Paper ID: 56174
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IAF SPACE PROPULSION SYMPOSIUM (C4)
Joint Session on Advanced and Nuclear Power and Propulsion Systems (10-C3.5)

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TRAJECTORY DESIGN FOR A TITAN MISSION USING THE DIRECT FUSION DRIVE

Abstract

Titan is the only satellite in our Solar System with a dense atmosphere. The main purpose of this work is to perform analysis of realistic new trajectories for a robotic mission to Saturn's largest moon, Titan, in order to demonstrate the great advantages related to the direct fusion drive (DFD). The DFD is a D -^{3}He fueled, aneutronic, thermonuclear fusion propulsion system, related to the ongoing fusion research at Princeton Plasma Physics Laboratory (PPPL) [1]. This fusion propulsion concept is based on a magnetically confined field reversed configuration plasma, where the deuterium propellant is heated by fusion products, and then expanded into a magnetic nozzle, providing both thrust and electrical energy to the spacecraft.

The trajectories calculations and analysis for the Titan mission are obtained based on the estimated characteristics provided by the PPPL [1]. Two different profile missions have been considered: the first one is a thrust-coast-thrust profile with constant thrust and specific impulse; the second scenario is a continuous and constant thrust profile mission, with a switch in thrust direction operated in the last phases. Each mission is divided into four different phases, starting from the initial low earth orbit departure, the interplanetary trajectory, Saturn orbit insertion and the Titan orbit insertion. For all mission phases, maneuver time and propellant consumption have been calculated. The results of calculations and mission analysis offer a complete overview of the advantages in term of payload mass and travel time.

It is important to emphasize that the deceleration capability is one of the DFD game changer: in fact, the DFD performance allows to rapidly reach high velocity and decelerate in even shorter time period. This capability results in a total trip duration of 2.6 years for the thrust-coast-thrust profile and less than 2 years considering the continuous thrust profile. The high payload enabling capability, combined with the huge electrical power available from the fusion reactor, leads to a tremendous advantage compared with present technology.

References:

[1] S. A. Cohen et al., Direct fusion drive for interstellar exploration, JBIS 72, 37 – 50 (2019).