UNITED NATIONS
Office for Outer Space Affairs

United Nations/Brazil Symposium on Basic Space Technology
"Creating Novel Opportunities with Small Satellite Space Missions"

NATAL, BRAZIL, 11 - 14 SEPTEMBER 2018

Thermal Analysis of the SPORT Project

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Abstract - SPORT Project is an international partnership between NASA, Goddard Space Flight Center, American Universities (UTD - University of Texas at Dallas, USU - Utah State University, UAH - University of Alabama in Huntsville), Private Aerospace Inc, the National Institute for Space Research (INPE) and the Technical Institute of Aeronautics at the Department of Aerospace Science and Technology (DCTA / ITA) in Brazil . This paper presents the thermal analysis for the SPORT Project on the orbital environment. The objective is to characterize the temperature distribution inside the spacecraft and verify the need for thermal control methods that accomplish the system requirements. The sources of energy on Low Earth Orbit are the direct solar radiation, Earth's albedo and irradiance, that behave as external heat loads. Internal heat loads are provided by the power dissipation from the electronic equipment. The thermal model was developed using Thermal Desktop and the numerical solver SINDA, both from C&R Tech. As a simplification, the simulation scenarios were the cases with critical high or low temperatures which correspond to beta angle zero and 74 degrees for the orbit parameters of the mission.

INTRODUCTION

This work presents the preliminary thermal analysis of the SPORT CubeSat. The analysis was based on a thermal mesh built over the mechanical model, the power dissipated by the equipment as internal thermal loads and the space environment as an external heat source.

The internal conduction and radiation processes among the elements and radiation to the space were considered. The results presented here correspond to the transient response of the elements' temperatures for a period of 10 orbits and indicate that the systems remained within the limits of operation.

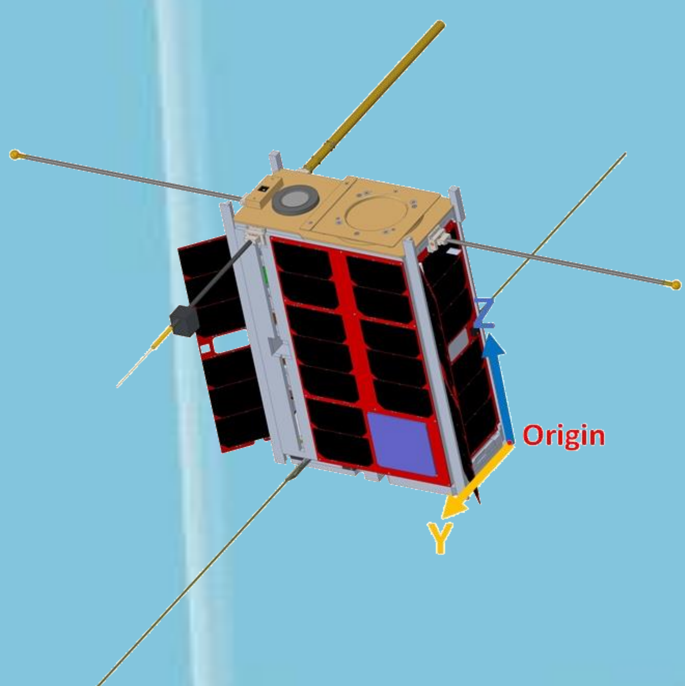


Figure 1 - SPORT

METHODOLOGY

The analysis was based on finite differences and the finite element method, considering the power dissipated by equipment and solar energy as heat source. The leakage and radiation processes between the elements and radiation to space were considered. The software used for the simulation was Thermal Desktop and SINDA, both from C&R Technologies. The results are displayed for the elements that are critical and indicate if the systems remain within the limits of operation.

