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CONCEPTUAL DESIGN STUDY OF CUBESAT-BASED EARTH TROJAN ASTEROID EXPLORATION ACCOMPANYING WITH KOREAN SUN-EARTH L4 MISSION

Abstract

Recently, with the development of miniaturization design technology for cubesat subsystems and payloads, the use of CubeSats for deep space exploration is increasing. MarCO and LICIACube missions successfully demonstrated that even cubesats can make significant contributions to deep space missions even though they must rely on the piggyback ride to the destination by mother spacecraft due to their limitation on propulsion and autonomous navigation capabilities. According to the 4th National Space Development Promotion Plan of Korea announced in February 2023, the Republic of Korea is preparing to establish a space system to observe solar wind at the Earth-Sun L4 (Lagrangian) point and is also preparing for asteroid exploration to investigate solar system origins. Furthermore, a Space Observatory mission at the Earth-Sun L4 was designated as one of its brand projects for space science exploration at the 3rd National Space Committee held in February 2025. The Korea AeroSpace Administration (KASA) has already initiated the pre-phase A study of the Earth-Sun L4 mission targeting a 2035 arrival to improve space weather forecasting capabilities as well as to enhance the understanding of heliosphere through comprehensive and coordinated observations with other existing and planned L1 and L5 missions. This paper proposes the unique cubesat mission to enhance the scientific value of the Korea L4 mission by adding an Earth Trojan asteroid exploration via a piggyback rideshare. At the Earth-Sun L4 point, two C-type Near-Earth Asteroids (NEA), 2010 TK7 and 2020 XL5, were discovered, with 2020 XL5, having a diameter of 1.2 km, being more suitable for exploration. The mission design suggests to flyby asteroid 2020 XL5 with the cubesat with the scientific observation and technology demonstration objectives. The scientific observation task includes analyzing the physical and chemical characteristics of Earth Trojan asteroids as well as addressing unresolved questions in planetary science. On the other hand, the key technological objective is to validate vision-based autonomous navigation technology which will be imple-

mented using stereo cameras and EKF-SLAM (Extended Kalman Filter and Simultaneous Localization and Mapping) for uncooperative and unknown targets. Based on scientific and technological objectives, mission requirements and phases were derived including a mission trajectory design for the approach phase as well as conceptual design of the cubesat with detailed system and subsystem requirements.