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IN-ORBIT THERMAL CHARACTERIZATION OF A 3U CUBESAT AND VALIDATION OF AN IN-HOUSE DEVELOPED TOOL FOR THERMAL ANALYSIS

Abstract

Politecnico di Torino is launching a 3U CubeSat, mostly developed by students. The CubeSat is equipped with 32 temperature sensors positioned on interesting points, allowing a comprehensive thermal characterization of the spacecraft in the space environment. The measured data is used to validate the results of the thermal analysis carried out by a tool developed in-house by the System and Technologies for Aerospace Research (STAR) group. This paper aims to collect and analyse the data collected in orbit

to complete the validation of the simulation tool.
The objective of the thermal analysis was to design the thermal control system (TCS) of the spacecraft and to evaluate its performance. The thermal analysis performed calculates the temperature distribution on the spacecraft and its evolution through time, thus solving a transient problem. The thermal model used to design the TCS of the mission is a lumped-parameter representation of the spacecraft, where the geometries are discretised with nodes having the properties of the surrounding volumes. After defining also the orbit and the environmental heat sources, at every time step a linearized system that considers radiative and conductive heat exchanges of every node is solved. The equations are formulated using the governing differential equation and solved using the finite difference method. This method is compatible with basic geometrical primitives (e.g. planar shapes, cuboids, etc.) that represent, in approximation, the real geometry of the internal components. The thermal model was implemented first using a MATLAB(R) based application developed by the STAR group. This tool allows the thermal analysis of CubeSat (up to 12U).
The first iteration of the thermal analysis was carried out using this tool. The spacecraft structure was modeled as an empty box and the subsystems with planar 2D "board-like" geometries, interconnected by node-to-node thermal links that represent the contact interfaces. For every internal component, a thermal dissipation was assigned, considering the average power consumption value derived from the operative modes of the mission.
As a specific application, the design process focused on the battery, which is one of the most critical components due to its lower temperature limit of 0C. The most effective solutions were found to be insulating the battery from the spacecraft structure, thermally linking the CDH assemblies to the battery holder, and choosing an appropriate high-absorptivity surface finish for the external panels.