Thermal Considerations for Critical CubeSat Missions

Improving system reliability through thermal management and parts selection

Jason Addy, David Twining, David Strobel

12th Annual CubeSat Developers' Workshop

Space Micro Flight Hardware

Image Processing Computers

S-Band Transponders

ProtonX Avionics Suites

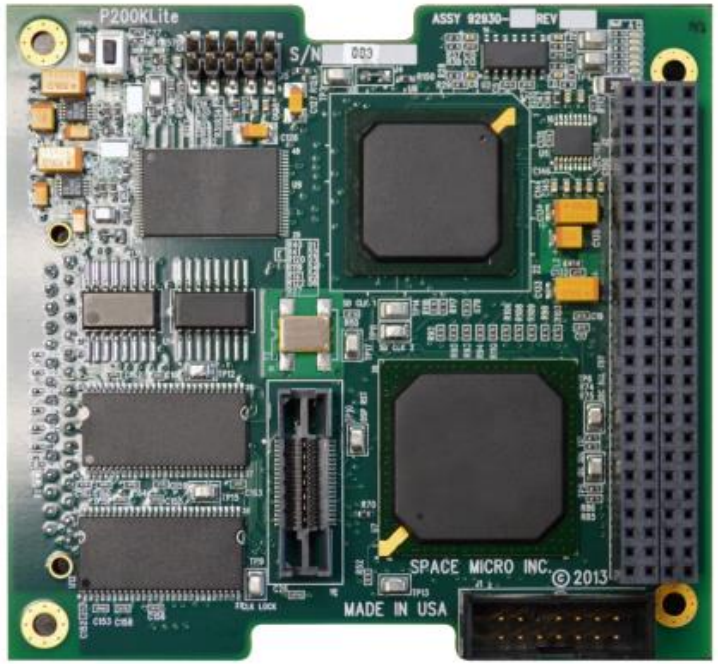
Ka-Band Transmitters

RF Beacons

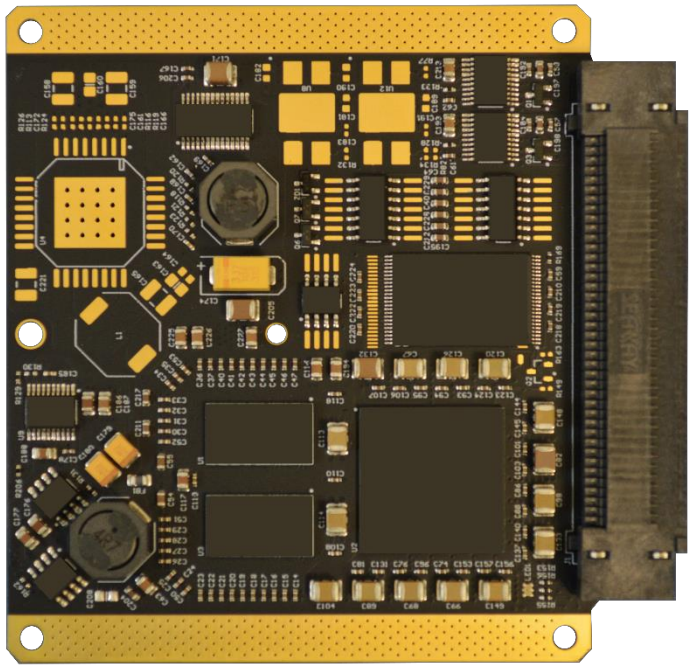
Star Trackers

CubeSat Products

- High performance single board computers
  (Enables reliable on-board processing)
- Parts grade customizable
- Radiation tolerant
  (TID & SEE)
- Design for excellent thermal dissipation
  (conduction cooled)



