

Thermal Modeling in Support of the Edison Demonstration of Smallsat Networks Project

Dr. Rob Coker

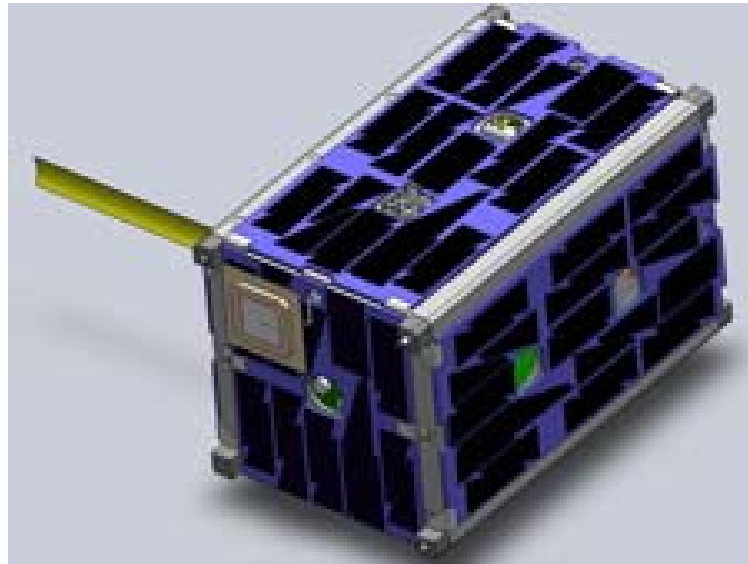
ES22/MSFC/NASA

43rd International Conference on Environmental Systems, 14-18 July 2013, Vail, Colorado



Introduction

- NASA will be launching a swarm of 8 1.5U 2kg cubesats (EDSN) similar to the PhoneSats
- Launching on new Super-Strypi vehicle in 2014 as secondary payload
- Nominally circular near-polar ~500 km orbit
- Demonstrate intra-swarm communications
- Multi-point in-situ data acquisition (EPISEM)



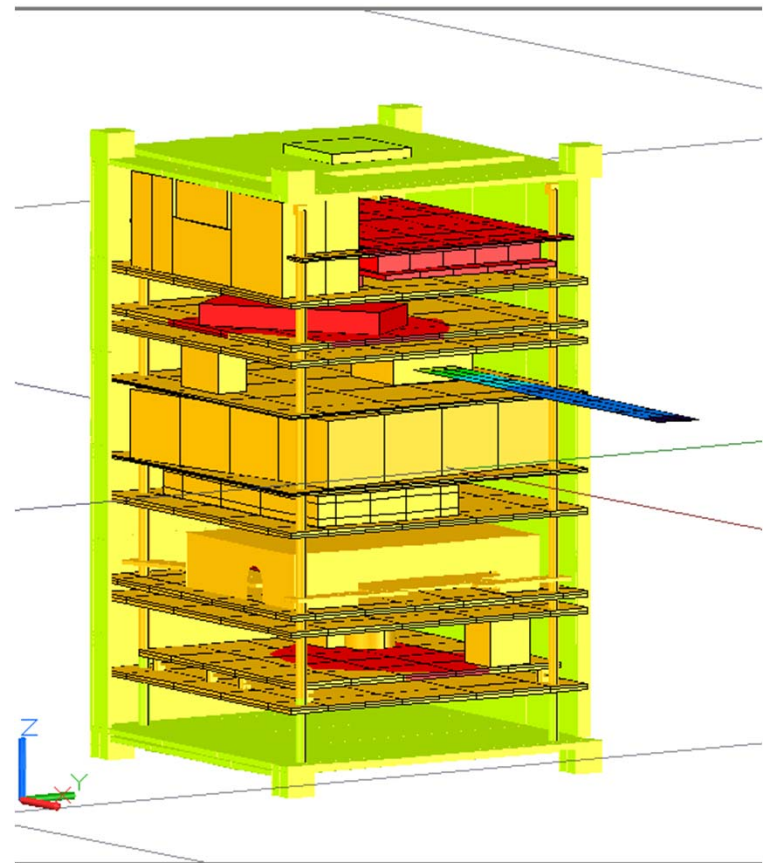
Thermal Issues

- Entirely passive
- Orbit details still in flux
- Covered in solar cells and magnetorquers
- Power details still in flux
- Thermal analysis needed (e.g., TVAC)
- Geometrically accurate thermal model constructed from CAD file



Thermal Model

- Imported into and run in Thermal Desktop
- Accurate thermal mass
- Geometries simplified
- Some details (wires, screws, backplane, etc.) ignored
- Accurate thermal and optical properties
- Only ~ 2 W of solar power
- Time-dependent heat loads for powered components and batteries (~ 20 Wh)

