first time in fall 2018—with an uncrewed Orion on top.⁷

According to the current plan, astronauts will fly on Orion and SLS for the first time during Exploration Mission-2, or EM-2, as early as August 2021. Indeed, NASA has already outlined the mission profile for EM-2: Four astronauts will travel in an elliptical orbit before heading for a slingshot around the moon and returning to Earth. When they swing around the moon, the EM-2 astronauts will travel farther into space than anyone since the final Apollo mission in 1972.⁸

Commercial Crew Program and the International Space Station

At the same time, work on the Commercial Crew Program intended to return the launch of astronauts to American soil has proceeded apace. NASA has already awarded contracts to Boeing and SpaceX to fly astronauts to and from the International Space Station.⁹ But human spaceflight remains a difficult and challenging endeavor, and spacecraft development delays mean the United States is likely to launch astronauts from the Kennedy Space Center by May 2018 at the earliest.¹⁰ Despite these delays, real progress has been made toward returning astronaut launches to the United States early on in the new administration.

However, these delays also mean the United States will have to rely on Russia to send astronauts to and from the International Space Station for at least another year. The United States and its international partners will continue to operate the station until at least 2024 thanks to the Obama administration's 2014 decision to extend its lifespan.¹¹ By the end of 2016, America's International Space Station partners—Russia, Canada, Japan, and the European Space Agency—had all agreed to extend the station's time in orbit.¹² Maintaining the International Space Station well after its designed 15-year service life will be a challenge, but it will keep Americans in orbit as Orion and the SLS come online. It will also give NASA the opportunity to test new technologies and conduct further research on the psychological and physiological effects of long-duration spaceflight.

Lingering questions: Asteroid Redirect Mission, planetary science, and sequestration

Despite this progress toward new human spaceflight capabilities, NASA faces lingering questions about critical components of America's space exploration program. Amid heavy skepticism from Congress, NASA has started work on a two-phase Asteroid Redirect Mission, or ARM.¹³ By 2021, NASA plans to launch a robotic mission to retrieve a boulder from a nearby asteroid and redirect it into orbit around the moon.

Sometime around 2026, astronauts aboard an Orion spacecraft will rendezvous with and explore this boulder. NASA argues that ARM is necessary to develop and test new technologies such as solar-electric propulsion that are necessary to send astronauts beyond the moon.¹⁴ But critics argue that these technologies can be developed without adding the cost and complexity of asteroid retrieval.¹⁵ The debate over ARM remains open, and its fate will be one of the first major decisions facing the new administration's NASA team.

Moreover, NASA's robotic exploration program has suffered from limited funding in recent years. Given the long lead times required to pull together robotic exploration missions—the Juno mission to Jupiter, for instance, was selected in 2005, launched in 2011, and arrived at its destination in 2016—lower budgets ensure that NASA starts work on fewer of these missions.¹⁶ The decline in robotic exploration missions also jeopardizes NASA's ability to adequately prepare for human expeditions to Mars and other destinations beyond the moon. Without adequate robotic infrastructure to relay communications back to Earth and survey the Martian environment, NASA will be forced to either delay current plans for a 2030s Mars mission or take greater than necessary risks with astronaut safety.

Finally, tight and uncertain budgets have limited NASA's ability to plan effectively for the future. Thanks to sequestration and other fiscal fights, NASA's budget declined from just more than \$18.7 billion in 2010 to less than \$16.9 billion in 2013—a cut of more than \$3.1 billion when adjusted for inflation.¹⁷ Budgetary pressure contributed to the Obama administration's decision to back out of cooperation with the European Space Agency's ExoMars robotic exploration program.¹⁸ The Europeans, in turn, went to Russia to help build and launch their spacecraft. Despite general public and congressional support for NASA and its mission, the stability and sustainability of its budgets remains an open question as the new administration's NASA team takes charge.

Moving forward

Stick to the plan

In spite of these lingering questions, the next NASA team will inherit a solid foundation for space exploration from former administrator Bolden. Orion and the Space Launch System will give NASA the ability to send astronauts farther than any human has ever gone before, while the Commercial Crew Program will return astronaut launches to American soil. America and its partners will maintain the International Space Station in orbit until at least 2024, and NASA's robotic exploration budget has recovered from deep cuts in recent years. In short, America's space program no longer stands at an uncertain crossroads and is poised to reassert American leadership in space.

But this foundation will crumble if the new administration hits the reset button on America's space exploration program. Instead of commissioning yet another time-consuming, high-level study of America's human spaceflight program that forces NASA to change direction, the Trump administration should build on the bipartisan consensus achieved by Congress and the Obama administration in 2010. This consensus set Mars as America's long-run human space exploration goal and provides a solid space policy framework for the United States.

