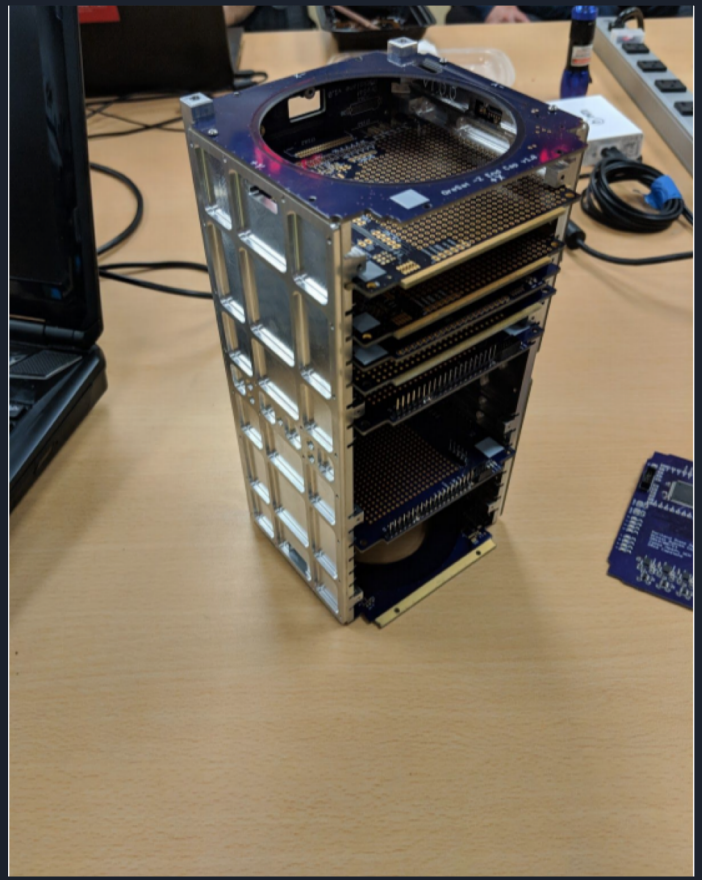
Thermal Analysis of a 2U CubeSat

Parker Southwick, Team Lead

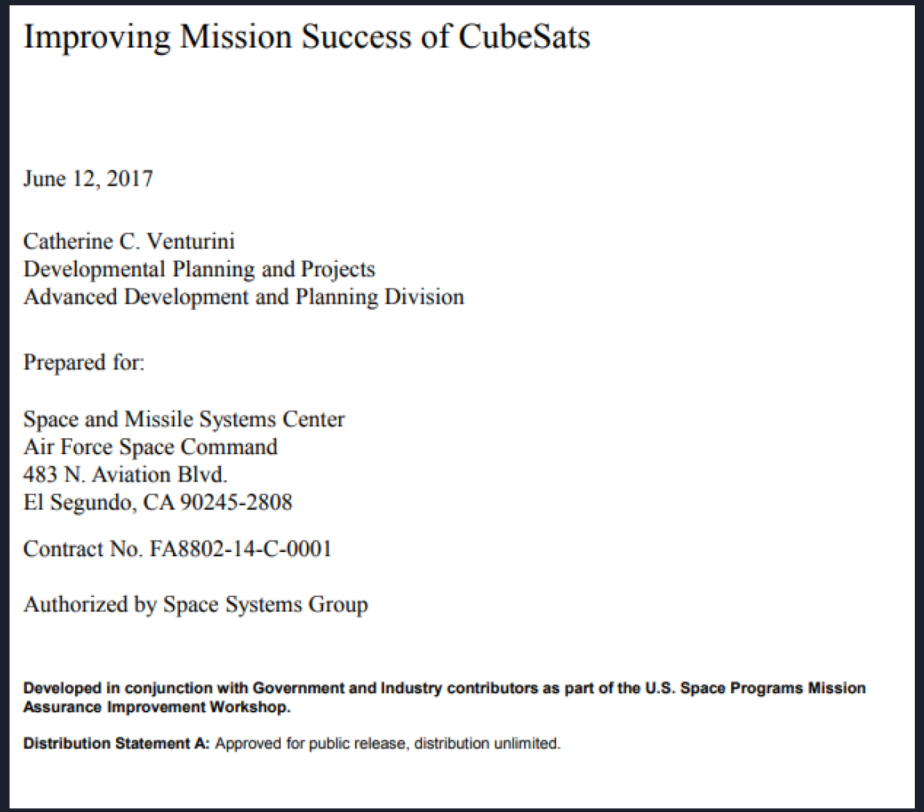
What is OreSat (before pic)

- 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



Improving Mission Success of CubeSats

June 12, 2017

Catherine C. Venturini
Developmental Planning and Projects
Advanced Development and Planning Division

Prepared for:

Space and Missile Systems Center
Air Force Space Command
483 N. Aviation Blvd.
El Segundo, CA 90245-2808

Contract No. FA8802-14-C-0001

Authorized by Space Systems Group

Developed in conjunction with Government and Industry contributors as part of the U.S. Space Programs Mission Assurance Improvement Workshop.

