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No bomb-grade uranium in space, says White House

NASA plans to award contracts this month for designs of nuclear reactors to be deployed on the lunar surface.

David Kramer

A month before it turns over the White House, the Trump administration has issued a new policy on space nuclear reactors that all but prohibits the use of highly enriched uranium (HEU) fuel. NASA, which had previously planned to use an HEU-fueled reactor to provide power on the lunar and Martian surfaces, now promises to use only low-enriched uranium (LEU).

In a space policy directive issued on 16 December, President Trump spelled out a “national strategy for space nuclear power and propulsion (SNPP)” that applies to both radioisotope power systems and fission reactors being developed to provide surface power and to propel spacecraft and rovers. The directive states that the use of HEU in SNPP systems “should be limited to applications for which the mission would not be viable with other nuclear fuels or non nuclear power sources.” HEU-fueled space systems must be approved by a gauntlet of White House entities, including the Office of Management and Budget, the Office of Science and Technology Policy, and the National Security Council. Other relevant agencies also could be invited to participate in the review, the directive stated.

NASA’s current radioisotope systems generate electricity from heat produced by the radioactive decay of plutonium-238. Although highly toxic, that isotope does not present proliferation risks. Opponents of civilian use of HEU welcomed the policy directive. “From my nonproliferation perspective, it is great news,” says Alan Kuperman, director of the Nuclear Proliferation Prevention Project at the University of Texas at Austin. “It is essentially what we requested when we met with NASA and the National Security Council over the last few years.”

The Department of Energy, in collaboration with NASA, plans to solicit proposals from industry in January for designs of surface power reactors. Three contracts valued at around $5 million each are expected to be awarded, says Anthony Calomino, nuclear systems portfolio manager in NASA’s Space Technology Mission Directorate. A solicitation for nuclear thermal propulsion system designs will follow in a month or so, he adds, for which another three $5 million contracts are likely to be issued. The design efforts will span 12 months.

Calomino says that HEU’s weight, cost, and performance advantages over LEU reactors won’t be sufficient to justify its use as fuel. Under the new directive, “it would really have to be that we can’t close a mission with LEU” for NASA to allow HEU in space.

Three years ago, NASA and DOE tested Kilopower, an HEU-fueled reactor designed at Los Alamos National Laboratory. Its designers said then that an LEU version would be two to three times as heavy. (See *Physics Today*, December 2017, page 26.) The 1 kW prototype reactor contained 30 kg of weapons-grade HEU (enriched to 93%), which is more than sufficient to fashion a nuclear explosive device. NASA said a full-scale, 10 kW Kilopower would require 50 kg of the same HEU.

A study completed early this year at Idaho National Laboratory concluded that surface reactors moderated by metal hydrides and fueled with high-assay low-enriched uranium (HALEU) would be just 25% heavier than Kilopower, which is a fast, or unmoderated, type of reactor. HALEU is enriched to just below the 20% uranium-235 threshold that delineates HEU.

NASA's initial requirements are for a 10 kW surface power reactor, to be qualified for a lunar launch by 2027. But the agency wants a system design that can be extended to versions of 40 kW or more, Calomino says.

Fully functional

For propulsion NASA is initially focusing on nuclear thermal systems, Calomino says. In that technology, the heat generated by the reactor is transferred to burn hydrogen fuel in rocket engines. The thrust is similar to that of today's conventional liquid-fuel rockets but has the potential to double the fuel utilization efficiency. That would make the nuclear thermal system attractive for a human mission to Mars. Should something go wrong en route, astronauts could return to Earth up to three months into their seven-month voyage. Using conventional rockets, that window would be only a few days.

"We want to demonstrate a fully functional, fully controllable reactor that can produce hundreds of megawatts of thermal energy to run the engine," says Calomino. At least four companies are expected to respond to the design solicitation: BWX Technologies, General Atomics, X Energy, and Ultra Safe Nuclear Corp.

The agency also will assess over the next several years whether nuclear electric propulsion would be useful for a human Mars mission, Calomino says. In that process, thermal energy from a nuclear reactor is converted to electrical energy, which is used to drive an ion thruster or other electrical spacecraft propulsion technology.

The two nuclear propulsion technologies differ widely both in the amount and in the duration of the power delivered, as well as in their purpose. Nuclear thermal is envisioned as providing 500 MW to 600 MW to produce the thermal energy needed for launch and boost, but it will consume the available fuel over five to six hours, Calomino says. Nuclear electric will produce 5 to 10 MW but can run continuously, generating low thrust over 10 000 or more hours. That could make nuclear electric—or solar electric, a variant that employs solar panels—good choices to power a slow-moving cargo vessel to Mars.