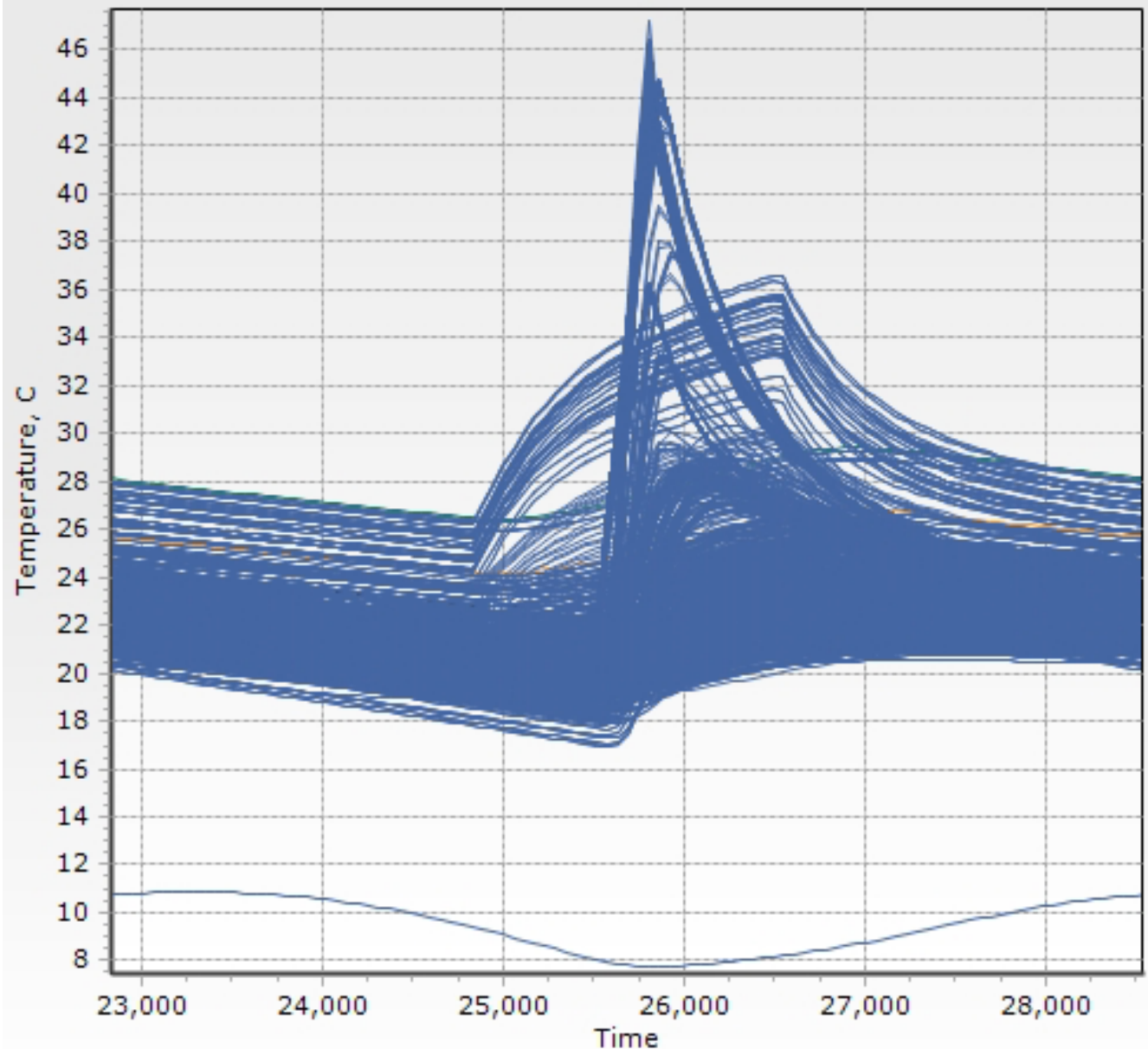


Thermal Model

- Included ~90 minute orbit and eclipses (~38% of orbit nominally)
- Orbit-averaged albedo
- Min and max solar and earth flux values
- Different orbit orientations (beta) and spacecraft orientations explored
- Different heat load duty cycles explored (e.g. everything on and everything off)
- Determined bounding temperatures for components

Results (hot case)