This framework leaves plenty of room for the new administration to put its mark on America's human space exploration program—without ripping it up at the roots. NASA's report, titled "Journey to Mars," for instance, provides a flexible, three-phase concept for progress. The first phase, which includes Scott Kelly's recent year-long mission on the International Space Station, tests the capabilities necessary for deep space exploration in low-Earth orbit. Next comes what NASA calls the "Proving Ground" phase, in which astronauts will learn how to live and work in the deep space around the moon. Finally, the "Earth Independent" phase will culminate in a human voyage to Mars.¹⁹

Fortunately, Congress appears to understand the importance of continuity in space exploration policy. Before the 2016 election, for instance, Sens. Bill Nelson (D-FL) and Ted Cruz (R-TX) introduced legislation that reaffirmed the bipartisan consensus on Mars as the next goal for America's human space exploration program.²⁰ This bill shows that members of Congress can work across party and ideological lines to ensure that the United States sticks to its own space exploration plan.

Cooperation across party and ideological lines will also be necessary to ensure that NASA receives sufficient and stable support moving forward. In particular, NASA should receive additional funding for the Orion and SLS programs, which are critical parts of any deep space exploration mission. This financial cushion can reduce the risk of budget-driven delays to both programs and help make sure that Exploration Mission-1 and Exploration Mission-2 launch according to NASA's current plans. In addition, robotic exploration—funded through NASA's Planetary Science Division—should be increased modestly to levels necessary to maintain the robotic infrastructure on and around Mars while meeting the congressionally mandated goal of launching a mission to Europa by 2023.²¹ Without the infrastructure and information these robotic explorers provide, future human expeditions beyond the moon will be more hazardous than necessary.

Work with international partners

At the same time, the new NASA team should identify and reach out to potential international partners for missions in the Proving Ground around the moon. This outreach should include traditional NASA partners such as Japan, Canada, and Europe while expanding to new players, including South Korea and India. By working with interna-

tional partners, NASA maintains and strengthens the global network of international scientific and engineering relationships it painstakingly forged over decades. Since the United States remains the only nation with the financial capacity and technical capability to carry out a robust program of space exploration, this network also ensures that the United States remains the global leader in space.

While NASA invites new and traditional partners to join Proving Ground missions, it should maintain the dialogue with China that has been established in recent years. Right now, the prospect of full-blown cooperation with Beijing on space exploration remains remote. But the recent cooperation agreement on air traffic control between NASA and the Chinese Aeronautical Establishment shows how incremental progress toward a more cooperative relationship in space could be made.²²

However, numerous political obstacles prevent cooperation with China in space. Here in the United States, Congress restricts NASA's ability to cooperate with China for a variety of valid reasons.²³ Even without legislative restrictions, the absence of a clear division between China's military and civil space programs would likely inhibit cooperation with NASA. Nonetheless, the United States has a significant national security interest in gaining insight into China's aerospace industry—insight that could be gained through incremental cooperation on space exploration.

The primary goal of any cooperation between NASA and China's space agencies should be to encourage China to clearly separate its civil space activities from its military space program—as the United States did with great success when President Dwight Eisenhower established NASA in 1958. There are two potential avenues for cooperation the United States could offer to induce these changes in Chinese behavior. First, the United States could invite Chinese scientists to contribute a scientific instrument to an upcoming robotic exploration mission. This sort of limited collaboration would allow the United States and China to work together on scientific and engineering processes.

Second, the United States should hold open the prospect of a Chinese spacecraft visiting the International Space Station. Such a visit has already been suggested by the European Space Agency and would require American and Chinese engineers to work together on the development of a common docking system.²⁴ This sort of limited cooperation would allow the United States and China to build confidence and trust in one another and work with other International Space Station partners. While the national security risks of a Chinese visit to the International Space Station are minimal, the gains—a look into China's aerospace industry and the separation of China's civil and military space programs—could prove substantial.

Conclusion

After eight years in office, NASA Administrator Charles Bolden leaves his successor the foundation for a rejuvenated—and realistic—space exploration program. Investments in new capabilities such as Orion and the Space Launch System will bear fruit in the coming years, allowing NASA to send astronauts farther than has been possible since the end of Apollo. Equally important, a new consensus on America’s next human space-flight goal—Mars—has emerged and solidified.

But American astronauts are not likely to reach Mars unless the new administration and its NASA team resist the temptation to hit the reset button on America’s space exploration program. Instead of commissioning yet another time consuming, high-level study of America’s space exploration program that forces NASA to change direction, the Trump administration should build on the bipartisan foundation that’s been laid since 2010. Another disruptive shift in NASA’s goals would jeopardize both this foundation and America’s leadership in space exploration.

For its part, Congress should reaffirm this consensus and provide NASA the resources necessary to build on the progress of the past eight years. Thanks to Bolden and his team’s leadership and bipartisan cooperation in Congress, the new administration and its NASA team will inherit a solid space exploration foundation on which it can build.

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