National Aeronautics and Space Administration

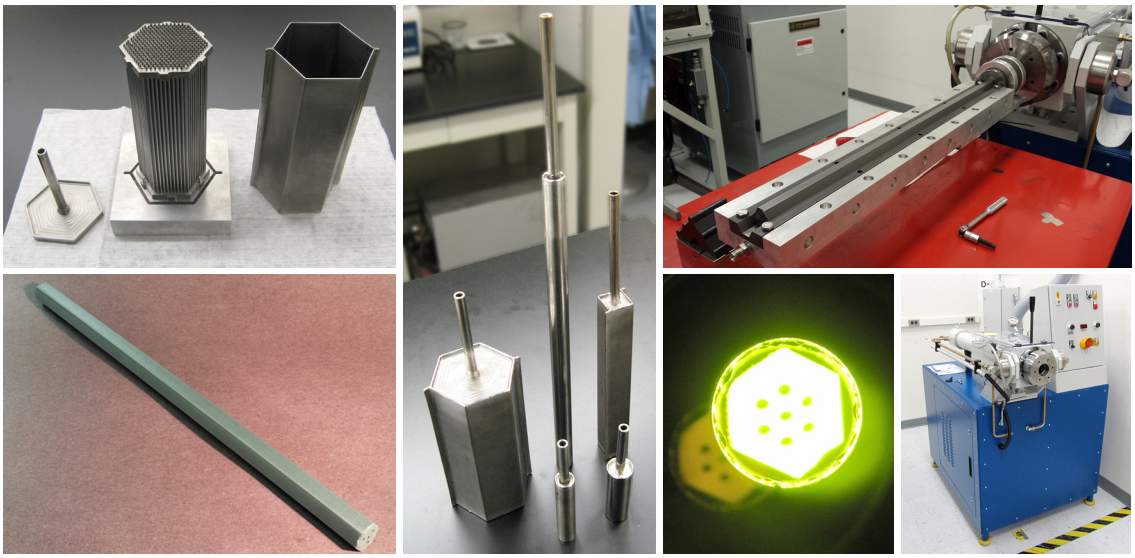
NASA**facts**

Space Technology
Game Changing Development
Nuclear Thermal Propulsion (NTP)

NASA's history with nuclear thermal propulsion (NTP) technology goes back to the earliest days of the Agency. The Rover and the Nuclear Engine for Rocket Vehicle Applications programs ran from soon after NASA's inception in 1958 until 1972. Since then, consistent recognition exists that an NTP-based vehicle design remains an important and viable option for exploration of Mars and beyond. NTP offers virtually unlimited energy density and a specific impulse roughly double that of the highest performing traditional chemical systems.

As missions aim for targets farther out into the solar system, nuclear propulsion may offer the only viable technological option for extending the reach of exploration missions beyond Mars. Because NTP provides the fastest trip time of all currently obtainable advanced propulsion systems, it is directly relevant to the Agency's vision, missions, and long-term goal of expanding human presence into the solar system and to the surface of Mars. Fast trip times will safeguard astronaut health by reducing exposure to zero gravity and cosmic radiation. Reduced travel time also reduces risks associated with reliability uncertainties inherent in complex systems as well as those associated with life-limited, mission critical systems.

To date, all nuclear propulsion system designs have been derived from reactors fueled by highly enriched uranium. Recent advances in materials technology may provide a more affordable pathway to development of a nuclear rocket engine. A shift to low enriched uranium (LEU)—defined as a concentration of lower than 20 percent uranium-235—offers several potential advantages for a nuclear propulsion development program. Security regulations for an LEU system could be less burdensome on the project budget and schedule. Handling regulations for an LEU source are similar to those for a university research reactor, opening up the development effort to partnerships with industry and academia. The ability to affordably produce isotopically pure tungsten would be required for the development of a ceramic-metallic (cermet) fueled NTP system



Advances in materials technology could lead to the production of LEU NTP fuel elements.

using LEU. This potentially “game changing” technology is key to the development of a cermet-based LEU NTP engine that could have extensibility beyond the current Mars campaign, and may provide the ability to develop these systems at an affordable level of budgetary commitment.

The overall goal of this game changing technology project is to determine the feasibility and affordability of an LEU-based NTP engine with solid cost and schedule confidence.

