Sensor Calibration and Testing for Hosted Small Satellite Payloads

Examining small satellite payload calibration testing processes and methods, including accuracy and precision, to discover ways to reduce cost and schedule while still meeting mission requirements.

1:20

Radiometric Calibration of SkySats Using Near-Simultaneous Crossovers with Sentinel-2 over Calibration Sites

Hannah Bourne, Arin Jumpasut, Alan Collison – Planet

ABSTRACT: Planet Labs currently operates a fleet of 21 high resolution Earth observation satellites known as SkySats. These sub-meter resolution satellites have high intra-day revisit rate capabilities, can image scenes in a range of viewing angles, create 3D scene composites and take videos even in regions traditionally difficult to observe due to low satellite capacity. The radiometric calibration of other satellite models within Planet’s fleet (Dove Classic, Dove R and SuperDove) is currently achieved using simultaneous crossovers with Sentinel-2. Radiometric calibration of SkySat imagery using Sentinel-2 poses unique challenges as it has relatively wide spectral bands and frequently takes images off-nadir. In order to achieve optimal radiometric calibration, SkySats are tasked to image Radiometric Calibration Network (RadCalNet) and Pseudo Invariant Calibration (PIC) sites daily to generate numerous near-simultaneous crossovers of these sites with Sentinel-2. Using a reference satellite to cross-calibrate is a common approach in radiometric calibration, however bidirectional reflectance distribution (BRDF) effects may affect accuracy especially if the viewing angles of the satellites are substantially different. Here we will discuss some of the current challenges and effects of applying this approach to SkySat imagery.

1:45

Improving the Radiometric Calibration of the Heterogeneous Planet Dove Fleet using Near-Simultaneous Crossovers with Sentinel-2 and Lunar Observations

Alan Collison, Arin Jumpasut – Planet

ABSTRACT: Planet currently operates a constellation of over a hundred satellites that collect a current image of the Earth each day. These satellites were launched over several years and cover several evolutions in design. This presentation will describe the process of updating the calibration of all the Planet Dove satellites using the archive of data in preparation for a new product release to customers in the summer of 2021. The on-orbit calibration methodology will be described combining simultaneous crossovers and lunar observations as well as results using the updated calibration. Research of per-scene harmonisation with a Sentinel-2 reference will also be shown demonstrating improvements in interoperability across different satellite generations.

2:10

Radiometric Calibration of the Rogue-Alpha, Beta Short Wavelength Infrared Sensors

Jon Mauerhan, John Santiago, Paul Zittel, Dee Pack – The Aerospace Corporation

ABSTRACT: We report on the ground and on-orbit radiometric calibration of the SWIR sensors on the Rogue Alpha/Beta CubeSats. Also known as AeroCube 15 A and B, this rapid prototype constellation comprised of two 30x10x10-cm CubeSats flying commercially available InGaAs cameras, was boosted into low Earth orbit on 14 January 2020. The sensor optics are outfitted with a narrowband filter centered within the atmospheric H2O overtone absorption band near 1.4 microns. Pre-flight calibration activities in the lab at the Aerospace Corporation included characterization of sensor linearity and pixel-to-pixel uniformity through the filtered optical system, and radiometric response was derived using measurements of Lambertian scattering surfaces illuminated by incandescent sources. In-flight radiometric calibration of both the SWIR sensors and visible-wavelength context cameras were performed via observations of stars Betelgeuse, Antares, Sirius, and Vega; these stars are frequently observed by our Astronomy Field Observations team at Aerospace and their modeled spectral energy distributions are utilized for radiometric calibration of various visible and infrared sensors. A dithered pointing strategy was used for imaging, enabling timely subtraction of the dark signal. The SWIR radiometric responses derived from each star are in excellent agreement with each other,
and also with the pre-flight lab radiometry. We discuss our methodology, results, application to a sample Earth image, and lessons learned for future programs.

2:35

**Evaluating Radiometry within a Heterogenous Satellite Fleet Via Continuous Moon Monitoring**

Michael Medford, Arin Jumpasut, Hannah Bourne, Kattia Flores Pozo – Planet

ABSTRACT: Planet currently operates a constellation of hundreds of satellites that collect multiple images of the Earth each day, constructing an historic daily catalog of the Earth’s surface taken over the past four years containing millions of images. Innovations in satellite and camera design over the past few years have resulted in a constellation containing several generations of instruments that require relative and absolute radiometric calibration to produce a seamless imaging product. We use the moon as a natural stable reference unencumbered by atmospheric effects present while nadir imaging and have amassed a database of over nine millions images of the moon taken by all of the satellites within our fleet since Q4 of 2016. We will present results on our lunar processing pipeline that leverages routinely automated near simultaneous imaging of the moon over the entire constellation to reduce intra-flock variations. We will discuss how lunar images help us detect hazing and scattered stray light across the image plane, as well as monitor imaging stability over our instruments’ lifetime.

3:00

**ACCURACy: Adaptive Calibration of Cubesat Radiometer Constellations**

John Bradburn, Henry Ashley, Mustafa Aksoy – University at Albany, SUNY

ABSTRACT: Recent technological advancements enable the cost-effective deployment of constellations of CubeSats. Constellations of radiometer equipped CubeSats have great potential for use in scientific missions for remote sensing objectives including weather tracking and storm imaging, climate change measurement, and atmospheric science, to name a few. While CubeSats provide a solution to challenges in cost, weight, and power, there exist drawbacks which make radiometer calibration more difficult, specifically due to increased sensitivity of the instrument to ambient conditions, resulting from the lack of an adequate thermal control system. To address this problem, a novel, constellation-level calibration framework is being developed called “Adaptive Calibration of CubeSat Radiometer Constellations (ACCURACy)”. ACCURACy clusters radiometers together using instrument-level telemetry data to identify radiometers in similar states, leveraging a relationship between radiometer gain and instrument telemetry data. These clusters are used to identify when radiometers make calibration measurements while in similar states and store these calibration measurements and times in calibration pools to calibrate other radiometers that are in a similar state in the future. This paper discusses the development of ACCURACy including a MATLAB framework and radiometer data simulator, as well as the performance of ACCURACy compared to current state of the art calibration techniques for constellations of CubeSats.