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EPOPEA MISSION: ADDRESSING THE CHALLENGES OF ENCELADUS' OCEAN WORLD EXPLORATION

Abstract

Enceladus Plume and Ocean Prospecting for Exo-Astrobiology (EPOPEA) is a mission concept developed over a three-month period at Politecnico di Milano, aimed at characterizing the physical, chemical, and biological environment of Saturn's moon. This is achieved through a study of Enceladus' internal structure and sub-surface ocean, as well as its South Polar Region (SPR), home to the so-called Tiger Stripes, which vent ocean material into space and represent the region of highest scientific relevance. Building on NASA's Enceladus Orbilander single-module mission concept, this study presents a different architectural solution that exploits both an Orbiter and a Lander, providing increased mission robustness and greater scientific return. Following the recent interest concerning ocean worlds, this paper outlines the criticalities that have been found throughout the design, and aims at providing a feasible architecture, taking advantage of current and future technologies, to serve as insight for upcoming mission designs. The most relevant drivers to consider surely are the low gravity of the moon, the Sun illumination in the SPR, temperature conditions, the long mission lifetime, and technology readiness in time for launch. With a 20 years overall lifetime from launch to disposal, EPOPEA is designed to be launched aboard NASA's SLS in October 2033, starting its scientific phase at Enceladus in 2051. After the interplanetary phase, the mission plans multiple moon fly-bys in the Saturn system, followed by 2 years flying around Enceladus. Three additional months at the scientific phase starting epoch shall be considered to surface mapping for landing site confirmation and Lander release. Over a thousand plume flythroughs will be conducted at different altitudes for passive plume sample collection, with all the criticalities that it ensues. Concurrently to on-orbit operations, 2 years of ground science are performed by the Lander, providing both passive and active sample collection on ground. All samples are in situ analyzed. The paper also presents the subsystem specifications, concept of operations and emphasizes constraints associated with planetary protection, which become especially stringent whenever possible life forms exist on the host body. Insight is provided into which technologies developments are critical, such as Next Generation RTGs, sampling mechanisms and components that can endure a lifetime of 20 years. The design predicts a 14-ton spacecraft, of which 750 kg are attributed to the Lander. This study shows that the mission objectives can be achieved despite the complexity intrinsic to that great endeavor.