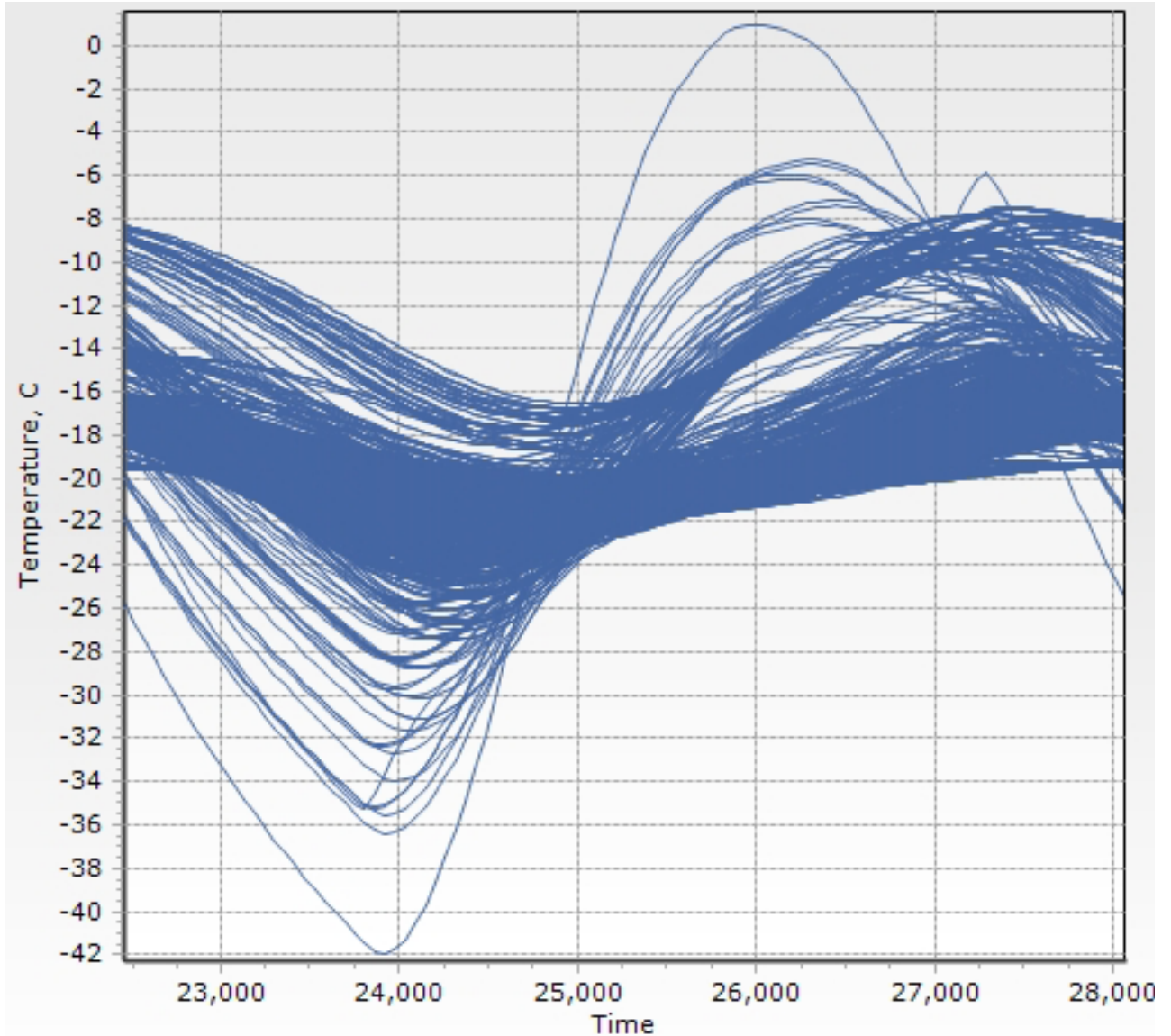
- Tumbling with $\beta=94^\circ$
- Maximum heat loads
- Components all on at once
- 5th orbit shown
- Just components included in plot



Phone, S-band radio, some shelves approach 50C.
Cold outlier is patch antenna.

