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SPACE PROPULSION SYMPOSIUM (C4)
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HYBRID NUCLEAR PROPULSION SYSTEM FOR A MANNED MARS MISSION (M3)

Abstract

Although shelved indefinitely due to the cancellation of the NASA Constellations program, plans to reach Mars with a human crew are still being investigated by the scientific community. In "Nuclear Propulsion for Human Exploration: the Mars and Moon Case", paper IAC-09-C4.7.-C3.5.1 [1], Lorenzoni et al compared M3 with chemical propulsion (CP) and with Nuclear Thermal propulsion (NTP), finding NTP more convenient than CP in terms of mass, while mission time improved only marginally. In Analysis of a Manned Mars Mission with Nuclear Electric Propulsion (NEP) System", paper IAC-09.C4.7.-C3.5.2 [2], Ferraro et al assumed a M3 using exclusively Nuclear Electric propulsion (NEP); using the same payload of [1], they found significant savings are possible in mass and especially in total mission time. With NEP this last is in fact a strong function of the electric power available, and turns out to be of order 100 d (one way) for a 300 MWe reactor. A large fraction of this time was due to the spiral trajectory to reach Earth escape speed from LEO, and to the similar deceleration to capture low Martian orbit. Because it is practically impossible to shield humans from the effect of solar and Galactic Cosmic Radiation (GCR), short interplanetary transits are a must for a M3, spurring interest in ways of shortening M3 as much as possible and thus ensuring the crew safe passage. In this context reducing the slow portion of the trajectory (the spirals around Earth and Mars) appears a convenient strategy. The goal of this paper is to show how a hybrid nuclear propulsion system could indeed achieve this result and abbreviate the Earth-Mars mission. The hybrid system consists of a reactor capable of operating in a dual mode, i.e., as a NTR using LH2 as propellant, with Isp of order 900 s, and as a power generator to feed a modular ion electric thruster of much higher Isp, e.g., about 10000 s. Hydrogen will therefore be used as propellant and as work fluid in the thermal to electric conversion system. Among the advantages of this strategy, besides shortening mission time, is the reduction in size and mass of the space radiator, one of the major components of the spacecraft mass budget [2]. From statements by General A. Perminov (RosKosmos) it appears that Russia is pursuing this strategy in its plans to explore Mars.