P200k-Lite



CSP

CubeSat Missions

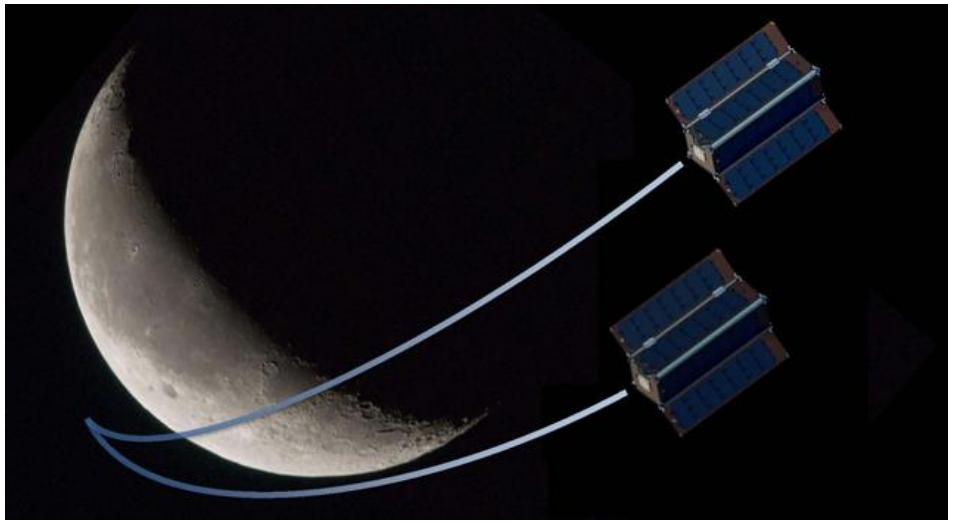
Typical Missions

CubeSats deployed from ISS. Image credit: NASA

- Short duration
- Gentle orbits
- High acceptable risk

Critical Missions

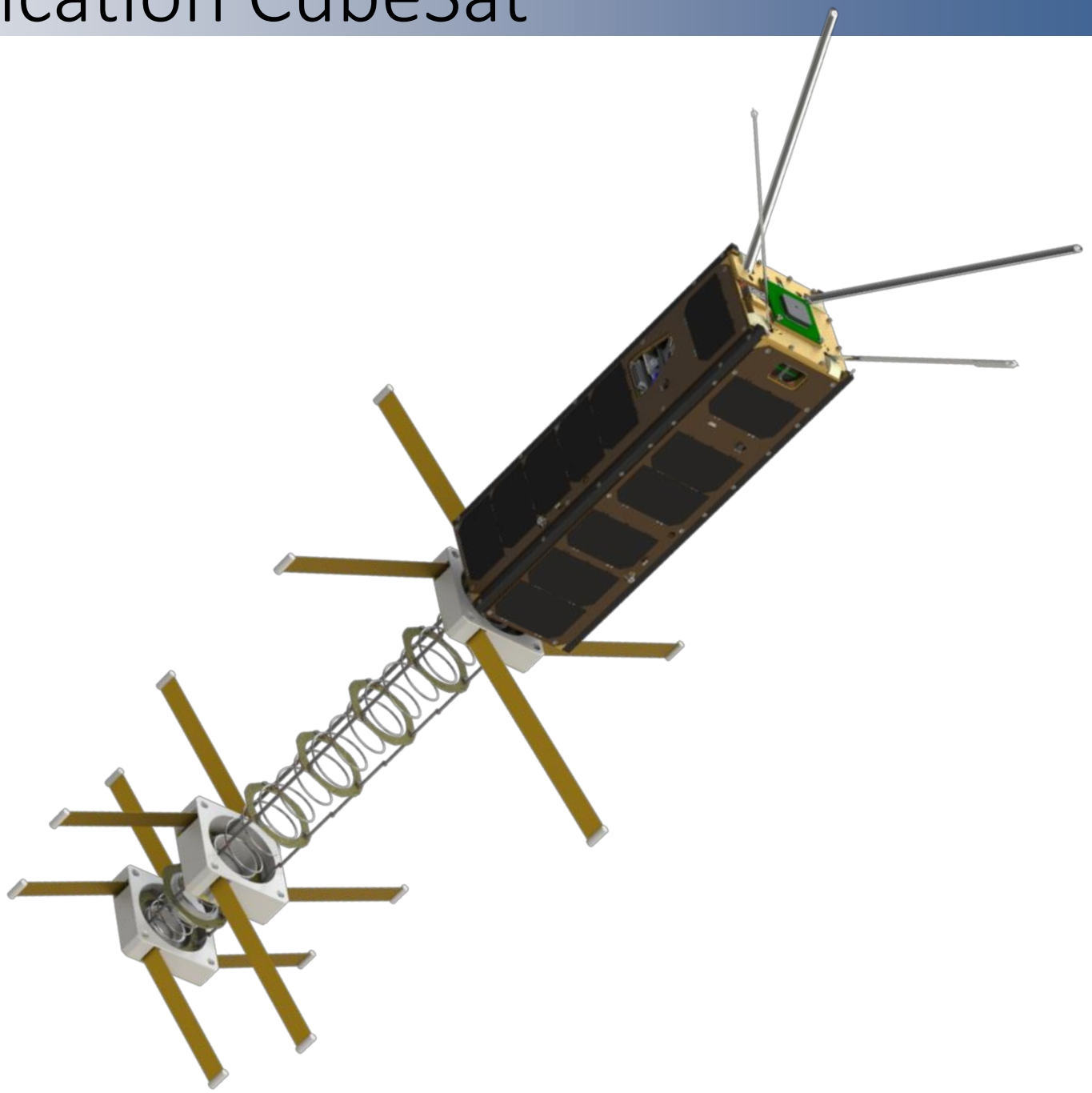
- Increased Capabilities
- Longer duration
- Harsher orbits
- Low acceptable risk