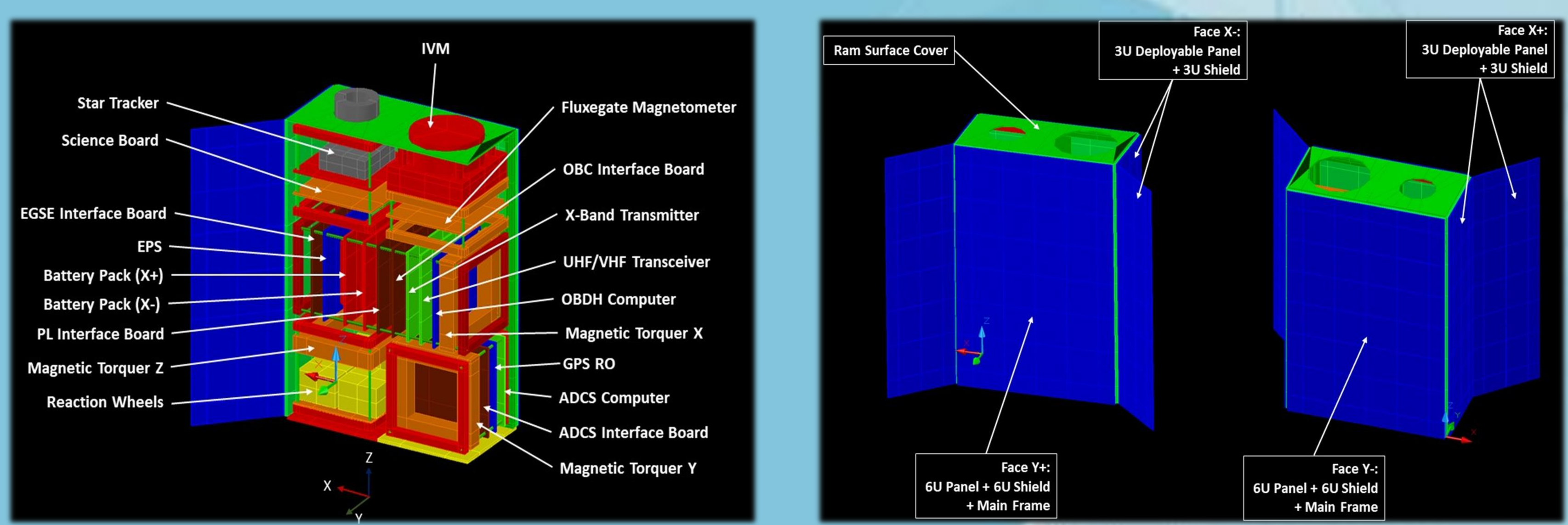


Figure 2 - Thermal Model

The Thermophysical and Thermo-optical properties used are shown below:

Table 1 - Thermophysical Properties [1]

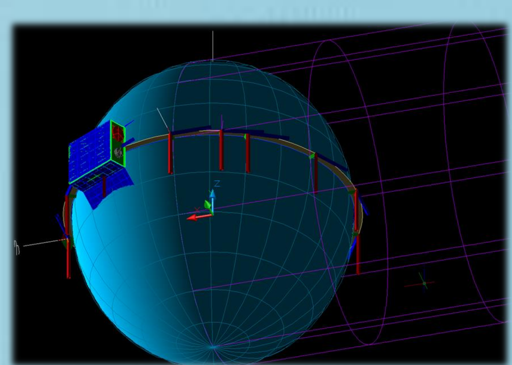
Material	K (W/mK)	Density (kg/m³)	Cp (J/kgK)
Aluminum	177	2710	960
Fiberglass	0.6	2080	1680

Table 2 - Thermo-Optical Properties Parameters [1]

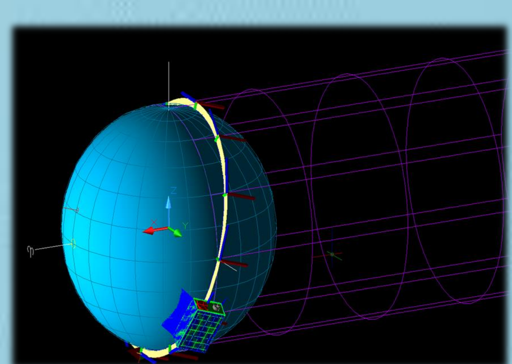
Material / Covered	Solar Absorptivity (α)	IR Emissivity (ε)
Anodized aluminum	0.86	0.86
Chromic aluminum	0.5	0.5
Solar Panel	0.735	0.91
Fiberglass	0.75	0.75

SPORT's orbit has an altitude of 400 km and is considered a Low Earth Orbit (LEO).

Cold Case Scenario:
The cold case occurs when the satellite spends the longest time in the eclipse period. This occurs when the angle **β** is **0º**.



