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THERMO-MECHANICAL DESIGN AND ANALYSIS OF A MULTISPECTRAL IMAGING PAYLOAD USING PHASE CHANGE MATERIAL

Abstract

CubeSats are on the rise in the last decade and have the potential to substitute big, expensive satellites in many commercial and scientific applications. A reasonable commercial application of these standardized small satellites are Earth Observation constellations with medium spatial, and high temporal resolution. The company Orbital Oracle Technologies GmbH (OroraTech) works on such a constellation of CubeSats to detect and monitor wildfires and other high-temperature events. One of the design challenges for any small satellite with high power instruments is thermal design and its thermal stability. The changing thermal environment of the low-earth orbit, the varying power consumption and thereby thermal activity of sensors and processing units combined with the low thermal inertias of small satellites create a challenging simulation and design task for the design of small satellites. In the case of OroraTech, each 3U CubeSat is equipped with an infrared sensor ensuring a resolution of 200m/pixel. The thermal stability of the sensor is a main driver of the design of the satellite, in order to achieve a reasonable measurement quality. Furthermore mass, volume and power restrictions of 3U CubeSats, but also the design for robustness of the satellite, limit the application of active thermal control for this use case. Thus, in a research collaboration between OroraTech, the Technical University of Munich and Fraunhofer IGCV this problem was addressed using a passive thermal control mechanism using phase change material (PCM) and thereby trimming the thermal inertia to achieve the desired stability and robustness. This paper will report on the different structure approaches, PCMs and additives that were investigated and the respective layout calculations to optimize the design with regard to thermal stability. Selected structure approaches which have been produced in metal by the additive manufacturing process laser-based powder bed fusion will be presented. The feasibility to implement PCMs in the hollow additive manufacturing part and tests of these PCM-designs in a thermal vacuum chamber will be discussed. The final design and its validation through thermal analysis in COMSOL and ESATAN-TMS and through structural analysis are also addressed. The presented passive thermal control mechanism will ensure the thermal stability for the first IOV mission of OroraTech, which is scheduled for launch in Q1 2021.