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GOES-17 Magnetometer On-Orbit Calibration Design and Results

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The Geostationary Operational Environmental Satellite-R (GOES-R) is a series of four NOAA weather satellites. Each spacecraft flies a Magnetometer instrument which includes two boom mounted fluxgate sensors located 6.3 and 8.5 meters from the spacecraft. Sensor readings are corrupted by both internal (bias and scale factor) and external (spacecraft emitted fields and misalignments) error sources. In order to estimate the bias, an on-orbit calibration is performed, slewing the spacecraft about multiple axes and then performing a fit of the data to determine zero offset and misalignment terms.

The first satellite in the series, GOES-16 was launched in November 2016. Its magnetometer calibration maneuver was found to be inadequate providing insufficient rotation about orthogonal axes. The uncertainty in the estimated biases was found to be in the 3-5 nanotesla range, exceeding the magnetometer accuracy requirement of 1.0 nanotesla.

Based on lessons learned, the maneuver was redesigned to provide multiple 360 degree rotations about two orthogonal axes, providing optimal visibility into bias and misalignment. Varying ambient fields over the duration of the calibration maneuvers, corrupts the ability to accurately determine parameters of interest. To address this issue, rather than assuming a constant field for the duration of the maneuver, a non-linear least squares filter was employed that uses a series of spline functions to better fit the ambient field. The number of splines can be varied to minimize the least squares filter residuals. Simulations were performed using 360 days of GOES-16 data to bound the uncertainty in the biases for given residuals of the fit to the ambient field.

Following the launch of the second satellite in the series, GOES-17 in March 2018, the new calibration maneuver and enhanced bias estimation algorithm were exercised twice. Based on the residuals of the fit, the uncertainty of the estimated zero offset was reduced by an order of magnitude from 3-5 nanotesla to approximately 0.4 nanotesla per axis. This paper provides details of the maneuver design and the innovative algorithm used to estimate the GOES-17 biases and misalignments.