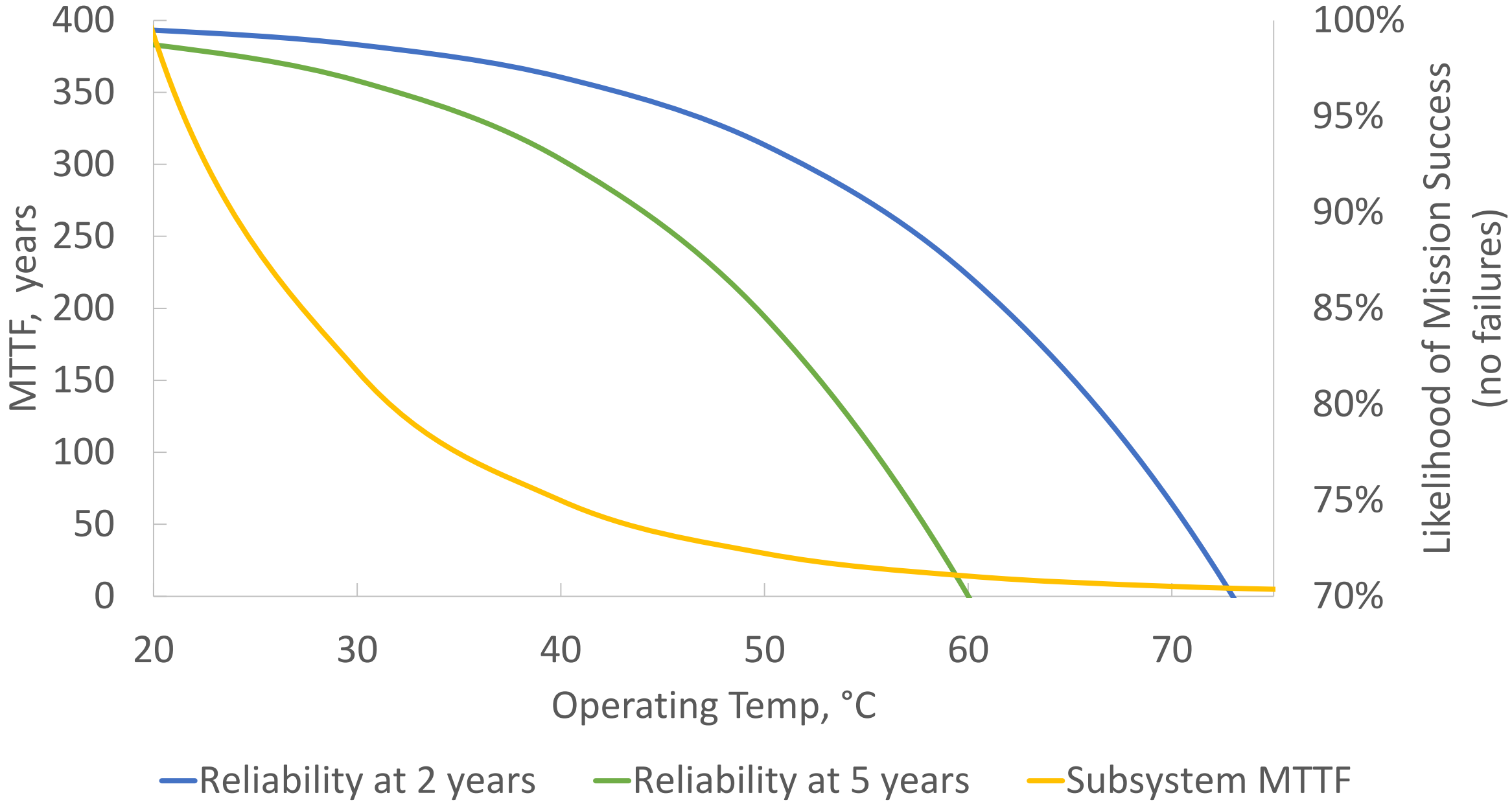
JPL's INSPIRE Project. Image credit: NASA/JPL-Caltech