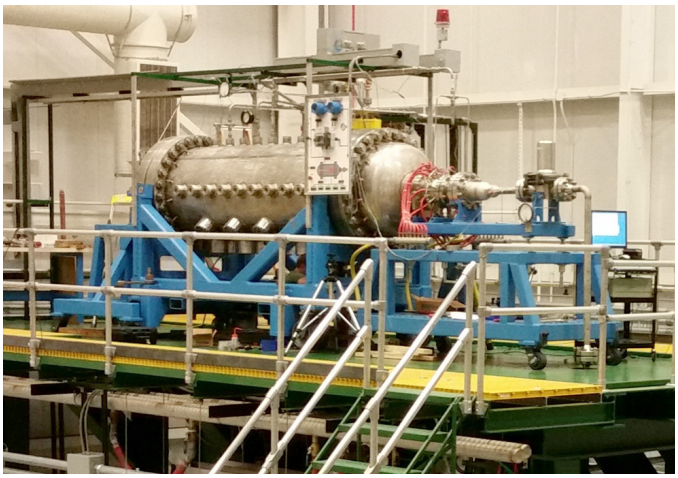
Initial project goals are to demonstrate the ability to purify tungsten to a minimum of 90 percent purity and determine the production costs at that purity level; to determine the technical and programmatic feasibility (pre-phase A level) of an NTP engine in the thrust range of interest for a human Mars mission; and to determine the program cost of an LEU NTP system and the confidence level of each major cost element.

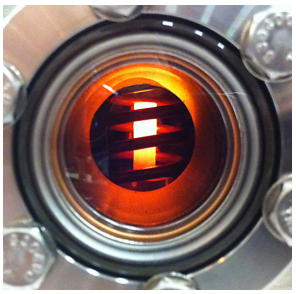
Because ground testing an NTP engine is more difficult than chemical engines, the project will examine the feasibility of contained engine testing within environmental and safety guidelines. Initial testing of fuel element materials will include non-nuclear tests in near prototypic conditions. An advantage of an LEU-based system is the possibility of total containment testing at a conventional propulsion test facility such as Stennis Space Center, which further reduces cost and complexity.

With the potential to provide high thrust at over twice the specific impulse of the best chemical engines, there is no doubt that the capability provided by NTP is a game changer for space exploration. The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA’s Space Technology Mission Directorate.

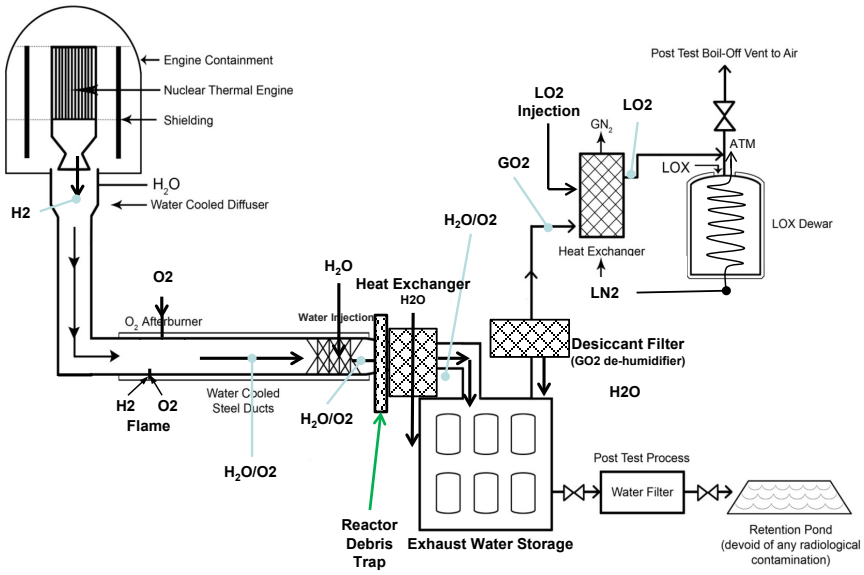
A video on NTP can be viewed here: https://www.youtube.com/embed/miy2mbs2zAQ.

For more information about GCD, please visit http://gameon.nasa.gov/





Non-nuclear testing of fuel element materials is an affordable approach to NTP engine development. Above are Marshall Space Flight Center test facilities: Nuclear Thermal Rocket Element Environmental Test System (NTREES); Compact Fuel Element Environmental Test (CFEET) System (above left); and a fuel element test in NTREES (above right).



Conceptual design of a totally contained engine ground test.

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