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ORBIT PREDICTION OF 16U CUBESAT OBSERVER-1A USING ONBOARD GPS DATA

Abstract

This research presents an innovative method on orbit determination and prediction of Observer-1A microsatellite, utilizing sparse position and velocity information derived from its onboard GPS receiver. The Observer-1A, Korea's first commercial 16U-size CubeSat for Earth Observation (EO) purposes, was successfully launched aboard SpaceX's Falcon 9 on November 11th, 2023. Initial two-way communication between the satellite and ground station was successfully established within 120 minutes of launch vehicle deployment, allowing for a 90-day early peration phase to verify all satellite subsystems and operation modes.

Aligned with the principles of newspace paradigm and CubeSat development philosophy, this study addresses several limitations inherent in CubeSat orbit determination and prediction. The utilization of Commercial Off-The-Shelf (COTS) products as primary components for the bus system may lead to irregular resets of the CDH system to safeguard against potential damage from Single Event Effects (SEE). In efforts to optimize spacecraft power consumption and allocate more power to the EO camera payload and data handling subsystem, the GPS receiver obtains a single-point solution using GPS L1 signal exclusively. Additionally, the orbit determination process using GPS raw measurements is excluded from the onboard processing algorithm to mitigate potential processing overload on the On-Board Computer (OBC).

To tackle these challenges, a comprehensive approach integrating GPS single-point position and velocity data with satellite status information such as Position-Dilution of Precision (PDOP), satellite attitude information and OBC reset status is proposed for precise and robust orbit determination of Observer-1A. Over a span of 90 days, satellite datasets including GPS-based solutions and satellite information were utilized to assess the proposed method. Throughout this process, the impact of irregular gaps in GPS data due to OBC resets on the orbit determination accuracy is analyzed.

Based on orbit determination results, orbit prediction is performed to generate a Two-Line Elements (TLE) set for satellite operation, including ground communication and mission mode. The generated TLE is compared to existing NORAD TLEs to validate the robustness and accuracy of the results. The orbit overlap method is also employed for self-quality assessments. Finally, this study emphasizes the significant impact of TLE accuracy on satellite operation processes, including the duration of ground communication time, ground antenna pointing accuracy, and EO mission data quality.