Paper ID: 12341
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Technology Roadmaps for Space Exploration (09)
Advancing Propulsion Technologies (4)

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NUCLEAR THERMAL ROCKET (NTR) PROPULSION: A PROVEN GAME-CHANGING TECHNOLOGY FOR FUTURE HUMAN EXPLORATION MISSIONS

Abstract

The NTR represents the next evolutionary step in high performance rocket propulsion. It generates high thrust and has a specific impulse (Isp = 900 s) twice that of today's best chemical rockets. The technology is also proven. During the previous Rover and NERVA (Nuclear Engine for Rocket Vehicle Applications) nuclear rocket programs, 20 rocket reactors were designed, built and ground tested. These tests demonstrated: (1) a wide range of thrust; (2) high temperature carbide-based nuclear fuel; (3) sustained engine operation; (4) accumulated lifetime; and (5) restart capability – all the requirements needed for a human mission to Mars. Ceramic metal fuel was also evaluated as a backup option. In NASA's recent Mars Design reference Architecture (DRA) 5.0 study, the NTR was selected as the preferred propulsion option because of its proven technology, higher performance, lower launch mass, versatile vehicle design, simple assembly, and growth potential. In contrast to other advanced propulsion options, NTP requires no large technology scale-ups either. In fact, the smallest engine tested during the Rover program – the 25 klbf "Pewee" engine is sufficient for a human Mars mission. In FY'11, NASA initiated a two track NTP effort that includes "Foundational Technology Development" followed by system-level "Technology Demonstration" projects. The Foundational effort will provide the technical basis for an "authority to proceed" (ATP) decision in 2015 with ground technology demonstration (GTD) tests beginning in 2019. The tests would be conducted at the Nevada Test Site and use the SAFE (Subsurface Active Filtration of Exhaust) test option. A flight technology demonstration (FTD) mission would follow in 2023. In order to reduce development costs, the GTD and FTD tests will use a smaller, lower thrust (5 – 7.5 klbf) engine that is based on a "common" fuel element design that is scalable to the desired higher thrust engines by increasing the number of elements in a larger diameter core that can produce greater thermal power output. The small engine can be used individually for robotic science missions, or arranged in a 2 – 3 engine cluster for higher payload missions. The FTD will provide the technical foundation for an "accelerated approach" to design, fabrication, and ground testing of the larger 25 klbf-class engine. Flight testing a NTR stage with clustered 25 klbf engines would occur next to support human asteroid missions in the late 2020's, followed by Mars orbital missions in the early 2030's, then a landing mission afterwards.