Hot Case Scenario:
The hot case occurs when the satellite receives thermal load for the longest time. This occurs when the angle **β** is **+74º**.



RESULTS

Cold Case:

Hot Case:

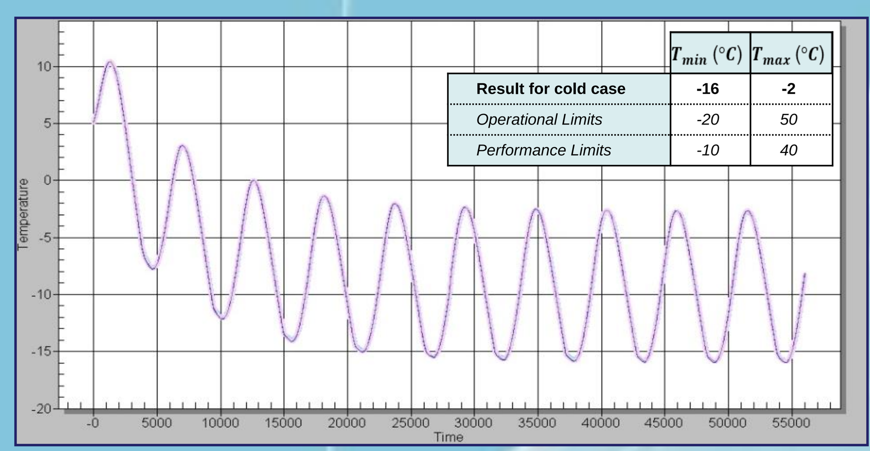


*Figure 3 - **IVM** Temperature Variation Over Time*

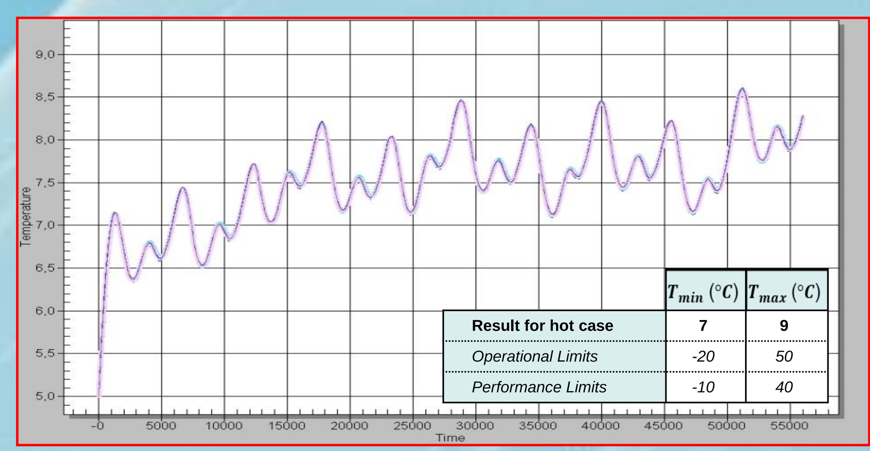


*Figure 4 - **IVM** Temperature Variation Over Time*

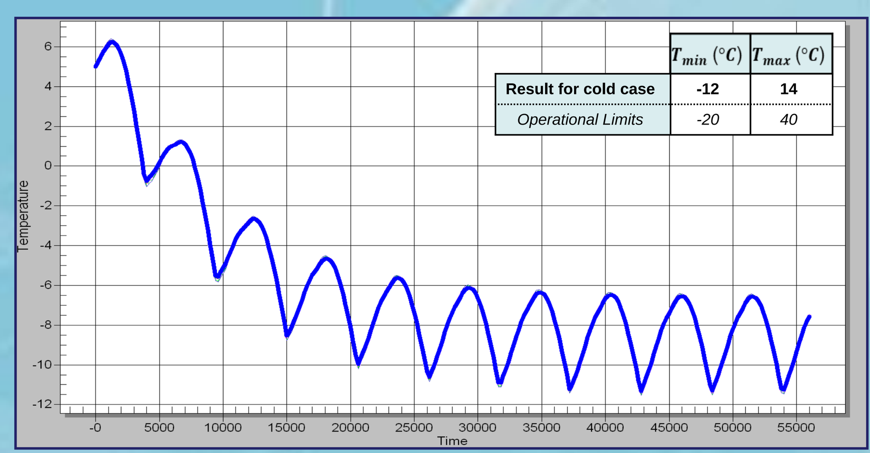


*Figure 5 – **Star Tracker** Temperature Variation Over Time*

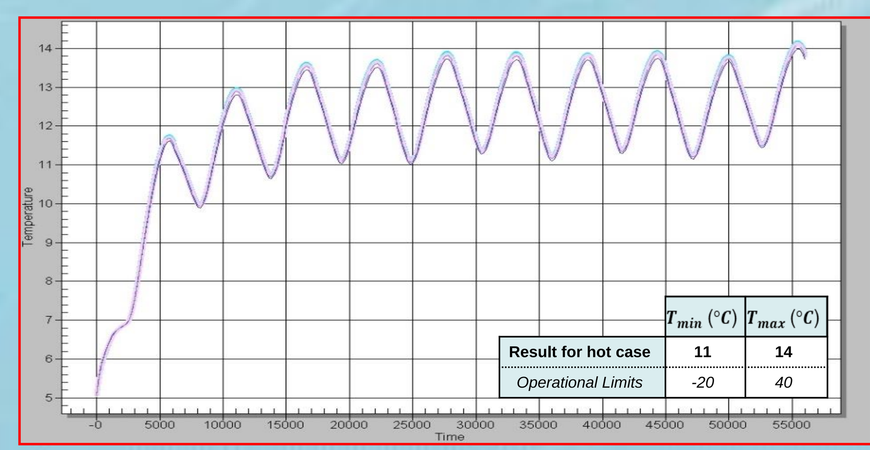


*Figure 6 – **Star Tracker** Temperature Variation Over Time*

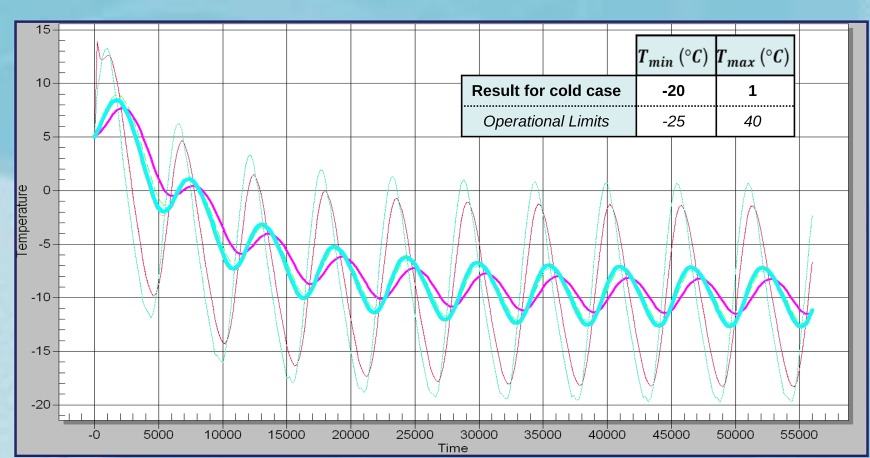


*Figure 7 – **X-Band Transmitter** Temperature Variation Over Time*

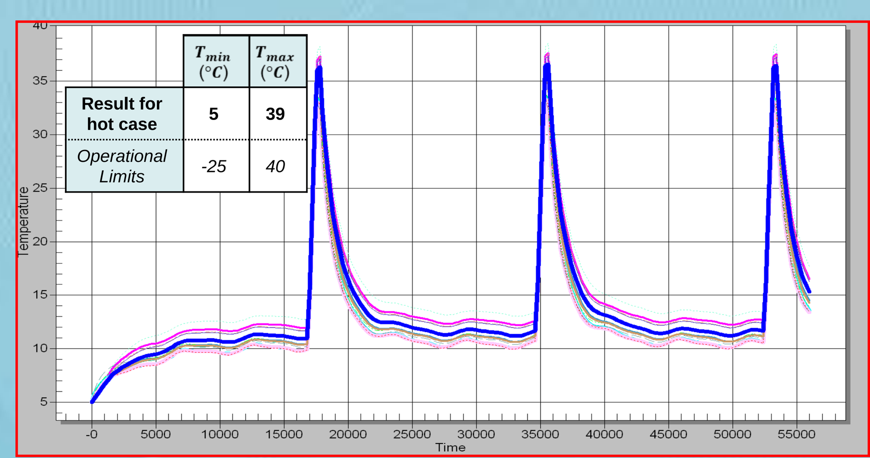


