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CUBESAT THERMAL MANAGEMENT SYSTEM DESIGN SUPPORTED BY MULTIOBJECTIVE DESIGN OPTIMIZATION

Abstract

The future for small satellites depends on the increments of performance and reliability of enabling and critical technologies such as navigation, propulsion, communications and thermal management. The last one is a challenging area of research, especially for missions with stringent thermal requirements such as astrobiology experiments, or observation in particular spectral bands (e.g. IR imaging payloads). To meet these requirements, the thermal engineer has to design the Thermal Control System, which has the purpose to keep the temperature of the equipment of the spacecraft inside the temperature limits for each mission phase. The research presented in this work can be framed in the field of thermal analysis and thermal design for space application, and it is targeted to miniaturised spacecraft, such as CubeSats and nanosatellites in general. In particular, the purposes of this research are 1) to develop a thermal analysis tool tailored to small space platforms, for the early design phases 2) to develop solutions for the thermal management system of small platforms. Therefore, to achieve these objectives effectively, a tool, named Small Satellite Thermal tool (S2T2), that supports both thermal analysis and thermal design, is developed in MATLAB® environment. Through the application, mission and platform data are provided to perform the first iteration of the thermal analysis, then, if the temperatures of the equipment result to be out of the operative range, the tool starts searching the optimal solution of the Thermal Management System according to an iterative process until convergence is achieved. At the end of the optimisation process, the solution is proposed to the analyst for final assessment and acceptance. An algorithm is integrated into S2T2 to speed up the thermal design task, using the thermal analysis with the support of the Multi-Objective optimisation exploiting the Multi-Design analysis. The purpose of this algorithm is to find the right combination of active and passive TMS solutions to meet the thermal requirements considering different surface finishes, thermal straps and heaters. . The methods and tool have been applied considering a 12U cubesat mission in LEO. For this mission, the use of heaters and thermal straps for critical items, such as pack batteries, is suggested to maintain the temperature in the operative range. The results are reported in this paper and particular attention is given to foster the use of a passive thermal control system in order to limit the power demanding.