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GUIDELINES FOR DEVELOPING A HIGH FIDELITY CUBESAT THERMAL ANALYSIS

Abstract

Canadian Space Agency launched the Canadian CubeSat Project (CCP) in 2018. 15 teams from post-secondary institutions across the country were selected, with each team responsible to design, build, test, launch and operate a 2U or 3U CubeSat. Currently, the project is in Phase C with CDR planned for early 2021. Space Concordia's Orbital Dust Imaging Nanosatellite (SC-ODIN) from Concordia University seeks to retrieve dust aerosol optical depth measurements over large geographic regions from low-earth orbit. To ensure reliable operation of the spacecraft, critical on-board components must be maintained within operational and survival ranges at all stages of the mission. As such, an accurate estimation of temperature distributions through a thermal analysis must be conducted to assess requirements compliance and the need for a thermal control system.

Generally speaking, thermal modelling and design for spacecrafts is not covered in the undergraduate engineering curricula and this poses a significant challenge to student CubeSat projects. A survey on CubeSat papers indicates that some teams build their thermal model using MS Excel. However, this can only provide rudimentary results at a systems level. For spacecrafts, a professional thermal modelling software is necessary to accurately capture the thermal environment. Even so, there are very minimal online resources on the utilization of these specialized software for CubeSat applications. This paper serves as a guideline for students taking part in their own low-earth orbit CubeSat mission by highlighting the objectives that must be reached in the process of performing a software-run thermal analysis and the various methods employed to do so. The definition of environmental parameters of solar flux and Earth-specific heat loads for worst case scenarios in low-earth orbit is discussed as well as computational methods of evaluating the spacecraft's equilibrium temperature. In addition, several approaches used in finite element analysis of properties definitions and geometry modelling are presented with the aim of familiarizing students with methods and assumptions tailored for a miniaturized satellite. This paper is therefore intended to fill in a knowledge gap on thermal analyses in student CubeSat projects worldwide.