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NASA's plan to visit an asteroid faces rocky start

Keystone US human spaceflight mission for the next decade may be over before it begins.

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Asteroid Redirect Mission
This concept animation shows notional crew operations during NASA's proposed mission.

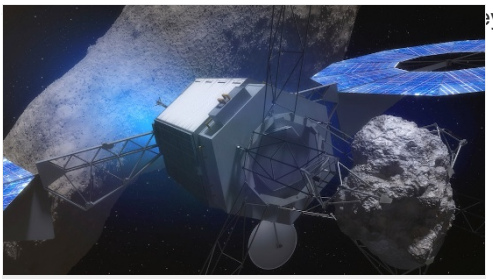
NASA's next vehicle designed to carry astronauts to space is set to launch early next month atop a trusty Delta 4 rocket for a crewless test flight. Current plans call for a piloted flight in the new Orion spacecraft in the mid-2020s, when the vehicle will ride atop a new NASA heavy-lift rocket to take astronauts beyond Earth orbit for the first time in a half-century. What's far less certain in the post–space shuttle era is where they'll go from there.

If the Obama administration and NASA have their way, the astronauts will be visiting a small asteroid that will have been nudged by a solar-powered robotic probe into a high, stable lunar orbit. During the monthlong mission the astronauts will rendezvous with the asteroid, perform spacewalks to gather samples and then return to Earth. The target asteroid has yet to be announced and a robotic space tug has yet to be built but NASA hopes to have the space rock relocated to the moon's vicinity as soon as 2021.

NASA calls this complex concept the Asteroid Redirect Mission (ARM) and bills it as the first crucial step toward human missions to Mars in the 2030s.

Others aren't so sure. In June of this past summer the National Research Council issued a report stating ARM could "divert US resources and attention" from more worthy missions. A month later NASA's Advisory Council criticized ARM as a "dead-end element" on the path to Mars. The harshest criticisms of all surprisingly came from asteroid scientists who voiced their discontent via statements from NASA's Small Bodies Assessment Group, calling ARM's science "not compelling". Mark Sykes, director of the Planetary Science Institute, blasted ARM in September while testifying to a congressional committee, saying that NASA's cost estimate of less than US$1.25 billion for the robotic component of the mission "strains credulity".

"I'm not a big fan of human space exploration as performance art, which is what ARM is," Sykes says. "Because the problem with performance art is that your next trick has to be bigger than your last trick — and that quickly gets unsustainable. ARM will never be



NASA

One option would involve sending a robotic probe to snatch a piece of rock from a large asteroid.

ey. It doesn't advance anything and everything that could benefit from it could be benefited far more by other, cheaper, more efficient means."

Michele Gates, NASA's program director for ARM, says that the mission concept is meeting its developmental milestones and that an independent cost assessment study is underway. She and other NASA officials note that the advanced propulsion required for ARM would be enabling technology for a broad range of future missions and that ARM would be a crucial test for many deep-space activities crucial for someday reaching Mars. And it would do all this while keeping astronauts sufficiently close to home so that if something goes wrong, they could attempt an emergency return to Earth.

"Last year, when the National Research Council released their report, we had very little detail on the ARM concept while their technical panel was doing their analysis," Gates says. "Given the amount of work that has been done in the past year, and the positive reception we've received from so many communities to our most recent sharing of results, I would encourage everyone to look at the latest data."

ARM's fortunes now appear more fragile than ever, and its fate may have already been sealed by this year's midterm elections, in which Republicans opposed to the mission took control of Congress. Still, NASA plans to conduct a formal review of the ARM concept in February 2015, and the Obama administration's next budget proposal is expected to request more funding for ARM, its signature effort in human spaceflight.

One basic concept helps explain how we got here, where ARM came from and why it has such a large and diverse set of critics: inertia, the tendency for things at rest to stay that way, and for things in motion to keep moving at a constant speed and heading.

In rocketry the effort required to overcome inertia, to change velocity and trajectory, is called delta-V. It's usually measured in metres or kilometres per second and you usually get it by firing propellant out of your engines. More delta-V lets you move larger objects at higher speeds to a wider variety of places but getting enough to send astronauts to land on a planet or a moon typically requires big, budget-busting rockets. Visiting smaller bodies like nearby asteroids and comets can be easier, because such trips often require less delta-V.

NASA and its rocket programs have inertia, too, but their trajectories are changed only through heavy expenditures of that most elusive propellant, political capital. One might call it delta-P.

President George W. Bush tried to change NASA's course with the Constellation Program, which promised to retire the space shuttles and build new rockets and spacecraft to take astronauts back to the moon and beyond. But his administration exhausted its delta-P with a costly war in Iraq. Plagued by budget problems, the program was seen as unsustainable by incoming President Barack Obama, who expended some delta-P of his own by canceling Constellation in 2009. Instead of immediately returning to the moon or going directly to Mars, Obama's NASA would focus on pursuing advanced propulsion technologies that could provide more delta-V for less money, using missions to unspecified locations in deep space as their proving grounds.

Inertia had other ideas. If Constellation disappeared, billions of dollars of contracts and thousands of jobs could vanish with it. Influential senators and representatives accused Obama of destroying NASA by canceling Constellation and providing no alternative destinations and deadlines. Faced with bipartisan congressional opposition the administration chose to preserve Constellation's crew vehicle, Orion, and grudgingly accepted the development of the Space Launch System, a rocket program eerily similar to Constellation's. But even so, senior Obama administration officials believed the president could still salvage his earlier proposals by announcing a new destination for NASA's astronauts and a timetable for reaching it.

