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RELATIVE GN&C SOLUTION TO DETERMINE SMALL-SCALE FEATURES AND THE INTERNAL STRUCTURE OF A 40 M DIAMETER ASTEROID

Abstract

Is performing a rendezvous with a 40 m diameter asteroid achievable? The Exploration of Near-Earth Asteroids (ENEA), a space mission concept developed by a team of 11 Master of Science students from Politecnico di Milano, addressed this inquiry. 2000 SG344, an asteroid measuring only 40 meters in diameter, stands out as the most challenging target among the three envisioned by the project due to its limited size. It is recognized as a potentially hazardous object and is currently ranked fourth on the European Space Agency's risk list for potential Earth collisions. For this reason, the mission intends to map its small-scale features and internal structure. The main challenges in designing the mission come from the weak gravitational pull of the asteroid, and its unknown shape, which cannot be accurately predicted during the mission design. This paper highlights the studied strategies and algorithms to perform rendezvous operations with 2000 SG344. A set of dynamic equations was developed in the LVLH reference frame to model the motion of the spacecraft around the asteroid. Due to the effects of perturbations, such as the solar radiation pressure, two different types of differential correction schemes were implemented to calculate the maneuvers needed to maintain the spacecraft on the desired trajectory. To tackle the challenges, the rendezvous was split into four distinct stages. The spacecraft would first observe the asteroid at a 100 km holding point, where the spin axis, rotational period, rough shape, and luminosity would be assessed. It would follow up with a second, closer, holding point at 15 km distance to map the surface. During this and the following phases, the spacecraft would be positioned between the Sun and the asteroid to achieve constant illumination conditions. Inspired by the Rosetta an OSIRIS-Rex missions, a stable rhombus-shaped orbit at 500 m distance was designed for high-resolution surface mapping of the target. Finally, a terminator orbit at 120 m distance was devised for the radio science experiment for gravity harmonics estimation. This study validates the feasibility of exploring very small celestial bodies with currently available technology, laying the groundwork for future space exploration and planetary defense investigations.