Communication CubeSat

- 3U CubeSat
- Integrated by Space Micro
- Cross-link to GEO
- Dissipate ≈ 30W for significant portion of orbit



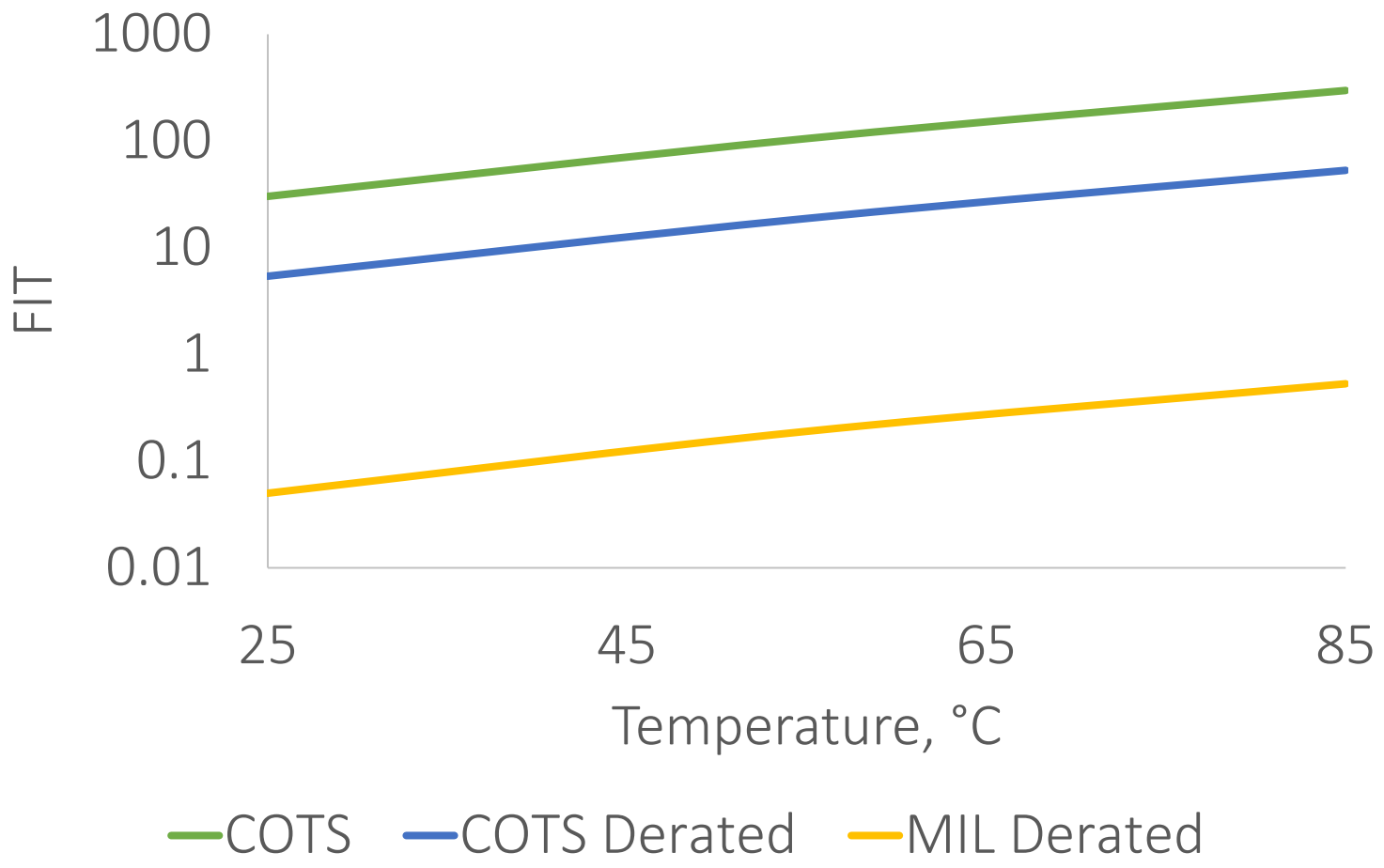
Temperature and Reliability



Methods to Improve Reliability

- Over-design the system (derate the parts)
- Consider temperatures during mechanical design
- Analysis/simulation
- Validate through testing

