On-Orbit Performance & Operation of the Attitude & Pointing Control Subsystems on ASTERIA

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SSC18-PI-34

Mission Overview

The Arcsecond Space Telescope Enabling Research in Astrophysics (ASTERIA) is a 6U CubeSat that was designed, integrated, and operated by the Jet Propulsion Laboratory (JPL) and traces its roots back to the ExoplanetSat project led by the Massachusetts Institute of Technology. It was launched on 14 August 2017 aboard the SpaceX CRS-12 mission to the International Space Station (ISS) and was deployed from the ISS on 20 November 2017 at an altitude of 400 kilometers and inclination of 51.6 degrees.

The underlying goal of the mission is to image and perform photometry on bright, nearby stars and possibly detect transiting exoplanets orbiting these stars. As a technology demonstration with an eye to enable this science, the payload must be pointed with a stability of 5 arcseconds RMS over 20-minute observations and a repeatability of 1 arcsecond RMS across multiple observations.

On-Orbit Pointing Results

Shown below is one representative example of the pointing performance while observing a star field around HD 219134. For this particular star field, the pointing repeatability was 1 milliarcsecond RMS from observation to observation and the pointing stability was 0.5 arcsec RMS over 20-minute observations. This is the best pointing performance achieved to date on a spacecraft this size. The pointing performance does vary with the number and brightness of the guide stars used. See the paper for further results on different star fields.

Pointing Control Approach & Software

A two-stage control system was employed to achieve the pointing requirements. A set of three reaction wheels controls the attitude of the spacecraft bus while a two-axis piezo stage translates the focal plane array orthogonal to the payload boresight relative to the lens to control the pointing of the payload. Up to eight 64-by-64-pixel windows are used to image stars at 20 Hz to provide the sensor feedback for the pointing control algorithms:

- Centroiding: Computes the centroids of the stars in each of the windowed images.
- Target size centering: Computes an offset used to remove the bias of the target star position.
- Pointing control: Computes the piezo stage position to stabilize the stars.
- Piezo & roll offload: Computes the quaternion command to keep the piezo stage roughly centered and remove roll error bias.

For More Information