An Additively Manufactured Deployable Radiator with Oscillating Heat Pipes (AMDROHP) to Enable High Power Lunar CubeSats

Cooperative Agreement (CA): 80NSSC20M0085

Jim Kuo (PI)
Osvaldo Castro
Spencer Miesner
Loren Barton

Benjamin Furst (NASA Partner)
Eric Sunada (Co-I)
Scott Roberts (Co-I)
Takuro Daimaru
Kieran Wolk

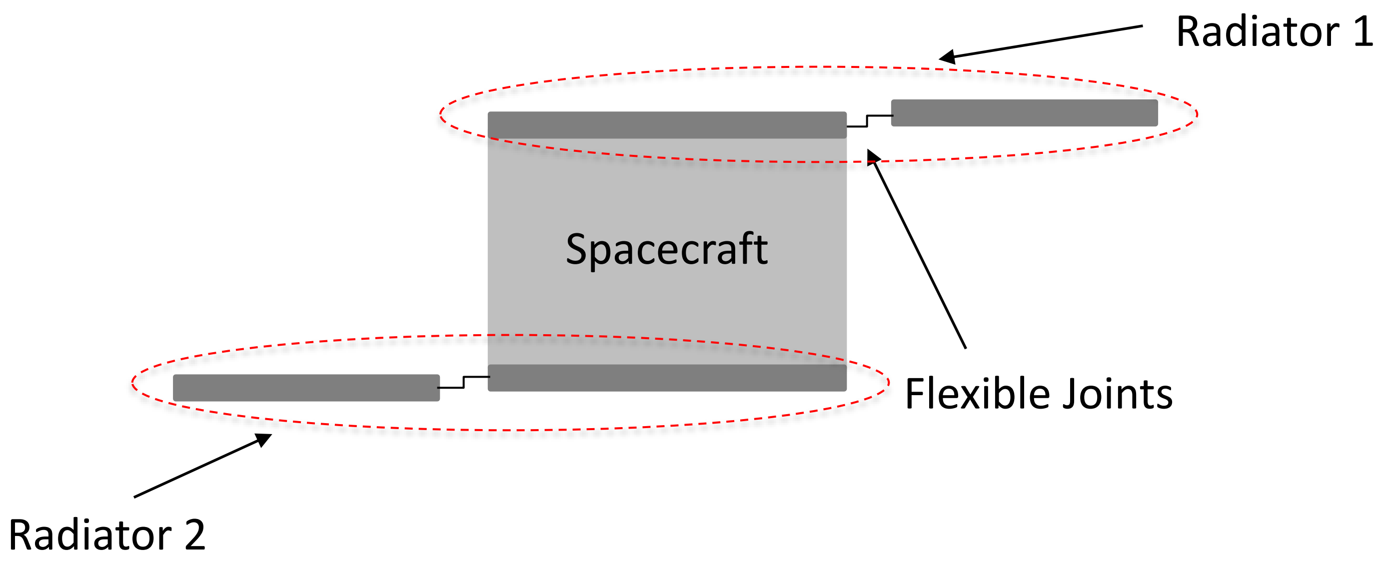
John Bellardo (Co-I)
Alicia Johnstone
Jered Bell
Gavin Goddard

Agenda

- Objectives
- Oscillating heat pipes
- Flexible joint
- Radiator
- Spacecraft
- Summary
- Next steps