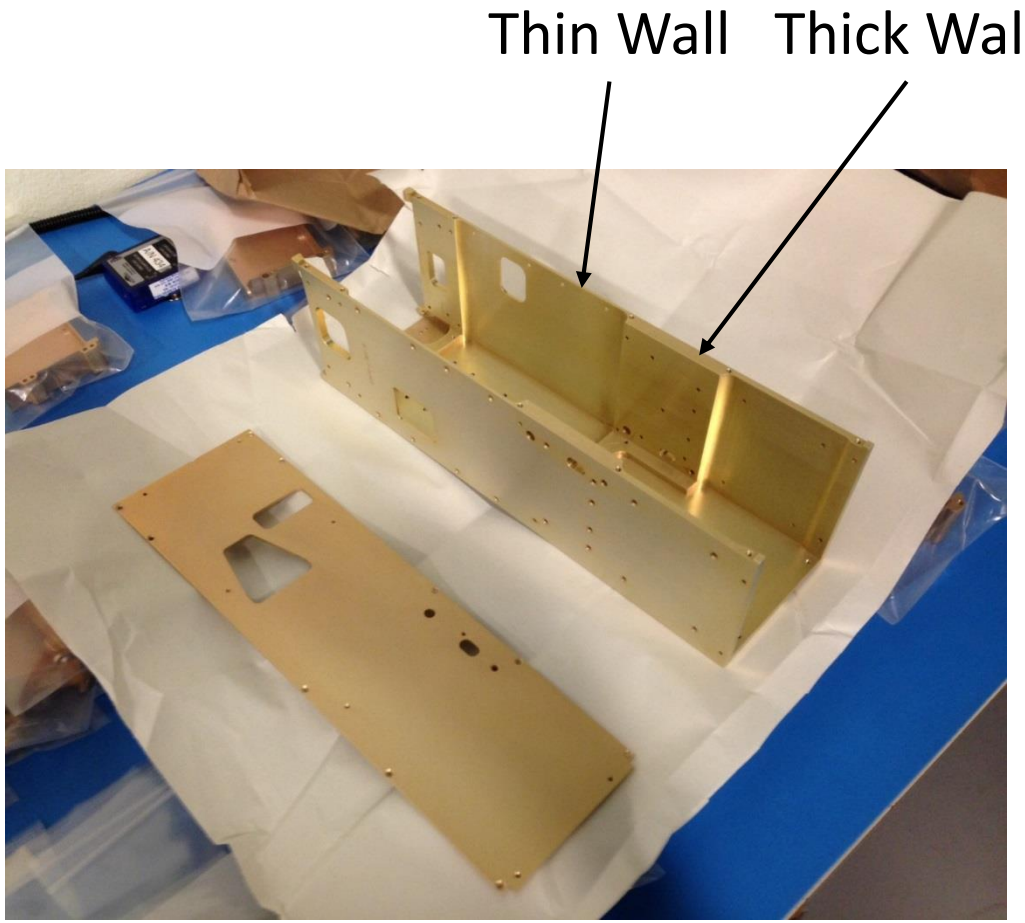
Derating and Parts Selection

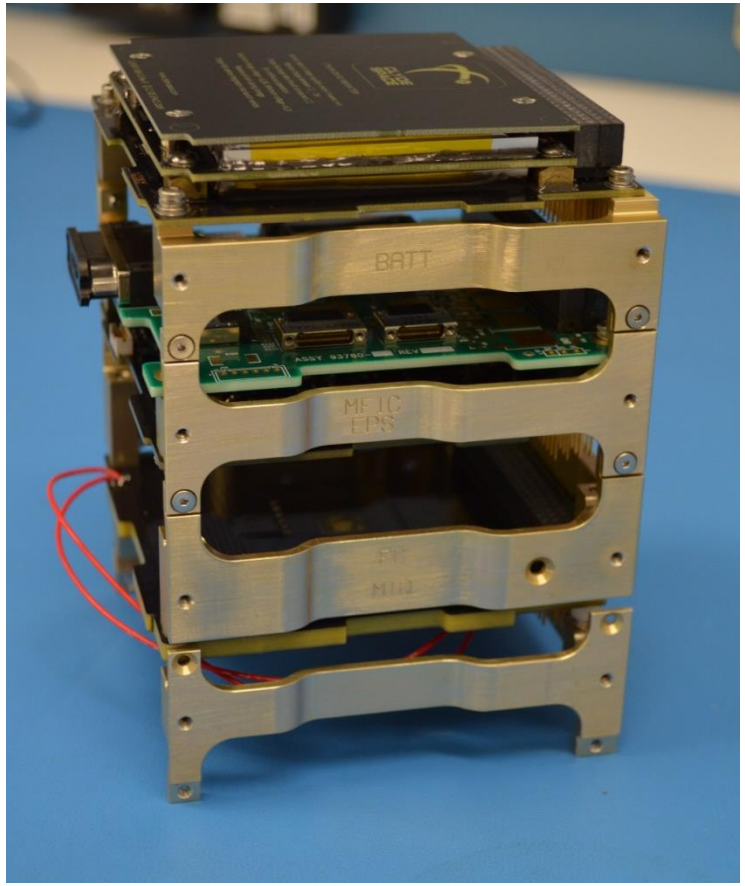


1000pF 0603 Ceramic Capacitor	5V rated COTS @ 5V	50V rated COTS @ 5V	50V rated MIL @ 5V
FIT at 25C	30.2	5.4	0.05
FIT at 55C	105.1	18.8	0.19