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

ANSYS®

Phase 1 - Literature

Summer 2012

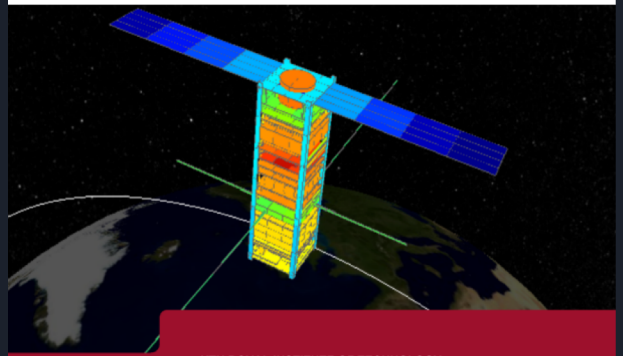
Thermal Modeling of Nanosat

Dai Dinh
San Jose State University

DEGREE PROJECT IN SPACE TECHNOLOGY,
SECOND CYCLE, 30 CREDITS
STOCKHOLM, SWEDEN 2016

Thermal Analysis and Control of MIST CubeSat

SHREYAS CHANDRASHEKAR



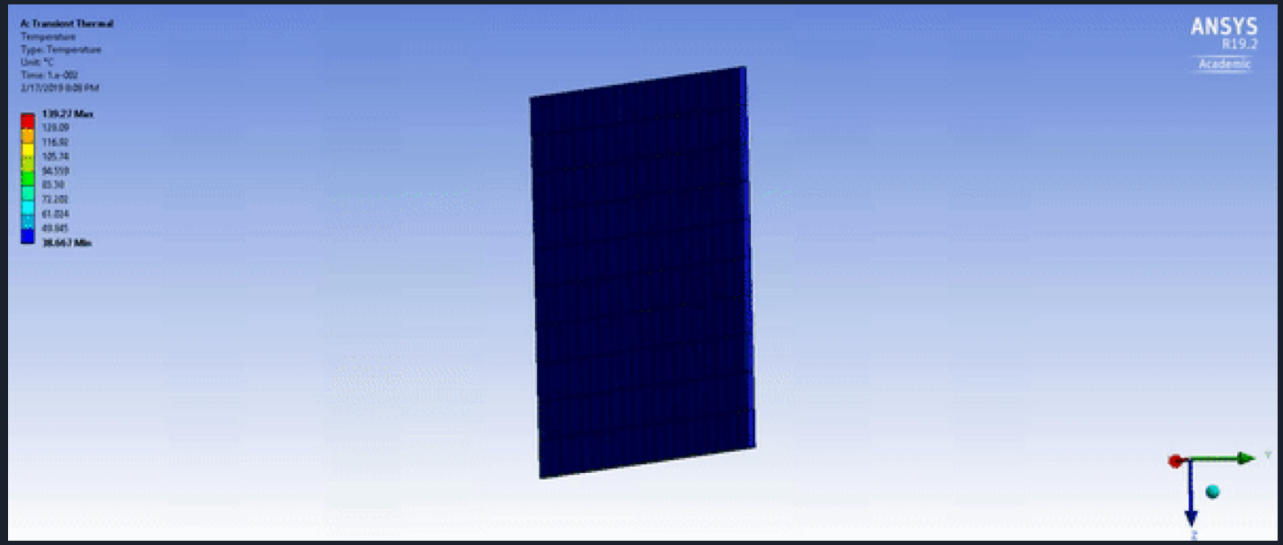
KTH ROYAL INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING

Phase 1 - Breadcrumbs

- Start small
- Make incrementally more complex experiments
- Work towards end goal

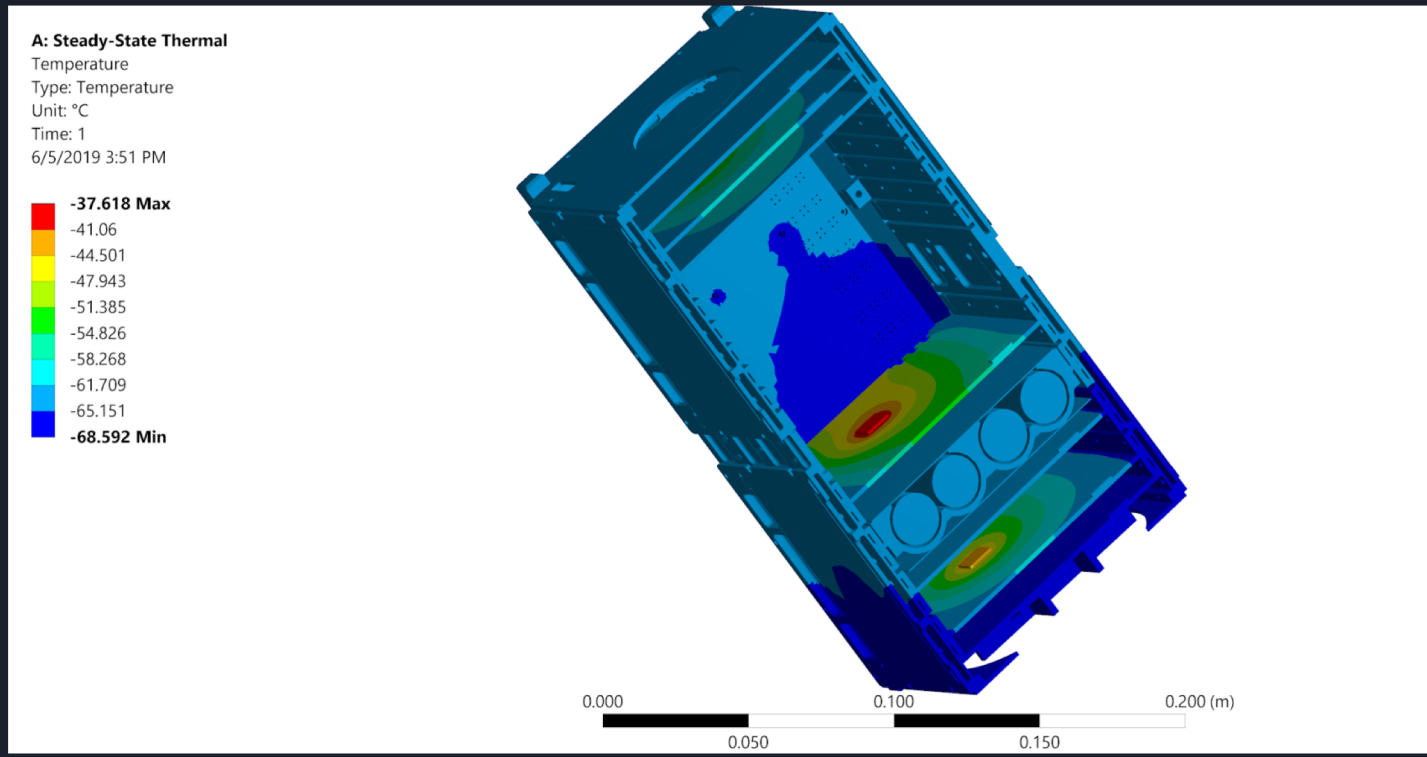
Phase 1 - Breadcrumbs (phase 2 spoilers)

Start with something easy, like this



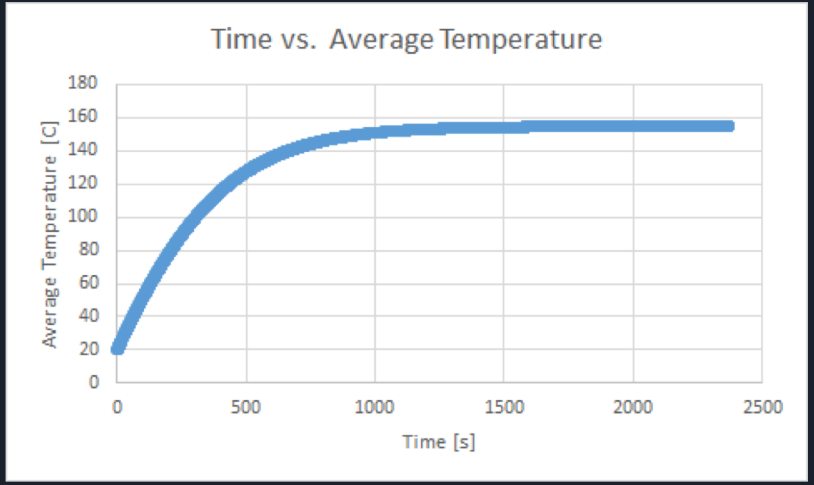
Phase 1 - Breadcrumbs (phase 3 spoiler alert)

