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A TRADE STUDY OF MISSION ARCHITECTURES FOR CENTRIFUGAL NUCLEAR THERMAL PROPULSION

Abstract

This work describes a trade study of possible architectures for rendezvous missions to the outer solar system utilizing centrifugal nuclear thermal propulsion (CNTP) as the primary propulsion system. The possible performance of CNTP has been predicted in a broad range between 1200 and 1800 s of specific impulse by various analyses, and with a wide variety of potential missions and destinations it is useful to characterize how some of these system and mission variables affect each other. In order to accomplish this study, the relationship between required delta-V and transfer time is established for the outer planets and one Kuiper belt object. The rocket equation is then applied to introduce potential CNTP performance parameters to the solution space such as specific impulse, engine mass, and engine thrust-to-weight ratio. Additional constraints are put on the system, such as injection stage mass and volume for a single launch of a commercial launch vehicle to low Earth orbit. Other complicating factors are also considered, including approximations of thermal and power needs for the duration of the mission. Payload mass is shown to be dependent on many of these factors, and varies for destination, vehicle, and trajectory. Margins of error for edge cases are also discussed, based on approximation errors and some comparison to historical data for similar missions. CNTP must still overcome many challenges in its development to realize successful planetary missions; however, exploring the major drivers of its use case can enable discussions on optimal configurations for CNTP mission architectures in the future and focus resources on the most promising yet realistic possibilities.