NRC's "Pathway to Exploration" Should Start with Asteroid Redirect Mission

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The National Research Council Committee on Human Spaceflight this month completed its two-year study--*"Pathways to Exploration."* It found that "NASA can sustain a human space exploration program… *but only when* that program has elements that are built in a logical sequence, and when it can fund a frequency of flights sufficiently high to ensure the maintenance of proficiency…" (italics ours). Despite its rejection by the NRC Committee, we argue that the Asteroid Redirect Mission (ARM) is an affordable and logical first step in such a sequence. ARM is not only consistent with the NRC Committee's own principles, but is also the only near-term initiative that can shape their recommendations into a sustainable human space exploration program. ARM would launch U.S. explorers into deep space beyond the Moon, and fits logically into an exploration program aimed at Mars.

To human exploration advocates like us, the NRC panel report at first seems welcome: an endorsement of NASA's long-discussed humans-to-Mars goal. The Committee calls sending humans to Mars a "horizon goal," one that U.S. efforts should continuously point to and advance toward. The Committee also provided some valuable guidelines on how to organize and conduct the human space program, but the practical implementation of those guidelines depends on today's political, technical, and funding realities. Grappling with those space exploration realities is, unfortunately, an area where the Committee's report falls short. It advises that NASA not embark on a deep space initiative until consensus on the specific exploration sequence has been reached, and funding is in hand to deliver the necessary technology. In our view, waiting to venture into deep space until the nation reaches a consensus on when and how to go to Mars—and until all required funds are deposited securely in a Mars "lockbox"—will ensure the nation remains stalled in low Earth orbit. Coupled with other "real-Earth" realities, such as ISS retirement in the mid-2020s, more delay could quite possibly end U.S. human space exploration altogether.

The last high-level review panel to review human space flight plans, the Obama Administration's 2009 Augustine Committee, attempted to deal with budgetary and policy realities by introducing a "flexible path" toward Mars. That path recommended engaging, challenging milestones to be met as budget and real politics permit. Early, modest milestones would lead eventually to achieving a human presence on Mars.

The 2014 NRC Committee rejected the flexible path approach, restricting NASA's efforts to technical objectives they felt were directly related to the Mars goal. But the NRC's objectives are not always linked so directly to Mars. Worse, their pursuit is unlikely to garner enough public interest to sustain a decades-long push toward the horizon goal.

The key element of a successful deep space initiative must be sustainability—the ability to withstand the competing forces of Washington politics, competing space industry interests, and the rapidly shifting whims of public opinion. Sustaining a goal as grand and far-reaching as Mars is impossible without an overriding geopolitical rationale. Without a strong and long-lived rationale, government support over many decades will not materialize.

In the Space Age, we have seen just two successful examples of government support for human space exploration initiatives. Apollo was formulated and sustained as a Cold War initiative to demonstrate the superiority of the United States vis-à-vis the Soviet Union. The International Space Station was saved from cancelation only because it was recast as a program to engage and partially fund the post-Soviet, Russian aerospace complex, precluding weapons technology transfer to terrorist states.

Other attempts to win government support for human space exploration initiatives failed: The shuttle was approved by Nixon to avoid committing to any new space exploration goal; it later suffered from chronic funding shortfalls that reduced its capability. Space Station Freedom was initiated by Reagan to retain U.S. space leadership, but didn't build momentum until it found its post-Soviet rationale under the Clinton administration. George H.W. Bush's Space Exploration Initiative, to return to the Moon and go on to Mars, was dismissed by a skeptical Congress. The Moon-oriented Constellation program, proposed by the second President Bush, never received adequate funding. Its schedule slipped approximately two years annually until it was found to be "unsustainable" and cancelled by the Obama team. These failed programs had a common flaw: they all lacked a strong geopolitical rationale.

Similarly, there is today is no compelling geopolitical rationale for a human deep space push toward Mars. Lacking this essential ingredient, should the U.S. give up on its human space program? The answer is "No": an existing geopolitical barrier fortunately prevents that sad choice. No sane American politician would announce today that "It's time for our nation to abandon human spaceflight. Let other countries assume that mantle of technological excellence and carry that enterprise forward." However, that assurance is not permanent. NASA and its supporters

should push to energize public interest for long-term human exploration of deep space. ARM is an attractive vehicle to start building that sustainable momentum

The NRC Committee thoughtfully provided guidance on how to construct a successful human space flight program: “NASA should:

> I. Commit to design, maintain, and pursue the execution of an exploration pathway beyond low Earth orbit toward a clear horizon goal…
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> II. Engage international space agencies early in design and development…
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> III. Define steps on the pathway that foster sustainability and maintain progress…
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> IV. Seek continuously to engage new partners that can solve technical and/or programmatic impediments…
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> V. Create a risk mitigation plan to sustain the selected pathway when unforeseen technical or budgetary problems arise.
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> VI. Establish exploration pathway characteristics that maximize the overall scientific, cultural, economic, political, and inspirational benefits without sacrificing progress toward the long-term goal:
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> a. The horizon and intermediate destinations have profound scientific, cultural, economic, inspirational, or geopolitical benefits that justify public investment;
> b. The sequence of missions and destinations permits stakeholders, including taxpayers, to see progress and develop confidence in NASA being able to execute the pathway;
> c. The pathway is characterized by logical feed-forward of technical capabilities;
> d. The pathway minimizes the use of dead-end mission elements that do not contribute to later destinations on the pathway;
> e. The pathway is affordable without incurring unacceptable development risk; and
> f. The pathway supports, in the context of available budget, an operational tempo that ensures retention of critical technical capability, proficiency of operators, and effective utilization of infrastructure.”