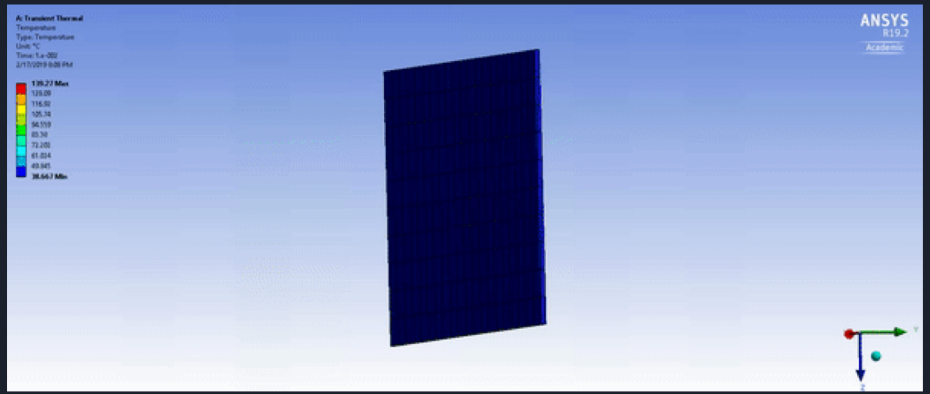
Work towards something that you lose sleep over

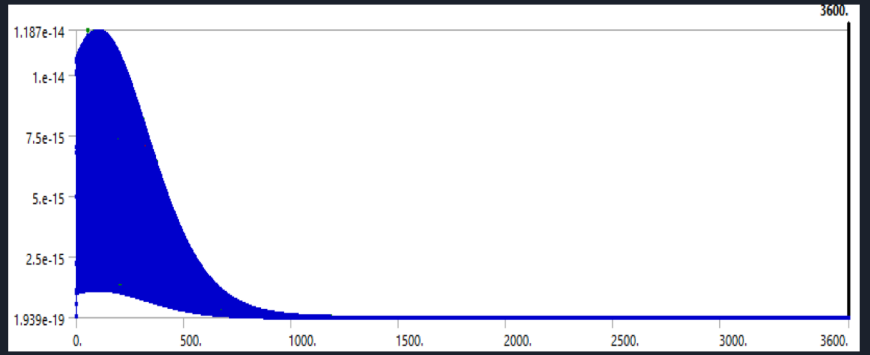


Phase 2 - The wall

- One of the initial bread crumbs
- Provides information about the boundaries of reality *woahh*

