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SMALL SATELLITE DESIGN FOR HIGH-RESOLUTION METHANE EMISSIONS MONITORING

Abstract

Anthropogenic greenhouse gas emissions have significantly contributed to the Earth's global temperature increase by disturbing the atmosphere's energy balance. In particular, methane, whose presence is partly attributed to fossil fuel production and use, has gained significant attention due to its high heat-trapping potential. Given its short atmospheric lifetime, reducing methane emissions can have significant short-term impact on global warming and limit its consequences. Accurately measuring these emissions is therefore crucial to mitigating them and supporting transparent policy implementation. However, real-time monitoring of individual methane emission sources using small satellite platforms poses a significant engineering challenge. In fact, the spacecraft's low size, weight and power (SWaP) heavily constrain instrument performances, on-board processing capabilities and communication link speeds. In this study, we present a 6U CubeSat design for real-time monitoring of point-source methane emissions from low Earth orbit, with an emphasis on the satellite bus specifications and payload requirements.

High spatial resolution of the spacecraft mission is achieved through enhanced data fusion algorithms of two instruments on-board the platform, an infrared spectrometer and an atmospheric LiDAR sensor. Furthermore, the small satellite is equipped with a novel neuromorphic on-board computer, enabling efficient real-time processing and autonomous operations through efficient neural networks. First, the mission and technical requirements allowing to meet the mission objectives are outlined. Then, a trade-off study between different spacecraft buses is presented, with an emphasis on meeting the sub-system technical requirements. The chosen bus is validated against mission specifications using a 3D model, a mass, power, and communications link budget, and thermal and structural simulations, after which the payload integration requirements are defined. Lastly, a life-cycle study is used to assess the project's

sustainability.

Through multi-sensor data fusion and neuromorphic computing, the baseline satellite design presented in this work presents an innovative, low-cost method for greenhouse gas detection. The proposed mission can help to achieve global greenhouse gas reduction targets by mitigating undesired emissions. Such technology is essential in promoting a more ecologically conscious and sustainable future on a global scale, as it provides an adaptable solution that establishes the benchmark for replicable and scalable models.