The Committee called these recommendations “pathway principles.” To win political and public support, proposed space initiatives should strive to incorporate as many of them as possible.

Indeed, we argue that NASA's current Asteroid Redirect Mission (ARM) is actually a timely implementation of several of the NRC's 2014 recommendations. When the expedient Obama goal of sending astronauts to a Near-Earth Asteroid (NEA) by 2025 proved too ambitious to achieve in light of projected budgets, launch system performance, and deep space systems, NASA in essence adopted NRC recommendation V (above). The agency reduced risk by taking a smaller step, targeting the Orion and its SLS booster toward cislunar space rather than a solar-orbiting NEA.

NASA also anticipated NRC recommendation VI (a and b*)* by identifying an intermediate destination that has "profound scientific, cultural, economic, inspirational, or geopolitical benefits." A small NEA, nudged into the Earth-Moon system by a low-cost, low-risk robotic mission, offers an early anchor for human activity beyond the Moon, providing opportunities for scientific exploration and astronaut operations in a deep-space environment. Detailed sampling and exploration of the asteroid can also demonstrate the commercial potential of asteroid resources, and accumulate some of the technical knowledge needed for deflecting Near-Earth Asteroids. These latter elements alone go far toward building public interest and investment in human deep space exploration.

We were disappointed in the NRC Committee's failure to see the merits of the Asteroid Redirect Mission. The panel apparently prefers that astronauts first repeat Apollo 8's journey to an empty lunar orbit, or perhaps navigate to an Earth-Moon Lagrange point that lacks any infrastructure or physical presence. (We doubt the Committee advocates delaying another decade before astronauts venture beyond the International Space Station).

In dismissing the ARM concept, the panel argued that "the ARM robotic asteroid redirect vehicle is considered a dead-end mission element, as its SEP [solar electric propulsion] capabilities are not leveraged in future missions as currently envisioned." The Committee favors nuclear thermal propulsion (NTP) over SEP as the preferred Mars propulsion scheme. Here the NRC ignores both history and political reality. Since the last NERVA test firing on Jackass Flats in 1972, Mars planners have hoped for the return of NTP, but no NASA administration has ever come close to resurrecting the technology. Environmental and political obstacles to testing will probably preclude its development for the foreseeable future.

As promising as NTP technology is, NASA has shown no appetite to campaign for its development. Postponing deep-space ventures until NTP is space-ready ensures we'll be waiting another fifty years. By contrast, powerful solar electric systems like those to be demonstrated by ARM can support human expeditions to Mars, carrying

pre-positioned cargo, habitats, landers, and propellant stores while chemical systems enable high-speed astronaut sorties. Far from being a dead-end, SEP may be the key to enabling at least the first few Mars expeditions.

It is true that the Asteroid Redirect Mission need not be on the human pathway to Mars. NASA has proposed it to gain early operations experience in deep space, beyond the Moon. We could certainly just fly Orion to an empty lunar orbit, waiting until larger boosters, propellant depots, and more capable crew habitats are built before reaching for the asteroids (or any celestial body). We could also choose to repeat Apollo-style sorties to the lunar surface, necessitating an extensive, expensive, and lunar-specific infrastructure. We are excited by human lunar exploration, to be sure, but that path alone is unlikely to accelerate progress toward Mars.

By comparison, the Asteroid Redirect Mission achieves deep space operations experience much sooner, and at much lower cost. ARM would move U.S. astronauts beyond the Moon, creating opportunities to proceed farther into interplanetary space, toward Mars. First, ARM would extend human space flight to a lunar Distant Retrograde Orbit. Sorties into true interplanetary space to a Near-Earth asteroid would follow, preparing for journeys to the Mars system (perhaps landing on Phobos or Deimos). The Martian surface--the horizon goal—would then be clearly visible, and clearly achievable.

In parallel with ARM, we could pursue an affordable lunar exploration program. Using our proven robotic capabilities, we can support international partner efforts at the Moon, focusing on specific demonstrations that move us along the Mars pathway. Embrace the Moon, but don't detour there, either.

NASA has in practice already adopted the best of the NRC recommendations and laid out a credible pathway to Mars. ARM's near-term objectives should, because of their tighter focus and lower costs, prove more sustainable over the coming decade, building momentum for deep space sorties along the Mars path. ARM's challenging and innovative operations around a small NEA or retrieved boulder, coupled with astronaut examinations of an ancient and potentially valuable object, may do much to restore near-term public interest in human space exploration. We won't be repeating Apollo, but trying something new and different while keeping our vision trained on Mars.

To summarize, the NRC Committee report promulgated many sound principles and recommendations for progress in human space exploration, but in the end failed to propose a realistic, sustainable program. By the Committee's own criteria, the NASA ARM concept is an attractive first step toward a long-range Mars program,

and is the only NASA deep space venture that can be achieved within the decade. While other nations strive for a repeat of Apollo, we can in the same time frame send explorers thousands of km beyond the Moon, poised for expeditions to Near-Earth Asteroids and the Mars system.

Sustaining a decades-long effort to reach Mars will be an unprecedented challenge, requiring political leadership and the cultivation of long-term public support. ARM is an innovative means to develop support from policy makers and the public. It ensures continued U.S. leadership in space, and starts us visibly and quickly down the long road to Mars.

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