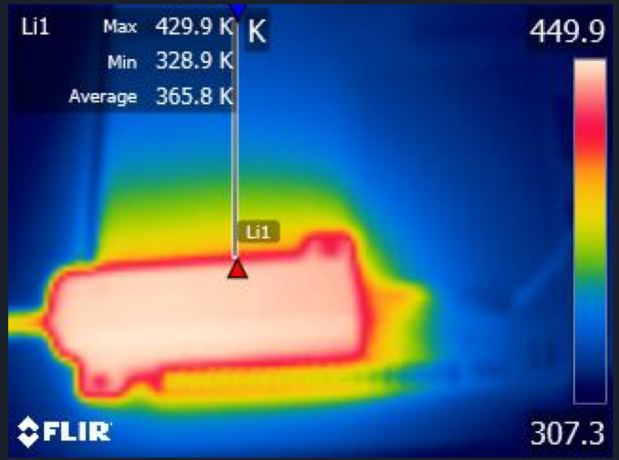


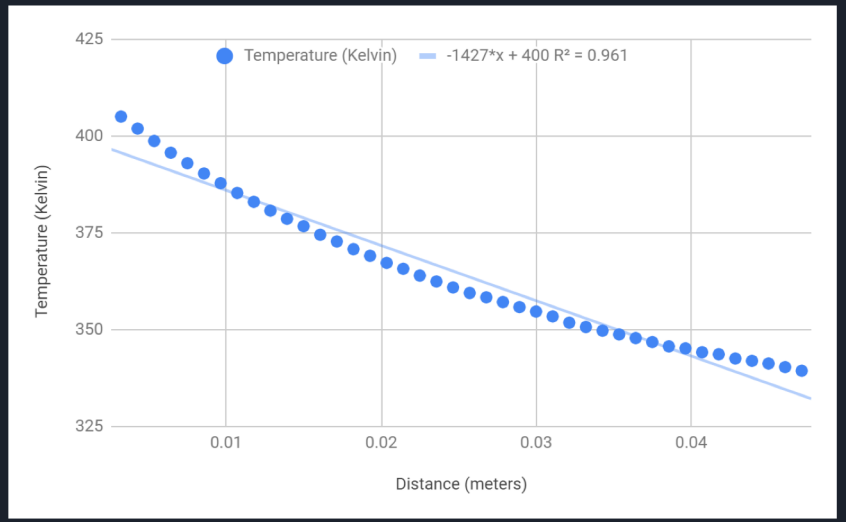




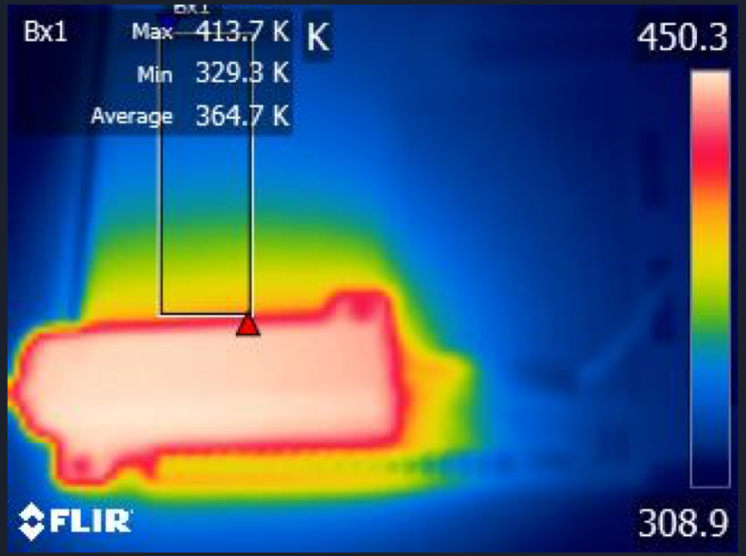
Phase 2 - Power resistor experiment

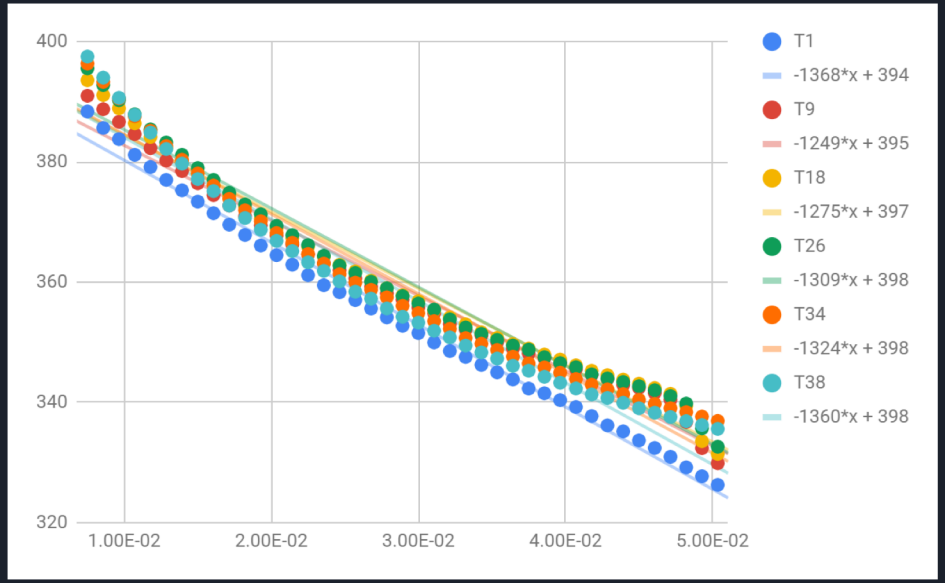
- Took a big 60 W rated power resistor, and turn the voltage high enough to simulate emitting 30 W of thermal power
- Avg. Thermal conductivity: 13.033 W/m*K
- σ = 0.7809



