HUMAN EXPLORATION / COMMERCIAL LUNAR MISSIONS USING NTR PROPULSION.

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Abstract: The Nuclear Thermal Rocket (NTR) represents the next evolutionary step in cryogenic liquid rocket engines. Unlike chemical rockets that produce their energy through combustion, the NTR derives its energy from fission of uranium-235 atoms contained within fuel elements that comprise the engine's reactor core. Using an "expander" cycle for turbopump drive power, hydrogen propellant is raised to a high pressure and pumped through coolant channels in the fuel elements where it is superheated then expanded out a supersonic nozzle to generate high thrust at a specific impulse of ~900 seconds or more – twice that of today's best chemical rockets. NTP has frequently been discussed as a key space asset that can bridge the gap between a sustained human presence on the Moon and the eventual human exploration of Mars. Recently, a human mission to a near Earth asteroid (NEA) has also been included as a "deep space precursor" to an orbital mission of Mars before a landing is attempted. In his "post-Apollo" Integrated Space Program Plan, Wernher von Braun proposed a reusable NTP stage (NTPS) to deliver cargo and crew to the Moon to establish a lunar base initially before sending human missions to Mars. The NTR was selected because it was a proven technology with twenty rocket reactors designed, built and ground tested in the Rover/NERVA programs [1]. These tests demonstrated the (1) thrust levels; (2) high fuel temperatures; (3) sustained operation; (4) accumulated lifetime; and (5) restart capability needed for an affordable in-space transportation system. Lunar transfer vehicle components – consisting of a NTPS with three 15 klb_f "SNRE-class" engines [2], an in-line propellant tank, plus payload – can be delivered to LEO in 70 t increments for assembly, then used for reusable cargo delivery and crewed lunar landing missions [3]. The NTPS can provide routine access to a variety of locations including Lagrange points, equatorial and polar orbits thereby allowing outposts to evolve into settlements capable of supporting commercial activities. Over the next decade collaborative efforts between NASA and private industry could open up new exploration and commercial opportunities for both organizations. With efficient NTP, commercial space habitation and crew delivery systems, a "mobile cislunar research station" can transport crews to small NEAs delivered to the E-ML2 point. Also possible are week-long "lunar tourism" missions that can carry passengers into lunar orbit for close-up examination (and picture taking), then return them to Earth orbit where they would reenter and land using a small reusable lifting body based on NASA's HL-20 design. Candidate lunar missions, key vehicle features and operational characteristics are described and presented.

References:

[1] Koeing D. R. (1986) Report LA-10062-H.
[2] Schnitzler B. G. et al. (2011) AIAA-2011-5846.
[3] Borowski S. K. et al. (2012) AIAA-2012-5144.

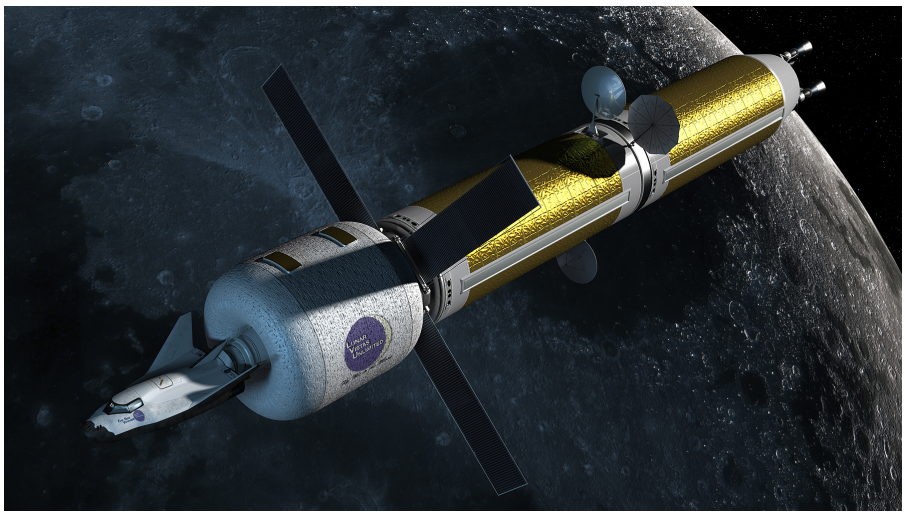

Figure 1. Commercial Week-long Orbital Tourism Mission to the Moon Using Reusable NTPS