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FEASIBILITY STUDY OF NUCLEAR THERMAL PROPULSION FOR MARS SAMPLE RETURN MISSIONS

Abstract

Nuclear Thermal Propulsion (NTP) has been identified as the leading propulsion candidate towards enabling human exploration of Mars for both opposition and conjunction class missions. NTP has also demonstrated its capability of higher payload mass fraction and reduced trip-times for robotic missions to the outer solar system. The NTP systems capability of generating both high thrust and high specific impulse (over twice the best chemical propulsion system) can enable a variety of ambitious robotic missions in the next phase of the NASA's planetary science missions program which are architecturally constrained due to the current available in-space propulsion solutions.

The purpose of this study is to investigate the feasibility of Mars sample return mission using NTP system. The NTP powered architecture addresses the constraints and challenges from the current chemical powered mission such as tight mass margins, restricted launch period opportunities and multiple system handoffs requirement. The study using NTP will also demonstrate the propulsion systems capability for a long duration round-trip Mars mission by addressing the challenges of cryogenic propellant boil off and the impact of lower engine T/W ratio in payload performance. The architecture development and high-fidelity mission analysis is performed using 'Spacecraft Integrated System Model' which includes systems engineering and domain engineering analysis model. The NTP engine model is based on the ceramic fuel element with reactor power of 330MW generating 15klbf of thrust and 900s of specific impulse. Preliminary results have demonstrated an NTP architecture can perform the sample retrieval and return mission using only a single commercial launcher with resiliency to launch delays due to wider launch window opportunities enabled by high performing in-space NTP system. The payload mass fraction is over twenty five percent for a similar trip times in comparison to traditional propulsion systems.