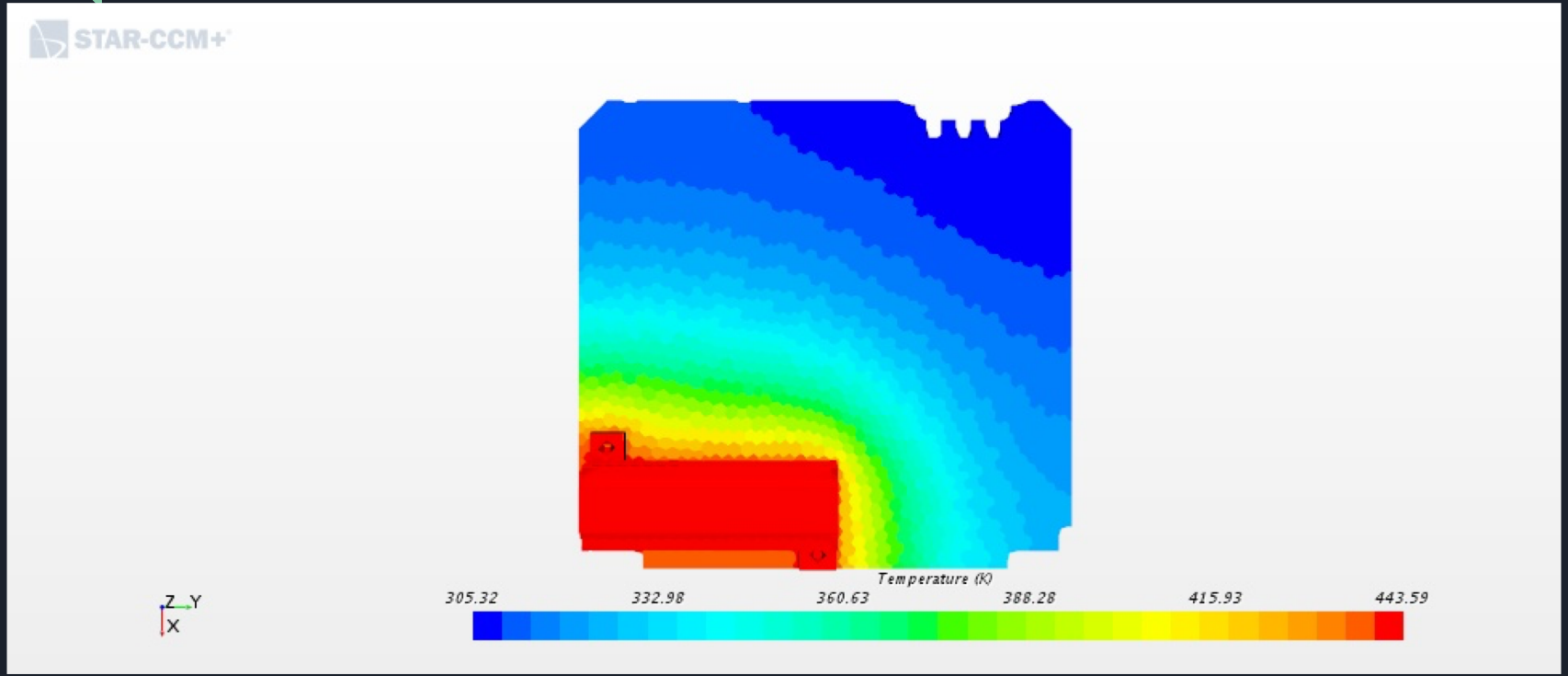


Phase 2 - Power resistor experiment

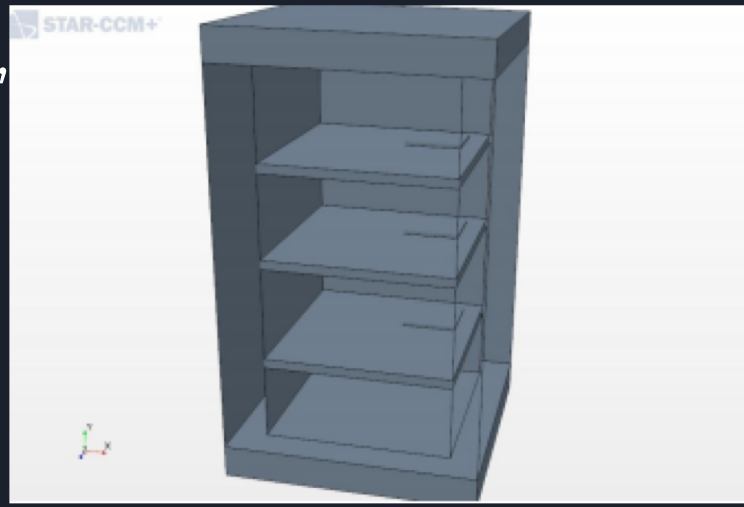




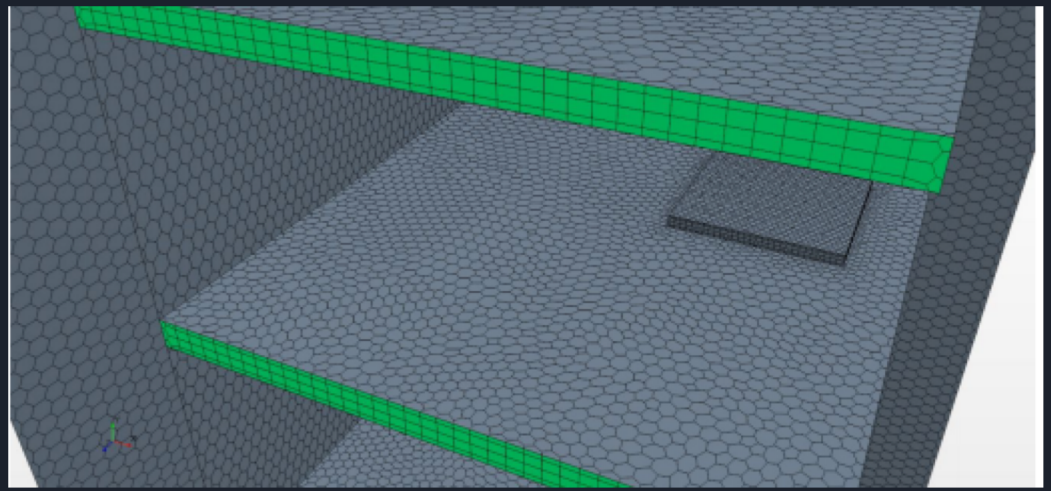
Phase 2 - Power Resistor sim



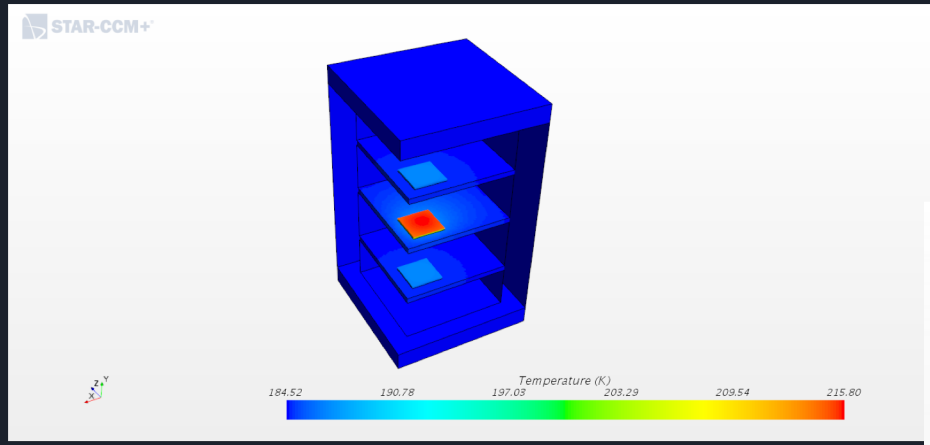
Phase 2 - “simple geometry”



- Typically a CFD solver
- Used to compare and contrast between ANSYS results
- + or - 10% from ANSYS = slam dunk

