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INERTIALLY AIDED VECTOR MATCHING FOR OPPORTUNISTIC NAVIGATION IN SPACE

Abstract

EXACT and SOCRATES are a pair of CubeSats that will have as their payload a hard x-ray/soft gamma-ray detector. One of the missions of these CubeSats is demonstrate opportunistic navigation using astrophysical signals of opportunity. Position, navigation and timing (PNT) for spacecraft operating outside of geosynchronous orbit is currently limited to Earth-based tracking. The navigation techniques that will be tested on-board EXACT and SOCRATES could serve to augment or eventually replace Earth-based PNT methods.

The opportunistic navigation technique that will be tested will use time-difference of arrival measurements of a signal arriving at two spacecraft to measure the range between the vehicles. In order to use this time-difference of arrival to update the PNT solution, the angle of arrival of the signal must be known in absolute coordinates. This requires that the detector which measures the signal is directionally sensitive, and that the vehicle must have an estimate of its attitude. For SOCRATES and EXACT, an inertially-aided vector matching algorithm will be used with data from a tri-axis magnetometer and angular rate sensors to estimate the vehicle's attitude.

The error in the attitude estimate for the vehicle will have a direct impact on the error in the final PNT solution. The purpose of this work is to analyze the effect of sensor noise on the final position solution, both in the angular rate sensor and tri-axis magnetometer, as well as the directional sensitivity of the signal detector. A combination of simulation data and hard x-ray and gamma-ray observatories is used to demonstrate the dependence of position solution accuracy on the quality of sensors used to determine attitude. This work will be used to inform the design of the attitude determination systems on-board EXACT and SOCRATES, as well as future missions that use navigation from astrophysical signals of opportunity.