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THE DESIGN EVOLUTION OF A NEXT-GENERATION MICROSATELLITE GREENHOUSE GAS MONITORING CONSTELLATION

Abstract

Since 2016 the Space Flight Laboratory (SFL), in partnership with GHGSat Inc., has successfully developed and launched nine greenhouse gas monitoring microsatellites into orbit. Beginning with the technology demonstrator, GHGSat-D (Claire), subsequent satellites have introduced new technological innovations, resulting in significant performance improvements in each successive commercial satellite. These microsatellites, engineered by SFL, have pioneered the detection of methane emissions from human activities with remarkable geospatial precision, a feat facilitated by SFL's Next Generation Earth Monitoring and Observation (NEMO) platform tailored for earth-observation missions. Each spacecraft is equipped with a compact infrared imaging spectrometer and auxiliary imager, complemented by SFL heritage subsystems for power generation, data management, attitude control, and communication. To date the GHGSat constellation has produced groundbreaking observations of methane emissions from over half-a-million facilities worldwide. Following the successful launch of Claire, GHGSat-C1 (Hugo) and C2 (Iris) marked the initial phase of commercial deployment, incorporating upgrades to enhance data transmission and reliability. These enhancements include an improved downlink transmitter, integration of new payload computer technology, and the addition of a fourth skew reaction wheel to ensure redundancy in attitude control. Subsequently, six more GHGSat spacecraft—C3 (Luca) through C8 (Océane)—were launched in two clusters, boasting significant improvements to the communication system, notably featuring a dedicated X-band downlink chain for the instrument. The new payload computer, having gained flight heritage, now replaces the original payload computer in the instrument. A custom launch-vehicle adaptor was developed and used across two launches to deploy each three-satellite cluster, maximizing utilization of the mass capacity of a single launch vehicle port. To streamline ground station operations and maximize coverage for instrument observation tasking, satellites within each cluster are strategically spaced along their orbits, covering a relative along-track distance of approximately 14,400 kilometers. Employing a novel formation control technique that utilizes differential atmospheric drag eliminates the need for a propulsion system. These ongoing innovations underscore the continued leadership of this small satellite constellation in methane emission detection, setting industry benchmarks for performance and efficacy.