FIT at 85C	296.9	53.0	0.53
(Example using MIL-HDBK-217 RevF)			

Mechanical Design

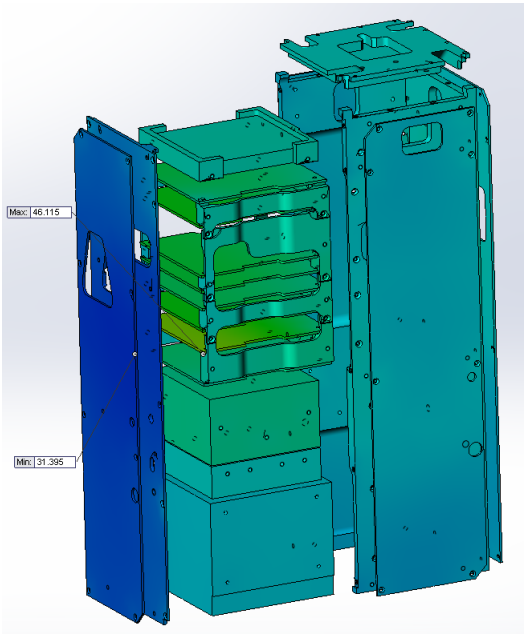
- Solid outer frame, not skeletonized
- Thicker walls around payload
- Brackets instead of standoffs.