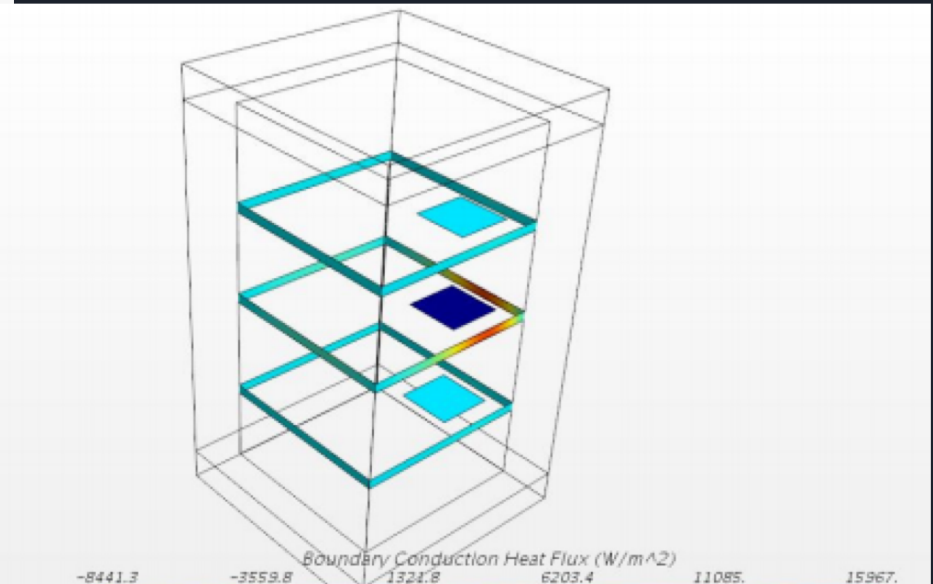


Phase 2 - Earth radiation, no solar, active boards simulation

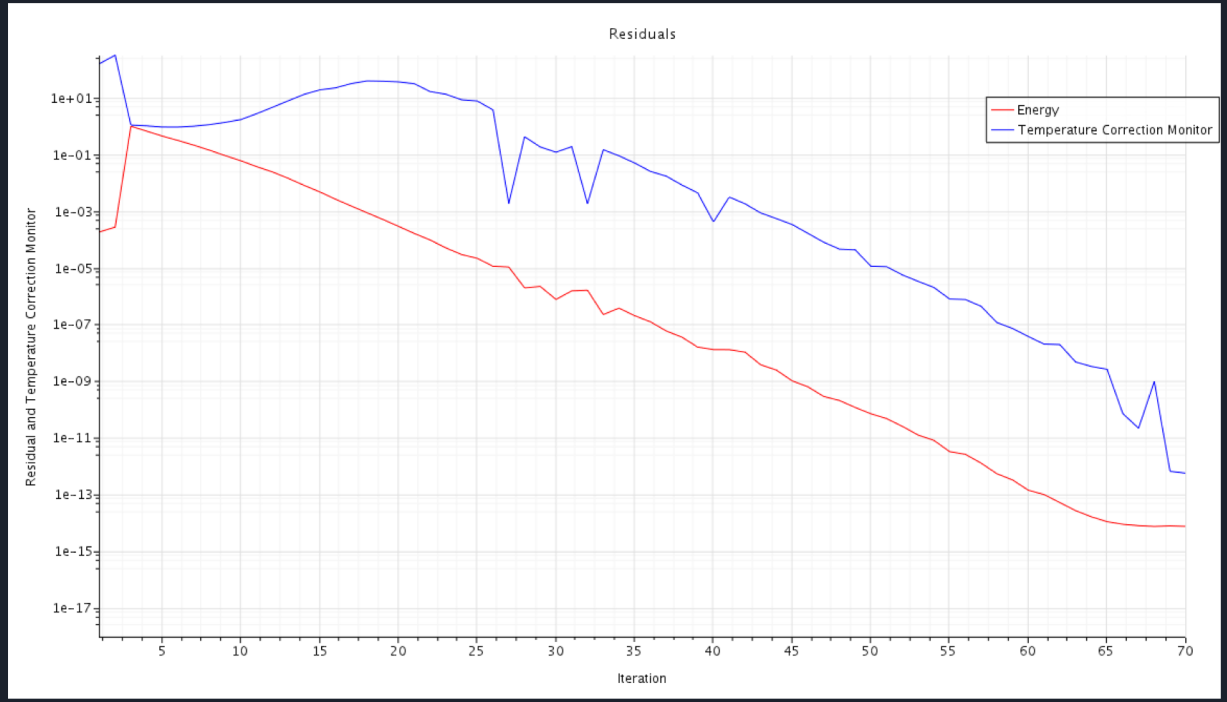


Temperature scalar

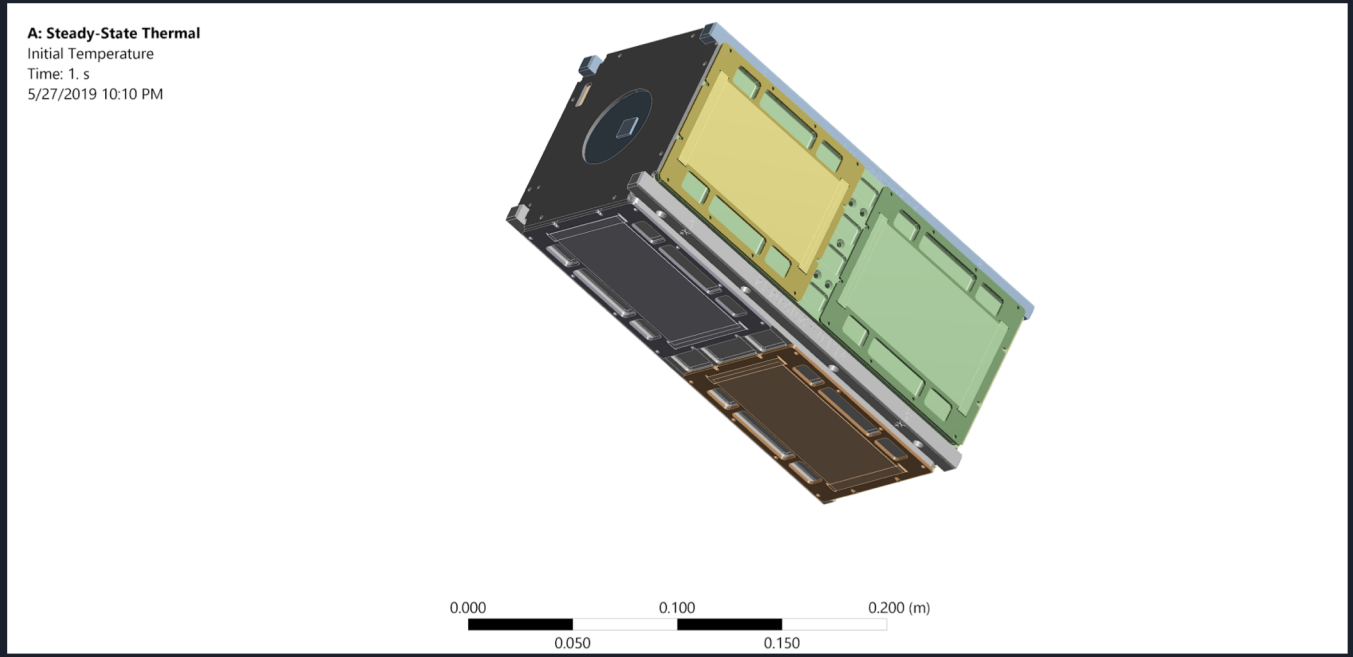
Boundary Heat Flux



Phase 2 - Residuals for aforementioned sim

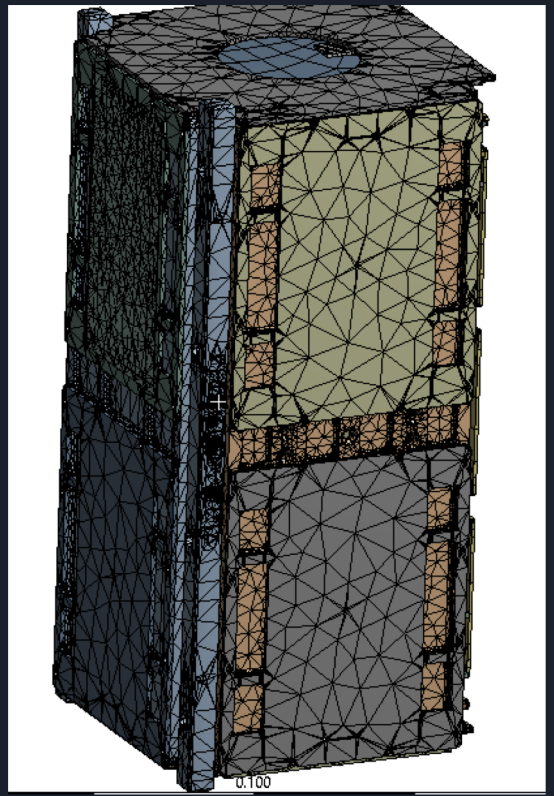


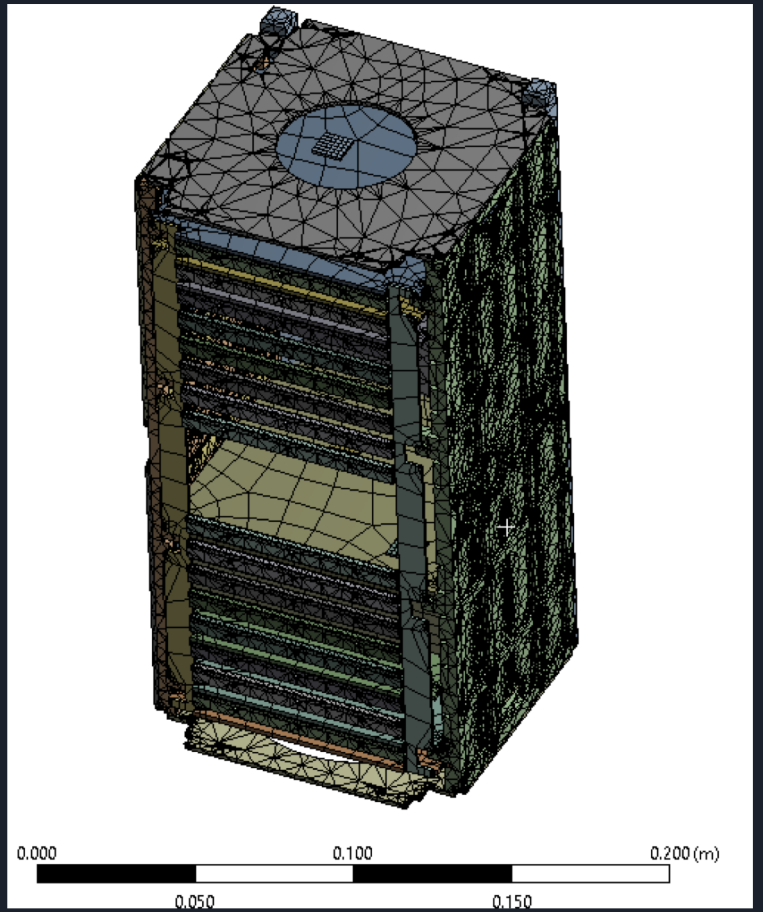