*Figure 8 – **X-Band Transmitter** Temperature Variation Over Time*

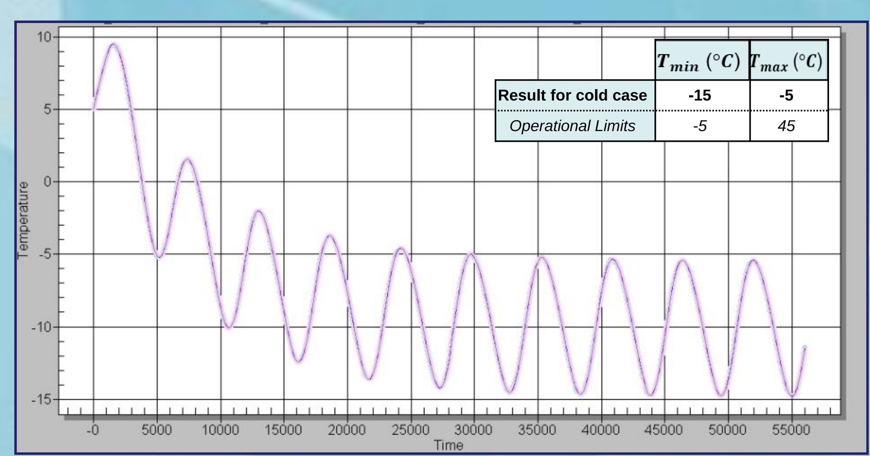


*Figure 9 – **Battery Pack** Temperature Variation Over Time*

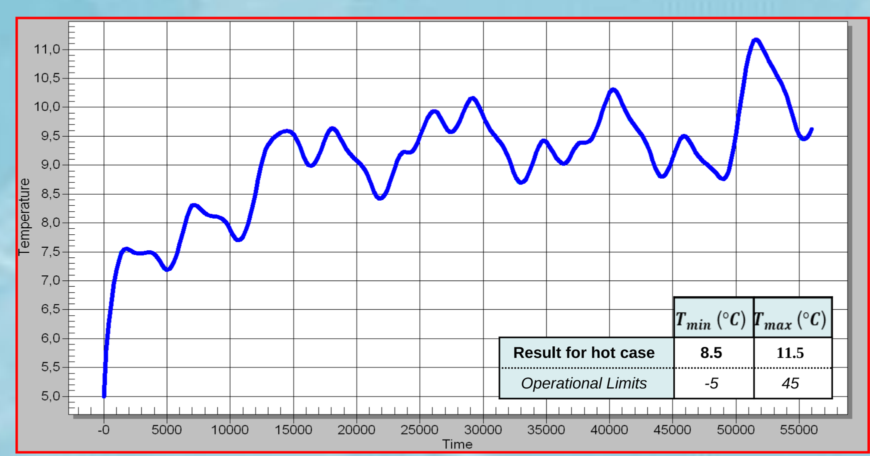


*Figure 10 – **Battery Pack** Temperature Variation Over Time*

CONCLUSION

This preliminary thermal analysis showed the results of the most fragile and critical equipment. The main objective of this study was to check if those equipment remained within operational temperature limits.

The results showed a tendency of battery to operate in a critical range during the cold case scenario. However this may be due to the batteries'' heater system not being considered.

The thermal load on the X-Band Transmitter was applied for 3 minutes during the hot case scenario and the results almost reach the operational limits.

REFERENCE

[1] Machado, H. A., **Análise Térmica Preliminar do Microsatélite SPORT**, Institute of Aeronautics and Astronautics, Technical Report, September, 2017.

[2] Rodrigues, M. P., **Projeto e Análise do Controle Térmico para Microsatélite Universitário ITASAT-1**. Institute of Aeronautics and Astronautics, Dissertação, 2011.

[3] Gilmore, D. G., **Spacecraft Thermal Control Handbook**, Vol. I – Fundamental Technologies, Virginia: American Institute of Aeronautics and Astronautics Inc., 2002.

[4] Peabody, H. L., **Building Thermal Models**, NASA Goddard Space Flight Center, Technical Report, 2017.

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