The MicroMAS CubeSat Mission: Demonstration of a Core Element of Atmospheric Constellation Sensing[1]

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The Micro-sized Microwave Atmospheric Satellite (MicroMAS) is a 3U CubeSat (30x10x10 cm, ~4kg) hosting a passive cross-track-scanning microwave spectrometer operating near the 118.75-GHz oxygen absorption line. MicroMAS aims to address the need for low-cost, mission-flexible, and rapidly deployable spaceborne sensors. The focus of the current MicroMAS mission is to observe convective thunderstorms, tropical cyclones, and hurricanes from a near-equatorial orbit. As a low cost platform, MicroMAS is a core element of a new observing system comprising multiple satellites in a constellation that can provide near-continuous views of severe weather. The existing architecture of few, high-cost platforms, infrequently view the same earth area thus potentially missing rapid changes in the strength and direction of evolving storms leading to degraded forecast accuracy. MicroMAS is a scalable CubeSat-based system that will pave the path towards improved revisit rates over critical earth regions, and achieve state-of-the-art performance relative to current systems with respect to spatial, spectral, and radiometric resolution. The current MicroMAS mission will demonstrate the viability of CubeSats for high fidelity environmental monitoring and space control that would provide profound advances by reducing costs, by at least an order of magnitude, while increasing robustness to launch and sensor failures.

The MicroMAS radiometer is housed in a 1U (10 x 10 x 10 cm) payload section of the 3U (10 x 10 x 30 cm) CubeSat. The payload is scanned about the spacecraft's velocity vector as the spacecraft orbits the earth, creating crosstrack scans across the earth's surface. The first portion of the radiometer comprises a horn-fed reflector antenna, with a full-width at half-maximum (FWHM) beamwidth of 2.4°. Hence, the scanned beam has an approximate footprint diameter of 17 km at nadir incidence from a nominal altitude of 400 km. The antenna system is designed for a minimum 95% beam efficiency. The next stage of the radiometer consists of superheterodyne front-end receiver electronics with single sideband (SSB) operation. The front-end electronics includes an RF preamplifier module, a mixer module, and a local oscillator (LO). The RF preamplifier module contains a low noise RF amplifier and a weakly coupled noise diode for radiometric calibration. The mixer module comprises a HEMT diode mixer and an IF preamplifier MMIC. The LO is obtained using a 30-GHz dielectric resonant oscillator (DRO) and a resistive diode tripler to obtain a 90-GHz LO frequency.

A key technology development in the MicroMAS radiometer system is the ultra-compact intermediate frequency processor (IFP) module for channelization, detection, and analog-to-digital conversion. The antenna system, RF front-end electronics, and backend IF electronics are highly integrated, miniaturized, and optimized for low-power operation. The payload also contains microcontrollers, one of which is used in the payload interface module (PIM), to package and transmit radiometric and housekeeping data to the spacecraft bus. A voltage regulator module (VRM) was also designed for the payload to convert the input bus voltage to the required voltages for the payload electronics.

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