The announcement came during an April 2010 speech at the agency's Kennedy Space Center near Cape Canaveral, Florida, where Obama pledged to send astronauts to an asteroid by 2025. There was only one problem — the agency was short of delta-P and delta-V. A major, politically untenable increase to NASA's budget seemed to be the only way to accelerate the development of rockets and life-support systems capable of sending astronauts on a months-long journey to a far-off asteroid by Obama's deadline.

Through a series of commissioned studies the agency began investigating whether instead of sending astronauts to an asteroid it could send an asteroid to the astronauts — perhaps on the International Space Station, in high Earth orbit or even around the moon.

The feat seemed possible, provided NASA could develop an advanced solar-electric engine. Although weaker than chemical rockets in terms of thrust, such an engine could sustain thrust for years, delivering a shift in delta-V great enough to retrieve a near-Earth asteroid.

The crucial work supporting this approach appeared in 2012, in a report produced by Caltech's Keck Institute of Space Studies. According to that study, for some $2.6 billion a robotic tug could rendezvous with a seven-metre, 500,000-kilogram asteroid, capture it in a deployable bag and push it into high lunar orbit by 2025 — that is, in time for astronauts to visit it to meet the president's deadline. One of the study's leads, Planetary Society co-founder Louis Friedman, presented the results to Lori Garver, then NASA's deputy administrator, who shared it with Bill Gerstenmaier, head of NASA's human spaceflight efforts. With support from NASA's top brass, the White House hesitantly gave its approval.

From this awkward timeline, ARM was born, albeit in slightly altered form: NASA revised the estimated cost downward by more than half and established two competing scenarios for delivering an approximately five-metre-wide object to high lunar orbit: option A — a grab-and-bag mission similar to that studied by Friedman and colleagues; and option B — use a robotic arm to pluck a small boulder off a larger asteroid. NASA plans to choose between these options this December.

The widespread criticism began after ARM was publicly disclosed in April 2013 and has continued unceasingly. Whether from hopeful astronauts wanting to return to the moon or go to Mars, space scientists opposed to all government-sponsored human spaceflight, government accountants concerned by possible cost growth or congressional Republicans steadfastly opposed to any proposal from Obama, almost every key space policy constituency has found a reason to oppose the mission.

"What the critics don't seem to understand is that if we don't send humans to an asteroid that is moved closer to Earth, we will send humans nowhere for the foreseeable future, which means the next decade or two," Friedman says. "If we drop this mission, our planned rockets and crew modules can go out as far as the moon but we won't be able to land without investments that are frankly unrealistic right now."

ARM's harshest critics, asteroid scientists such as Sykes of the Planetary Science Institute and planetary scientist Richard Binzel of the Massachusetts Institute of Technology in Cambridge, remain unconvinced. "It's an empty threat to say if you don't take this thing that came from nowhere you'll get nothing and that will be the end of everything," Sykes says. "Well, you know, okay, fine — pull the trigger, guys. Maybe some people don't get the toy that they want but there are other options our leaders can pursue."

Sykes says he and many of his peers do want an asteroid mission; they just envision something far different and more transformative than NASA's deadline-driven ARM proposal. Some asteroids, Sykes notes, are rich with water ice that can be processed into rocket fuel, but he is skeptical that ARM will develop the technology required to use those valuable resources. He also believes astronauts need new, better technologies to perform tasks in outer space. His hopes for such an ambitious mission plunged, he says, when NASA's ARM team sent peacemaking envoys to a recent meeting of asteroid scientists in Washington DC.

"They were showing the jetpacks and spacesuits astronauts would wear to go to the bag that has the rock brought back to lunar orbit, and how they would interact with it," Sykes recalls. "I felt like we were looking at a Neolithic cave painting. Do we really want to grab an asteroid's surfaces with our fingers in gloves and examine them with eyeballs through a faceplate? They do surgery in Africa and mining in Brazil through telepresence. Let's do it on an asteroid. You'll have the sense you're there and you can perform delicate operations. You'll be able to observe across wavelength regimes and sensitivities far better than human."

Binzel's arguments stem more from simple statistics, which he highlighted in a recent op-ed in *Nature*. The sheer number of near-Earth asteroids now thought to be in native orbits amenable to low delta-V visits from astronauts, he says, obviates the need for an expensive redirect mission. It's better and cheaper, he argues, for NASA to look harder before it leaps. Binzel proposes the agency forget about the 2025 deadline in favor of first building a space telescope to map the near-Earth asteroids.

"By the time we would tow a tiny rock into lunar orbit, we'll be discovering more attractive, larger objects passing through the Earth–moon system that are easy to reach," Binzel says. "A retrieval mission gets you one asteroid, but a survey gets you thousands that you could potentially visit, at a much lower cost." At current rates of discovery, he adds, NASA will be breaking the law by 2020, when a congressionally mandated deadline expires for the agency to map 90% of potentially hazardous asteroids some 140 metres or larger in size. An asteroid-surveying telescope could solve that, too.

Lindley Johnson, program executive for the NASA Near-Earth Object Program, acknowledges that the agency is currently in danger of slipping its 2020 deadline for mapping hazardous objects and that Binzel is correct in pointing out that an adequate survey has yet to be performed.

Add it up and a grim conclusion seems inescapable: There is a very real possibility that by failing to first invest in finding ideal asteroids for human missions, NASA's prioritization of ARM could become a very expensive mistake. As has happened several times before, inertia and internecine conflict again seem set to send the agency's latest plans for human spaceflight tumbling into the void, boldly going nowhere.

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