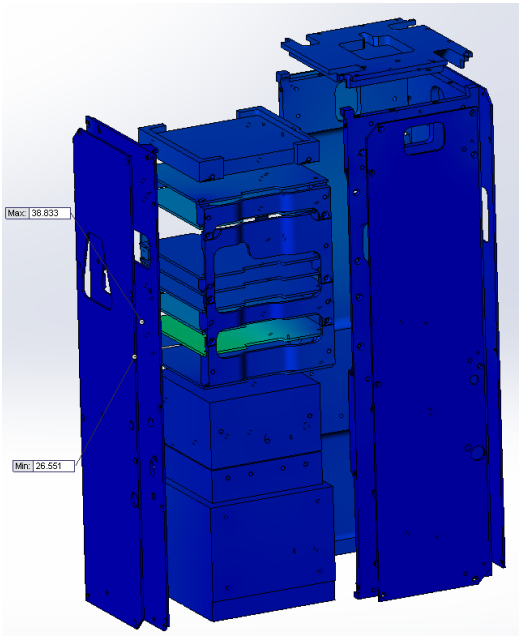


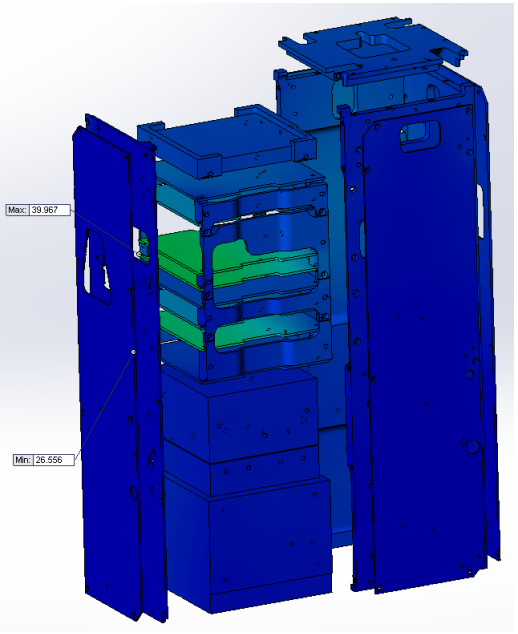


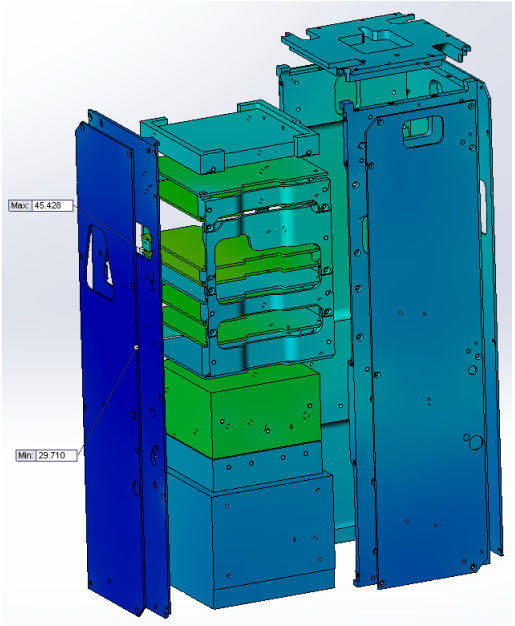
Thermal Analysis

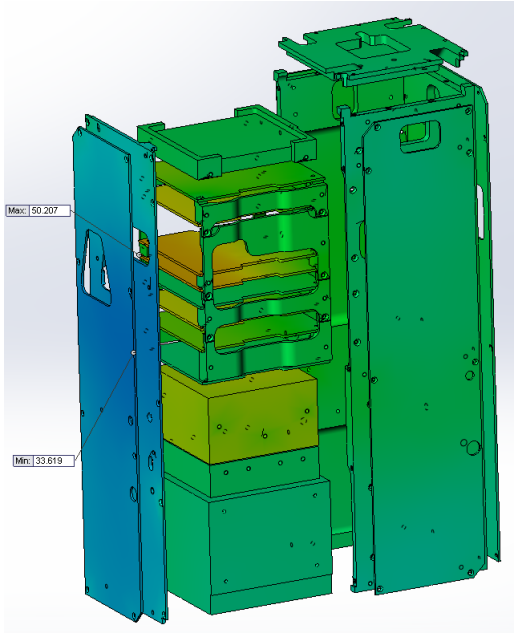
- Implement during design phase
- Compare with test results

