Thermal Analysis of a 2U CubeSat

Parker Southwick, Team Lead
What is OreSat (before pic)

- 2U CubeSat
- Mission is to observe cirrus clouds in low earth orbit over the course of 1-1.5 years
- Become Oregon’s first meteor shower
- Secondary mission is to promote STEM outreach in the state of Oregon
Why thermal analysis?

- Heat death is a common occurrence
- 45% of academic and 77% of cubesat launches are successful between 2003-2014
The BIG questions

- What are our steady state worst case scenarios?
- Are we concerned about being too hot, too cold, or both?
The plan

1. Baseline research, experiment planning, learning software

2. Creating baseline simulations and collecting experimental data to weigh against simulations
   a. Introduction of secondary solver

3. Taking complex geometry and comparing/contrasting between two different solvers
   a. Actionable suggestion for black ano due to worst case cold scenario prediction
Phase 1 - Ansys
Phase 1 - Literature

**Thermal Modeling of Nanosat**

Dai Dinh  
San Jose State University

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**Thermal Analysis and Control of MIST CubeSat**

Shreyas Chandrashekar
Phase 1 - Breadcrumbs

- Start small
- Make incrementally more complex experiments
- Work towards end goal
Phase 1 - Breadcrumbs (phase 2 spoilers)

Start with something easy, like this
Phase 1 - Breadcrumbs (phase 3 spoiler alert)

Work towards something that you lose sleep over
Phase 2 - The wall

- One of the initial bread crumbs
- Provides information about the boundaries of reality
Phase 2 - Power resistor experiment

- Took a big 60 W rated power resistor, and turn the voltage high enough to simulate emitting 30 W of thermal power
- Avg. Thermal conductivity: 13.033 W/m*K
- $\sigma = 0.7809$
Phase 2 - Power resistor experiment
Phase 2 - Power Resistor sim
Phase 2 - “simple geometry”

- Typically a CFD solver
- Used to compare and contrast between ANSYS results
- + or - 10% from ANSYS = slam dunk
Phase 2 - Earth radiation, no solar, active boards simulation

Boundary Heat Flux

Temperature scalar
Phase 2 - Residuals for aforementioned sim
Phase 3 - *Real* geometry
Post removing parts that were deemed “unnecessary”, we made a big, ugly mesh consisting of 660,000 elements, trimmed down from 810,000 with the at-the-time current CAD model.
Phase 3 - The Final Results - STAR-CCM+ sims

Steady-State cold case with passive DXWifi
Phase 3 - The Final Results - STAR-CCM+ sims

Steady state hot case with passive DXWifi
Phase 3 - The Final Results - ANSYS sims

Steady state cold case with passive DXWifi
Phase 3 - The Final Results - ANSYS sims

Steady state hot case with inactive chips
Conclusion

We provided the suggestion of anodizing the satellite black in order to retain heat, due to the cold case scenario prediction being much scarier than the hot case scenarios.
Thank you Oregon Space Grant Consortium for making this project a reality.