THE FEASIBILITY OF 24 HOUR COMMUTER FLIGHTS TO THE MOON USING NUCLEAR THERMAL ROCKETS WITH LUNOX AFTERBURNERS

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ABSTRACT

The prospects for "24 hour" commuter flights to the Moon, similar to that portrayed in the movie *2001: A Space Odyssey* but on a more Spartan scale, are examined[1] using two near term, "high leverage" technologies -- liquid oxygen (LOX)-augmented nuclear thermal rocket (NTR) propulsion and "lunar-derived" oxygen (LUNOX) production. Iron-rich volcanic glass, or "orange soil," discovered during the Apollo 17 mission to the Taurus-Littrow Valley, has produced a 4% oxygen yield in recent NASA experiments using hydrogen reduction. LUNOX development and utilization would eliminate the need to transport oxygen supplies from Earth and is expected to dramatically reduce the size, cost and complexity of space transportation systems. The LOX-augmented NTR concept (LANTR) exploits the high performance capability of the conventional liquid hydrogen (LH_2)-cooled NTR and the mission leverage provided by LUNOX in a unique way. LANTR utilizes the large divergent section of its nozzle as an "afterburner" into which oxygen is injected and supersonically combusted with nuclear preheated hydrogen emerging from the engine's choked sonic throat -- essentially *"scramjet propulsion in reverse.*" By varying the oxygen-to-hydrogen mixture ratio, the LANTR engine can operate over a wide range of thrust and specific impulse (Isp) values while the reactor core power level remains relatively constant. The thrust augmentation feature of LANTR means that "big engine" performance can be obtained using smaller, more affordable, easier to test NTR engines. The use of high-density LOX in place of low-density LH_2 also reduces hydrogen mass and tank volume resulting in smaller space vehicles. An implementation strategy and evolutionary lunar mission architecture is outlined which utilizes Shuttle-derived heavy lift launch vehicles and conventional NTR-powered lunar transfer vehicles (LTVs), operating in an "expendable mode" initially, to maximize delivered surface payload on each mission. The increased payload is dedicated to installing "modular" LUNOX production units with the intent of supplying LUNOX to lunar landing vehicles (LLVs) and then LTVs at the earliest possible opportunity. Once LUNOX becomes available in low lunar orbit (LLO), monopropellant NTRs would be outfitted with an oxygen propellant module, feed system and afterburner nozzle for "bipropellant" operation. Transition to a "reusable" mission architecture now occurs with smaller, LANTR-powered LTVs delivering up to 36 tons of cargo and "Earth-supplied" LH_2 to LLO on each piloted flight (an ~400% payload increase over that achieved with the earlier expendable "all LH_2" NTR systems. As initial lunar outposts grow to eventual lunar settlements and LUNOX production capacity increases, the LANTR concept can enable a rapid "commuter" shuttle capable of 24 hour "one-way" trips to and from the Moon. A vast deposit of "iron-rich" volcanic glass beads identified at just one candidate site -- located at the southeastern edge of Mare Serenitatis -- could supply sufficient LUNOX to support daily commuter flights to the Moon for the next 9000 years!

1. S. K. Borowski and L.A. Dudzinski, "*2001: A Space Odyssey*" Revisited – The Feasibility of 24 Hour Commuter Flights to the Moon Using NTR Propulsion with LUNOX Afterburners," AIAA-97-2956, American Institute of Aeronautics and Astronautics (July 1997) and NASA/TM—1998-208830 (Dec. 1998).