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

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NUCLEAR FUSION POWERED TITAN AIRCRAFT

Abstract

Titan is one of the most interesting locations in the solar system. It has a thick atmosphere, surface oceans and under ice oceans. Its terrain is complex and varied. NASA first explored Titan with the Cassini mission that produced close-up photographs of the planet at both visible and infrared wavelengths. The next mission will by the Dragonfly mission that will land a quadcopter on the surface. This will allow for study of one region on Titan.

This paper discusses a system for Titan exploration enabled by nuclear fusion power. A Direct Fusion Drive (DFD) engine would bring a spacecraft to Titan orbit in less than two years. DFD uses a novel radio-frequency heating plasma heating system and deuterium-helium-3 fuel. DFD has a simple linear geometry. Magnetic confinement is used with a combination of low-temperature superconducting solenoidal coils and hybrid coils for the mirror coil and magnetic nozzle. The field reversed configuration (FRC) is a closed magnetic region where fusion occurs. A lower temperature plasma flows around this region removing the fusion products. This secondary flow permits variable thrust and exhaust velocity. The fusion fuel is injected with a low-energy neutral beam system. Tritium from side reactions leaves the FRC before it can fuse. Neutrons are only produced by deuterium-deuterium side reactions and are much lower energy than those from deuterium-tritium reactions. This greatly reduces radiation damage to the walls and superconducting coils thus making multi-year life a possibility A Brayton Cycle heat engine recycles waste energy for the plasma heating. Reactor startup is done using conventional fuels.

A second fusion reactor, configured as a power reactor, would be used for an electric Titan science aircraft. This vehicle would do a powered entry to Titan and then have the capability to fly anywhere on the moon at subsonic speeds. Optimization studies presented in the paper show that the propulsion system is only used at low speeds during entry, hence a distributed propeller system was designed. After landing, it could do aerial reconnaissance of the surface from any altitude and land at interesting spots. The aircraft could carry multiple payloads including a Titan submarine and a high-power drill. The science vehicle would have up to 1 MW of available power. This would be used for the engine, but also would be available to the science payloads. The transfer stage would remain in orbit and act as a

high-power communications relay and would have its own set of science missions. DFD would allow it to change inclination as needed to cover different areas of the surface.

This paper provides a conceptual design of the system including the transfer vehicle, the nuclear fusion engine, and the Titan aircraft. A detailed design of the fusion reactor is presented including mass budgets. Simulation results for all parts of the mission are provided.