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DIRECT FUSION DRIVE FOR A HUMAN MARS ORBITAL MISSION

Abstract

The Direct Fusion Drive (DFD) is a 1-20 MW nuclear fusion engine that produces both thrust and electric power. It employs a field reversed configuration with an odd-parity rotating magnetic field heating system to heat the plasma to fusion temperatures. The engine uses deuterium and helium-3 as fuel and additional deuterium that is heated in the scrape-off layer for thrust augmentation. In this way variable exhaust velocity and thrust is obtained.

This paper presents the design of an engine for a human mission to orbit Mars. The mission uses NASA's Deep Space Habitat to house the crew. The spacecraft starts in Earth orbit and reaches escape velocity using the DFD. Transfer to Mars is done with two burns and a coasting period in between. The process is repeated on the return flight. Aerodynamic braking is not required at Mars or on the return to the Earth. The vehicle could be used for multiple missions and could support human landings on Mars.

The total mission duration is 310 days with 30 days in Mars orbit. The Mars orbital mission will require one NASA Evolved Configuration Space Launch System launch with an additional launch to bring the crew up to the Mars vehicle in an Orion spacecraft.

The paper includes a detailed design of the Direct Fusion Drive engine. Subsystem designs are presented including the high temperature superconducting magnets, heat engine for waste energy recycling, RF system for the rotating magnetic field heating system, radiators and the engine startup/restart system. The computation of the specific power for the engine is presented along with a full mass budget for the engine. The paper includes the trajectory design and end-to-end mission simulations.