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MINING THE MAIN BELT COMETS: A CONCEPTUAL MISSION DESIGN

Abstract

Small Solar System Bodies (SSSBs) have long been believed to answer fundamental questions regarding planetary sciences and are considered the potential solution to sustainable space exploration. Among these, Main Belt Comets (MBCs) within the asteroid belt have garnered particular interest for their potential as repositories of volatile materials essential for sustaining human presence in space.

This paper focuses on the conceptual design of the mining mission on active Main Belt Comets (MBCs) in the asteroid belt that have been observed to release a trail of dust when passing through the perihelion. Of the ten currently confirmed MBCs, this mission represents a pioneering endeavor in mining and extracting resources on the active Main-Belt Comet 324P/La Sagra, a consideration made on the size and stability of the MBC. Based on the underlying assumption of utilizing a free Starship launch in the future with the capacity to deliver 21 tons of payload to a Geostationary Transfer Orbit (GTO), the mission presented is a concept study focused on bringing samples of volatile materials, such as water ice and organic compounds, back to Earth, seeking to advance scientific understanding of planetary formation and the origins of Earth's water. Alternatively, the extraction of regolith provides the key to finding a sustainable source of rare materials, demonstrating mining technology for SSSBs in the process.

The study focuses on a specific use case example of extracting Oxygen from mined regolith for the International Space Station (ISS) and future manned missions, investigating the technical and economic feasibility of the concept. To this end, the design of the spacecraft subsystems is conducted based on the mission requirements, with simultaneous identification and evaluation of the technology readiness level of components compatible with such missions. This paper also identifies the challenges associated with deep space mining on small bodies owing to reduced gravitational forces and the extensive need for trajectory optimization for more realizable delta-v requirements. By addressing these challenges and refining mission parameters, the mission's scientific return can be maximized to achieve groundbreaking discoveries in planetary science and identify more MBCs for future missions.