Phase 3 - *Real* geometry



Phase 3 - Real geometry

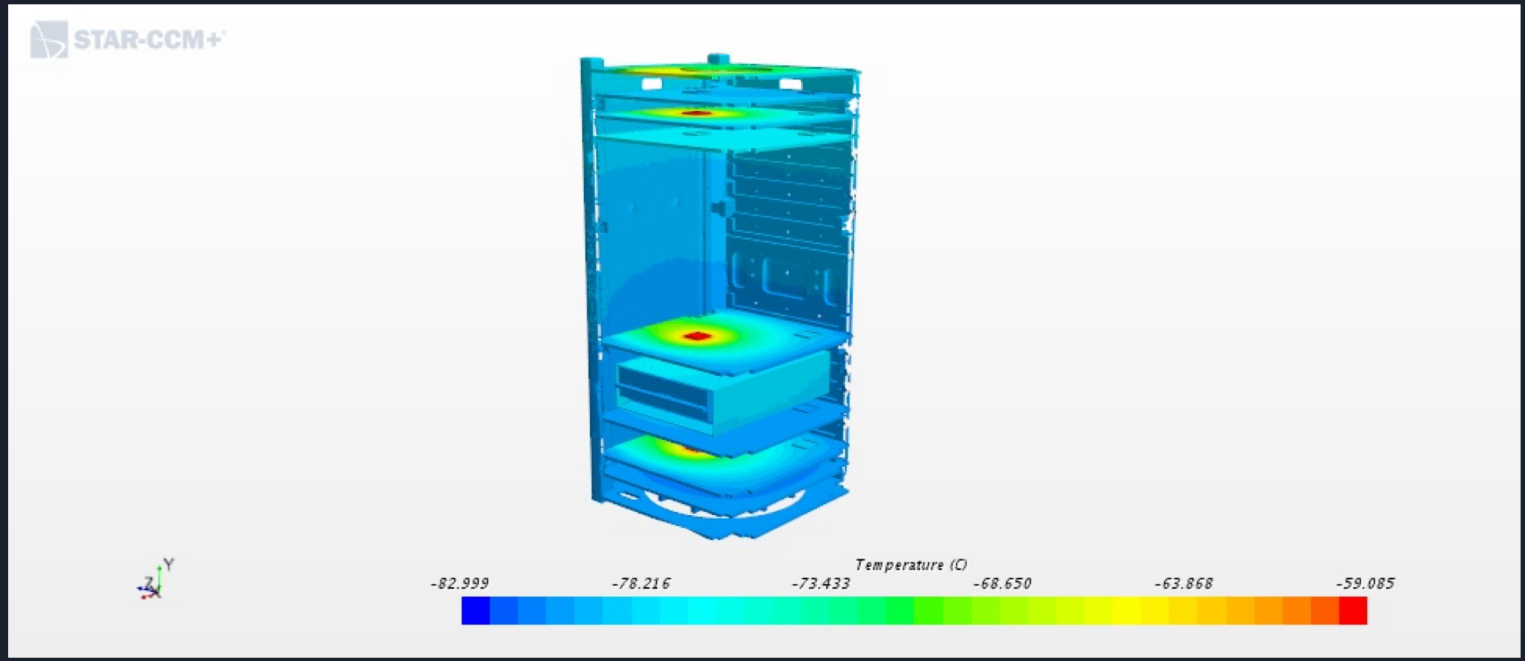
Post removing parts that were deemed “unnecessary”, we made a big, ugly mesh consisting of 660,000 elements, trimmed down from 810,000 with the at-the-time current CAD model.





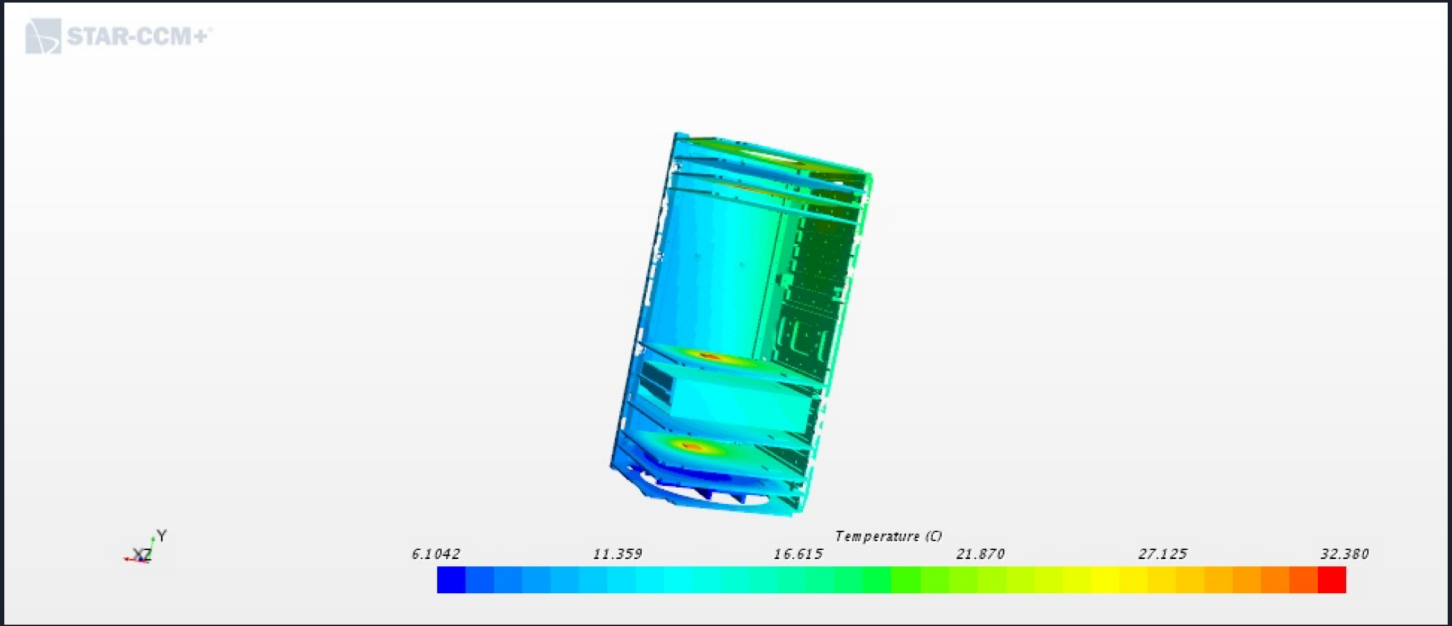
Phase 3 - The Final Results - STAR-CCM+ sims

