21st IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Satellite Operations (3)

Author: Dr. Joseph Gangestad
The Aerospace Corporation, United States

Mr. Darren Rowen
The Aerospace Corporation, United States
Mr. Brian Hardy
The Aerospace Corporation, United States
Dr. David Hinkley
The Aerospace Corporation, United States

FLYING IN A CLOUD OF CUBESATS: LESSONS LEARNED FROM EARLY-ORBIT OPERATIONS OF AEROCUBE-4 AND AEROCUBE-5

Abstract

The recent development of key technologies such as the P-POD and the Aft Bulkhead Carrier has made possible the mass deployment of CubeSats—up to two dozen or more—in a single launch. But immediately after deployment, all of the CubeSats occupy the same orbit with very little along-track separation, and tracking individual vehicles is challenging. Most CubeSat programs rely on Two Line Elements (TLEs) released by the Joint Space Operations Center (JSpOC) to make contact with their satellites, but a period of up to two weeks may elapse before the JSpOC can correlate radar tracks to specific vehicles and correctly tag the TLEs. In the meantime, most programs can count on only intermittent contact with their CubeSats. In September 2012, The Aerospace Corporation (Aerospace) launched three 1U CubeSats—known as the "AeroCube-4" series—as secondary payloads on an Atlas V launch vehicle from Vandenberg Air Force Base. More than a year later in December 2013, two more 1.5U CubeSats—the "AeroCube-5" series—launched. In each case, approximately one dozen total CubeSats were deployed by the launch vehicle, of which the AeroCubes occupied one of eight P-PODs. Every AeroCube vehicle carries a GPS receiver that provides a position fix to a precision of approximately 20 meters. Performing high-fidelity orbit determination on a series of fixes yields an ephemeris that can, in turn, be converted into a TLE that is known to correlate exactly to the individual vehicle in question. These "homemade" TLEs enable regular communications with the AeroCubes very shortly after launch. This paper will discuss the early-orbit operations process and lessons learned for the AeroCube program and highlight recent experience with AeroCube-4 and -5. By prioritizing GPS acquisition, high-fidelity ephemerides and TLEs for both AeroCube-5 vehicles were available 6 hours after deployment, and regular tracking with GPS allowed the Aerospace operations team to create new TLEs on a daily basis while awaiting the JSpOC solution. Aerospace has developed a positive, collaborative relationship with the JSpOC; providing high-fidelity ranging data of the AeroCubes assists analysts at the JSpOC with correlating radar tracks in their own data set. Furthermore, the AeroCube program has learned the value of including early-orbit operations as a key factor in satellite design: expecting two weeks of intermittent or no contact on orbit has ripple effects through a CubeSat's communication, power, and thermal subsystems.