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IAF SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (6)

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NUCLEAR FUSION PROPULSION SYSTEM FOR HUMAN MISSIONS TO MARS

Abstract

One of the biggest challenge with future human missions to Mars will be the radiation exposure to astronauts during the long duration transit times between Earth and Mars. As per NASA's design reference architecture 5.0, the conjunction class trajectory concept is preferred over opposition class due to low delta-V requirements. However, the conjunction class trajectory using chemical propulsion system takes 174 days of transit times from Earth to Mars and 201 days for the return journey. A nuclear fusion propulsion system with a very high specific impulse and moderate thrust has the capability to further reduce the transit trip times by more than a factor of 3. The reason for the high performance is due to the possibility of high energy gain in the propulsion system. In a traditional solar or fission electric propulsion system, the power is used to run an electric propulsion system. In a fusion or fission/fusion hybrid system, the power delivered to the fuel then ignites the fuel, releasing energy greatly amplifying the power delivered to produce thrust and exhaust velocity not possible in conventional propulsion systems.

This paper will present the conceptual mission design and conjunction class trajectory analysis for a human mission to Mars using nuclear fusion propulsion system. The propulsion parameters such as required specific power, specific impulse and thrust are initially determined for the mission. A detailed high-fidelity trajectory analysis including delta-V requirements, launch schedule and trip times for a round trip mission starting from low Earth orbit is presented. The spacecraft's initial parking orbit for in-orbit assembly and departure is considered to be circular with 400 km in altitude. The spacecraft's outbound and return trajectory consists of three phases, acceleration, coasting and planetary capture phase. The trajectory results will be compared with the NASA design reference architecture and the benefits of nuclear fusion propulsion over chemical propulsion for human missions to Mars will be discussed.