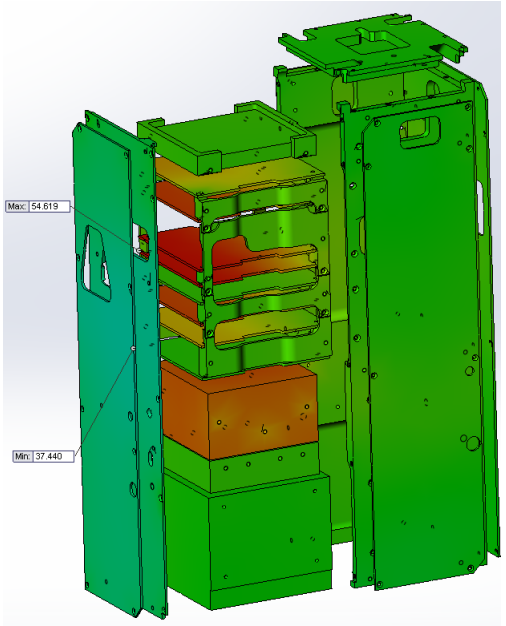


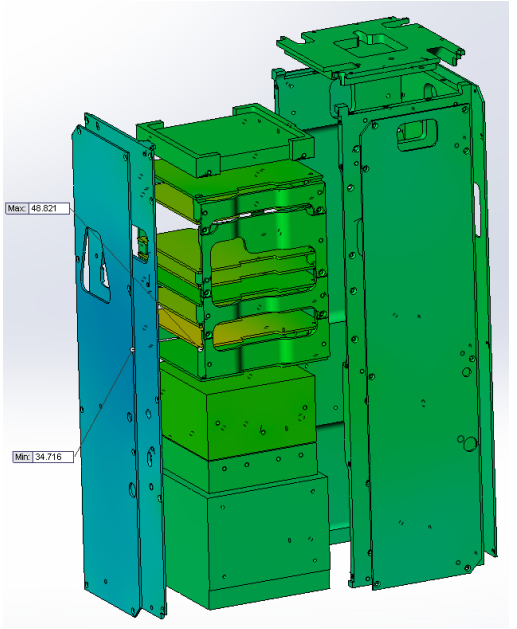




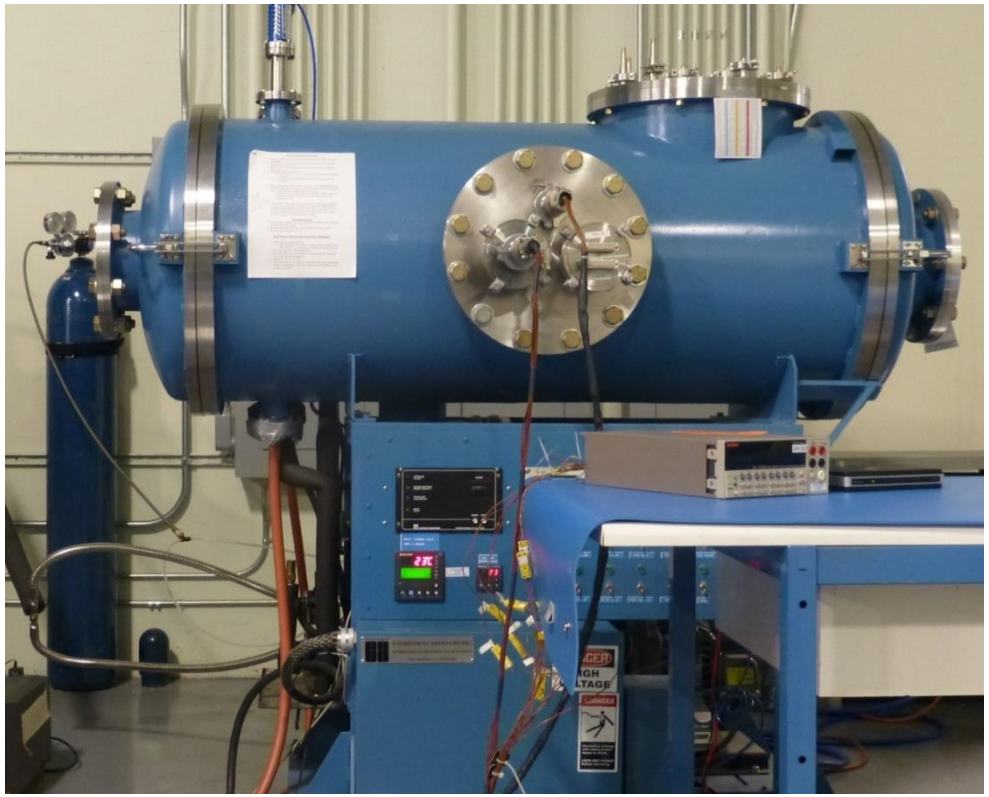


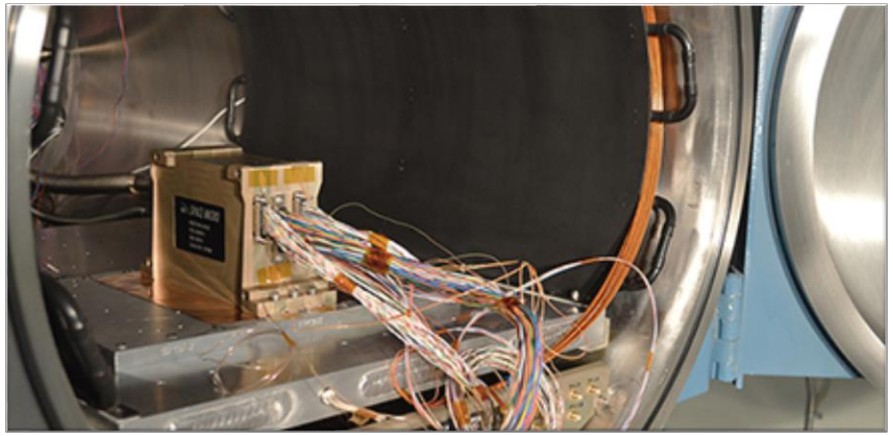






Testing





- Thermal Vacuum (TVAC)
- Validates model against actual hardware
- Verify operation/survivability at temp
- Adds margin
- Dynamics of the operation

Summary

- Why is thermal management important?
  - Improve overall reliability (mission success)
- How are thermal issues addressed and mitigated?
  - Parts selection
  - Mechanical design
  - Analysis/simulation
  - Test