IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
CATEGORY C "TECHNOLOGY" - Extra Session (10)

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DEEP-SPACE SOLID PROPULSION SYSTEM FOR ORBITING EXPLORATION OF LARGE GRAVITY BODIES BEYOND THE ASTEROID BELT

Abstract

Orbiting and landing explorations of icy moons around Jupiter, Saturn, and Uranus, which hold significant scientific potential, represent leading trends among advanced nations. However, Japan's deep-space exploration strategy focuses on round trips to small celestial bodies and flybys of large gravity bodies, i.e., planets, icy moons, large asteroids. This limitation originates from the imbalance between the securing power and heat source and the space probe system costs of these trips. More specifically, inserting a space probe into orbit around a large gravity body such as Jupiter requires a significant velocity increment (i.e., delta-V), which necessitates a high-power heating system to maintain the temperature of the entire propulsion system and in turn requires an increase in space probe size. By contrast, solid propulsion systems, which operate effectively at low temperatures and are typically less expensive than liquid systems, can revolutionize space probe design for deep-space exploration. By enabling operations

under environments beyond the asteroid belt with low-temperature requirements, a larger space probe size, reduced power consumption, and lower costs, solid propulsion systems can significantly alter the design paradigms for deep-space missions, particularly for reaching distant large gravity bodies such as Jupiter. This concept hinges on the development of solid propulsion technologies capable of achieving the necessary delta-V in the gravitational fields of distant planets. The initial phase focuses on gathering experimental data on the long-term stability and reliable ignition and burning of solid rocket motors under possible space conditions such as low temperatures, high vacuum environments, and high levels of radiation. This study presents the preliminary findings from this research, detailing a conceptual study of a solid rocket stage for inserting probes into planetary orbits and gathering essential data for the design of this type of propulsion system. The objective is to enhance the flexibility of solar system navigation through the advancement of solid propulsion systems.