National Aeronautics and Space Administration

NASAfacts

Space Technology

Game Changing Development

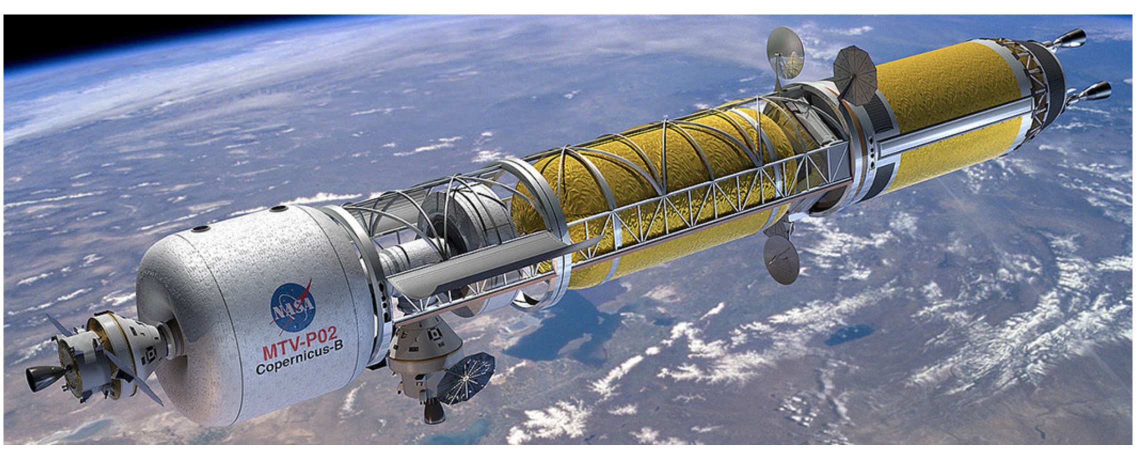
Nuclear Thermal Propulsion (NTP)

Nuclear thermal propulsion (NTP) can help enable detailed exploration of the solar system, extensive development and utilization of cis-lunar space, and robust human Mars architectures. The development and utilization of first generation NTP systems will provide the foundation for even more capable space fission power and propulsion systems. The fission energy source that powers NTP is extremely efficient, and can be used in a variety of ways to enable safe, robust missions and a power-rich environment anywhere in the solar system.

NASA's history with NTP technology goes back to the earliest days of the agency. NTP was considered for use as the upper stage of the Apollo moon rocket, as well as for Mars missions considered for an Apollo follow-on. Potential advantages of NTP for human Mars missions include significantly reduced transit time and total round-trip time, robust abort capability, reduced astronaut exposure to radiation and other hazards, reduced cost (fewer ETO launches per mission), and a more achievable launch cadence.

NTP will only be utilized if development is affordable and viable. The overall goal of the ongoing Game Changing Development (GCD) technology project is to determine the feasibility and affordability of an LEU-based NTP engine with solid cost and schedule confidence.

To improve affordability and viability, NTP systems that utilize low-enriched uranium (LEU) instead of highly-enriched uranium (HEU) are being devised. Advanced fuel manufacturing techniques will help enable the use of LEU in certain fission systems previously thought to require HEU. The current LEU NTP baseline engine relies primarily on advanced manufacturing techniques to fabricate the high performance LEU fuel. In the cooler regions of the engine (<2000 K) a Mo/UN ceramic metallic (Cermet) alloy is utilized, and in the hotter regions



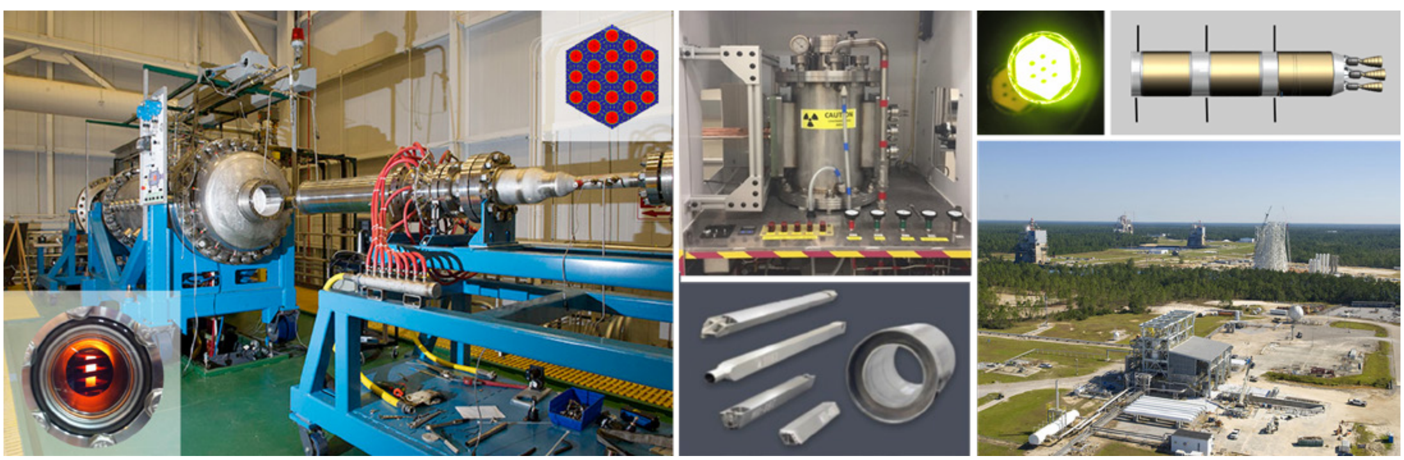
(>2000 K) a Mo/W metal alloy is used in conjunction with UN or UO2 fuel. The Cermet fuel enables a broad range of LEU NTP options (typically above 20 klbf thrust), and would also be suitable for use in HEU systems if extremely low thrust (<< 20 klbf) / small engine size was required. The use of LEU is consistent with US policy for civilian fission systems, reduces security-related cost and schedule impacts (compared to HEU), and greatly increases programmatic flexibility to allow extensive participation by industry and academia.

NTP fuel is currently being developed and fabricated by BWXT. Fuel samples are undergoing non-nuclear testing in NASA's Compact Fuel Element Environmental Tester (CFEET), helping to validate fabrication techniques and performance. Non-nuclear testing of full-length fuel segments is planned for NASA's Nuclear Thermal Rocket Element Environmental Simulator (NTREES), and potential follow-on projects may include in-pile fuel element testing at a Department of Energy facility such as Idaho National Laboratory's "TREAT."

Full utilization of NTP systems will also require an engine ground test facility. Research at NASA's Stennis Space Center (SSC) has shown that it may be feasible to fully capture the hydrogen exhaust from an NTP engine ground test by combusting the hydrogen and then condensing the resulting steam in a sealed system cooled by a counter-flow heat exchanger. The resulting water would be held in storage tanks, checked for any potential contamination, and then (if needed) cleaned using commercially available technologies. Although regulations permit the release of low levels of radiation from a wide range of sources, the exhaust capture system would be designed to capture all potentially radioactive effluent from an NTP ground test.

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 first generation NTP is a game changer for space exploration. Follow-on space fission systems will have an even greater impact. The 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 at:
https://www.youtube.com/embed/miy2mbs2zAQ.



Above left: NTREES test facility; Insets: top right, core design; lower left, prototype testing. Top center: CFEET tester, lower center: fuel rod samples. Above right: CFEET element test, conceptual craft; lower right, testing facilities at Stennis Space Center

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