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VERIFICATION AND VALIDATION OF AN OPTICAL CUBESAT PAYLOAD FOR STRATOSPHERIC AND ORBITAL MISSIONS

Abstract

The increasing congestion of Earth's orbital environment has made the detection, tracking, and characterization of Resident Space Objects (RSOs) a critical challenge for space situational awareness (SSA) and space debris mitigation. Optical payloads designed for high altitude and small satellite platforms must operate in extreme thermal and mechanical conditions while maintaining high imaging fidelity. However, verification and validation (V&V) processes for these payloads remain complex, as ground-based tests often do not fully replicate the orbital spaceflight environment. To bridge this gap, a structured multi-phase test campaign has been developed to be used for testing and V&V for the SOBER optical payload, designed using a CubeSat standard, and can be validated in similar flight environments before full mission deployment. This paper presents V&V methodology and results from three key test phases. Phase 1 consists of thermal vacuum and vibration testing, replicating launch and flight conditions to evaluate the payload's mechanical integrity, thermal stability, and imaging performance in a pressure vacuum. Phase 2 is field testing in extreme environments, conducted in a high-latitude and dark zone to assess system performance under rapid temperature cycling and varying illumination at ground level. Phase 3 is aircraft environment testing, leveraging a high-altitude research flight test to validate optical performance and data capture in reduced pollution environment before final platform deployment. A key focus is the validation of the payload, consisting of a visible-light camera and a longwave infrared sensor to capture raw image data about RSO signatures across multiple spectral bands with telemetry information. The phased testing ensures sensor performance is characterized under ranges of atmospheric conditions, including controlled vacuum environments, real-world scenarios with cloud cover, temperature & force extremes, and fluctuating radiative backgrounds. By cross-referencing results from laboratory, field, and airborne tests, this approach provides a robust dataset to improve calibration models and validate imaging algorithms before final deployment. The last phase of this test campaign will be the launch of SOBER payload onboard the ESA BEXUS 37 high-altitude balloon, where the payload will undergo near-space validation at 27–30 km altitude. This final test confirms sensor performance in a space-like thermal and optical environment, providing critical insights into atmospheric interference effects and imaging system limitations. The structured V&V framework outlined in this study enables a scalable and cost-effective methodology for qualifying optical payloads for both high-altitude and orbital applications, supporting future SSA and Earth observation missions.