Results (cold case)

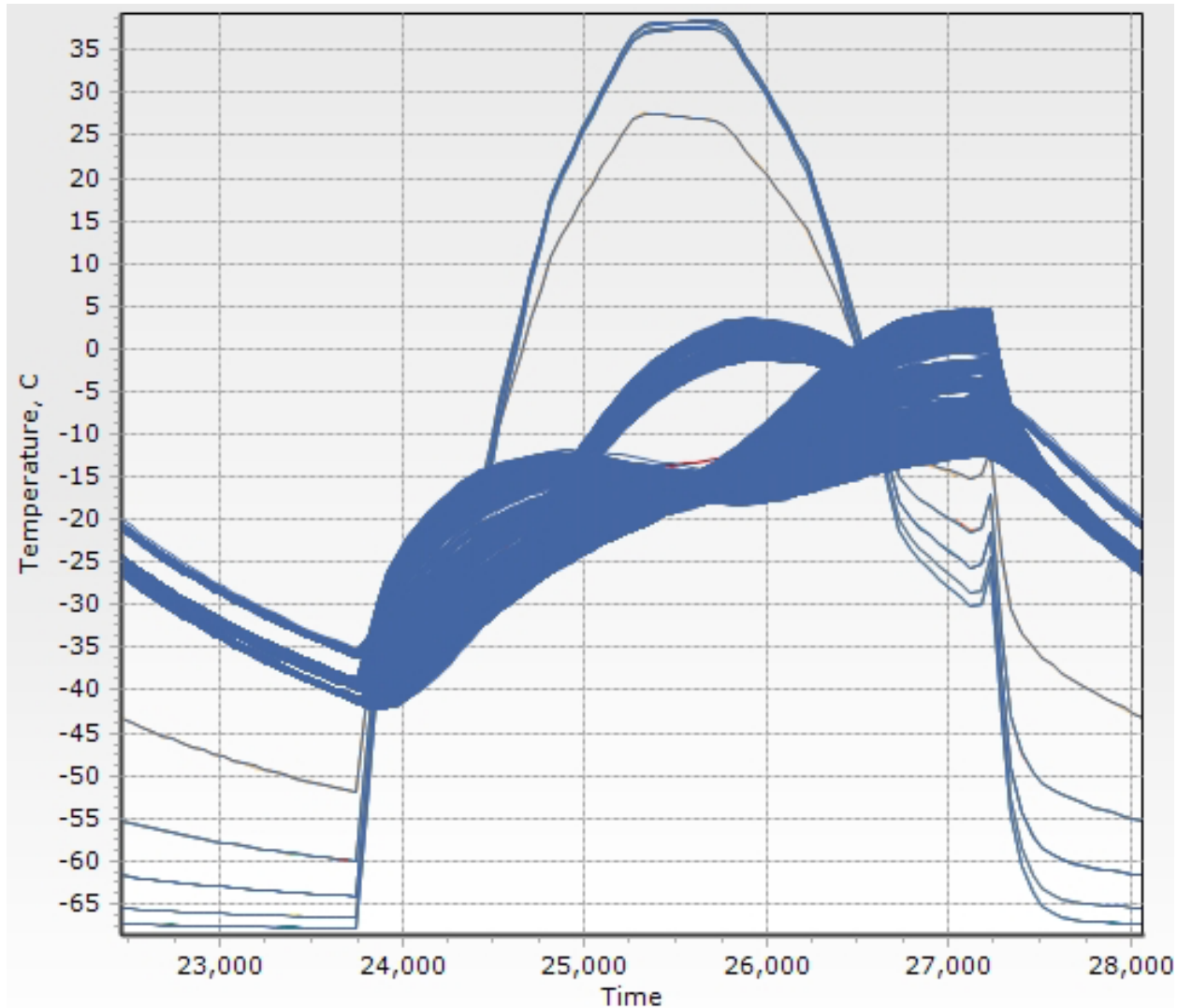
- Stabilized with $\beta=0^\circ$
- Minimal heat loads
- 5th orbit shown
- Just components included in plot



Extremes are patch antennas.

Results (cold case)

- External components only
- Structure, solar panels, magnetorquers, tape measure antenna



Extremes are tape measure antenna.

Summary (hot)

- EPISEM peak temperature close to its maximum nominal operating temperature
- All other components well within maximum temperature limits
- Longer duty cycle for phone (unlikely given power limitations) would be possible concern

Summary (cold)

- Thin steel TM antenna gets very cold
 - Released after ~30 mins in space
- GPS patch antenna gets slightly colder than nominal operating limits if shaded for long periods (but not an expected issue)
- Longer duty cycle for phone (unlikely given power limitations) would be possible concern
- Batteries:
 - slightly below nominal discharging limit
 - colder than nominal charging limit even in nominal model
 - testing shows loss of capacitance is deemed acceptable
 - dissipation rate only estimated

CONCLUSIONS

- Thermal Desktop modeling of EDSN spacecraft show no significant thermal concerns
- Some components near to limits in extreme cases
 - Risk deemed minimal and acceptable
- Loss of battery efficiency due to low ($<0^{\circ}\text{C}$) temperatures deemed acceptable
 - Partially mitigatable by time of day of launch (beta)

UPDATE: de-scoping of EDSN hardware in works...