Steady-State cold case with passive DXWifi



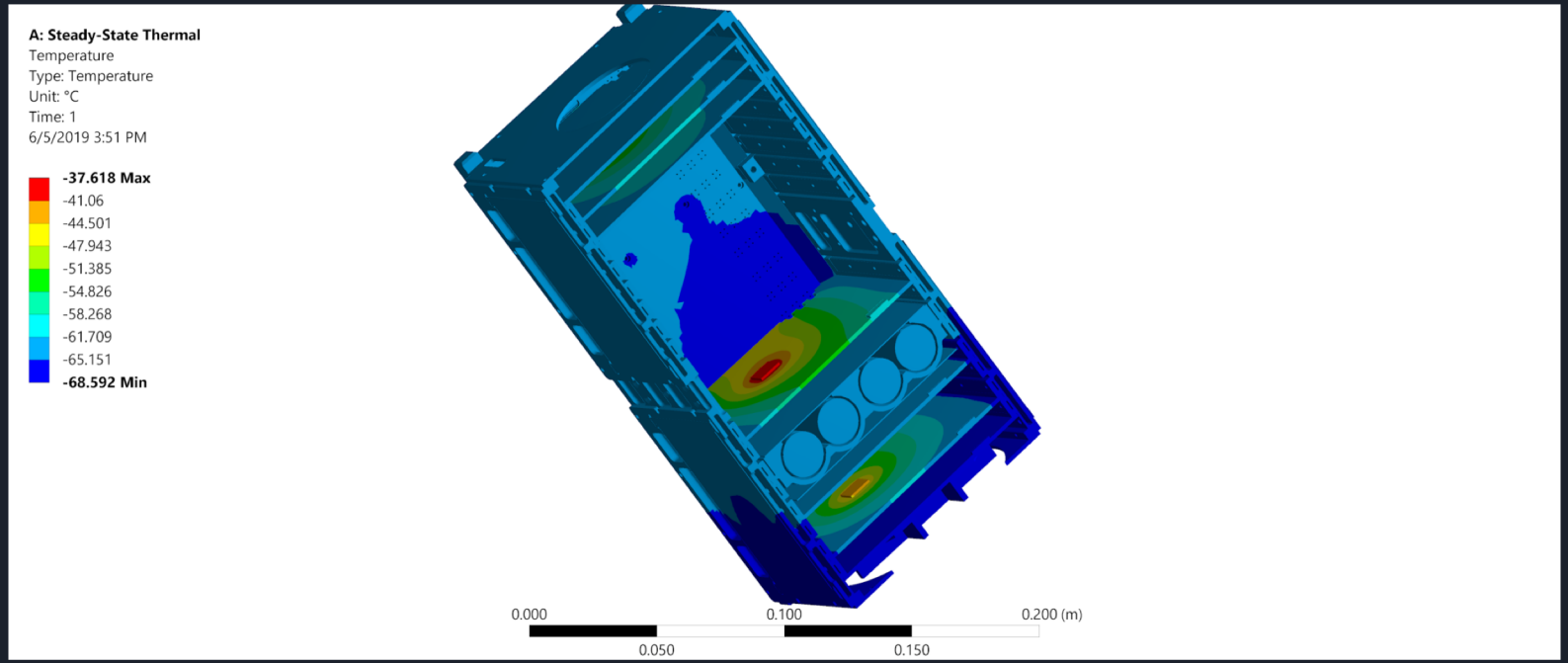
Phase 3 - The Final Results - STAR-CCM+ sims

Steady state hot case with passive DXWifi



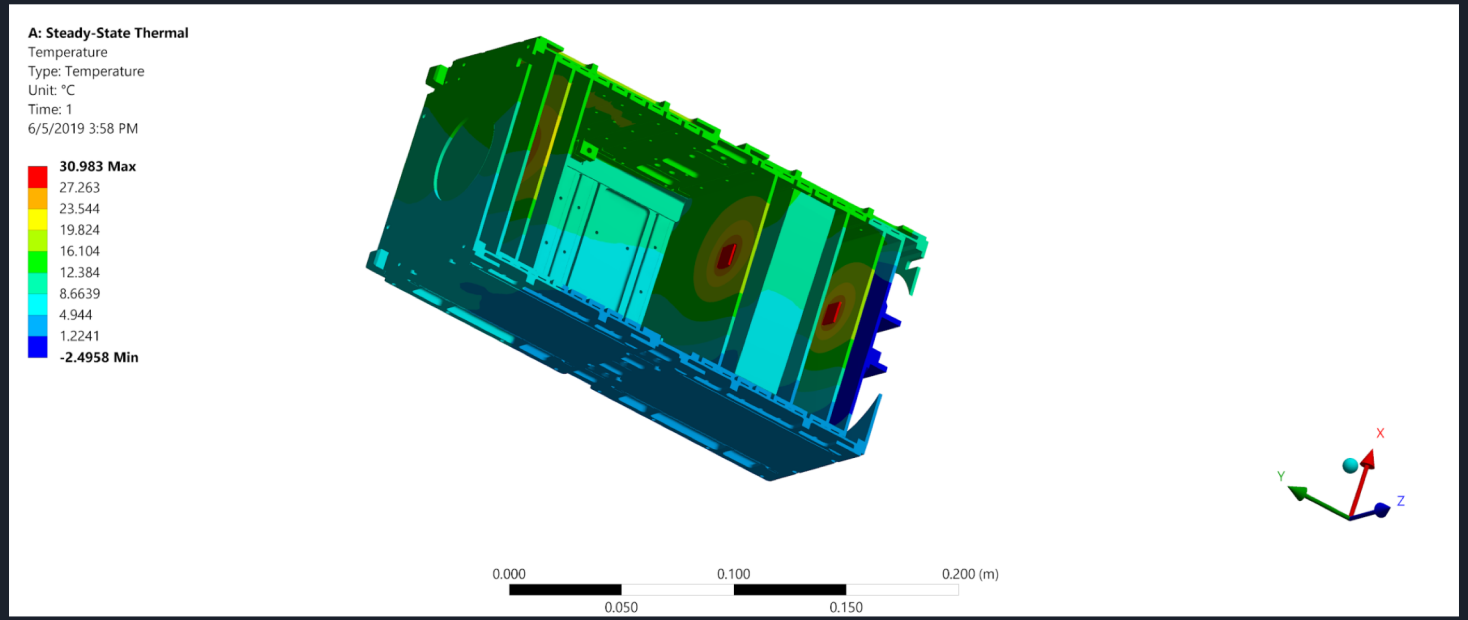
Phase 3 - The Final Results - ANSYS sims

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.