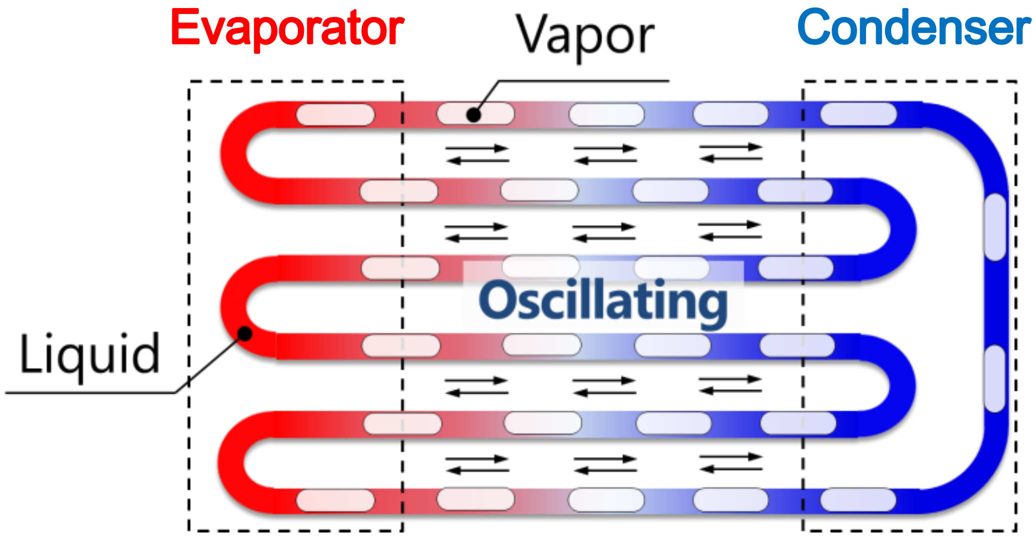
Objectives

- Develop CubeSat that incorporates an additively manufactured deployable radiator with oscillating heat pipes (AMDROHP) capable of dissipating 50 W in Low Earth Orbit
- Develop a flexible OHP joint with a conductance of ~6 W/K that can fit in a CubeSat package.
- Design a CubeSat mission and integrate AMDROHP into CubeSat design.



Oscillating Heat Pipes (OHP)

- Two-phase heat transfer device
- Self excited oscillating motion through fluid evaporation and condensation
- Effective thermal conductivities in excess of >2,000 W/(mK)

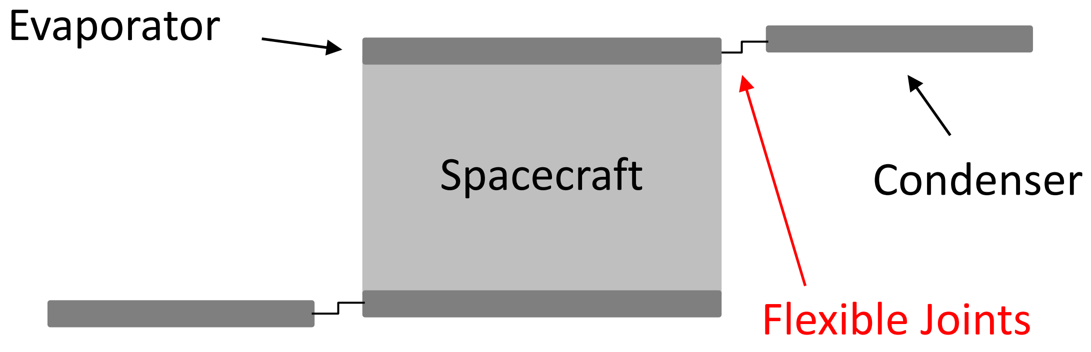


Flexible Joint

Objective: Design a flexible joint allows for fluid flow between evaporator and condenser

Topics:

- Design exploration
- Analysis and experimentation



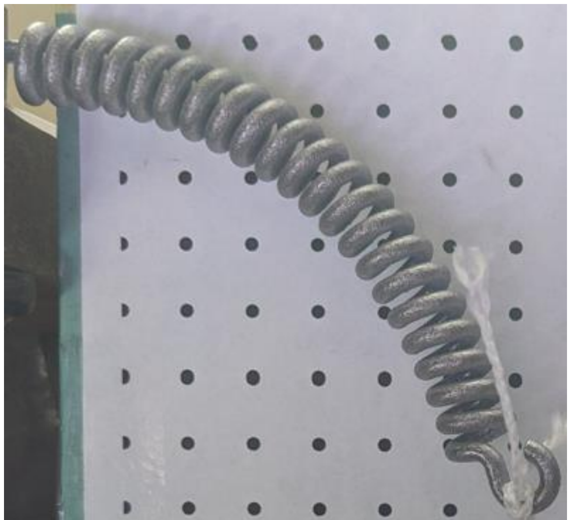
Joint Design – Design Exploration

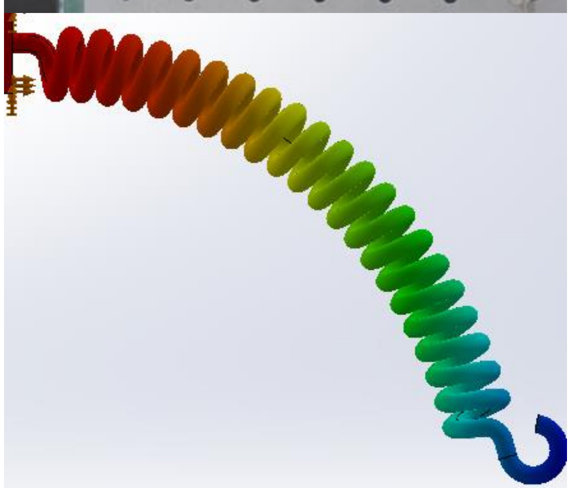
Helical coil

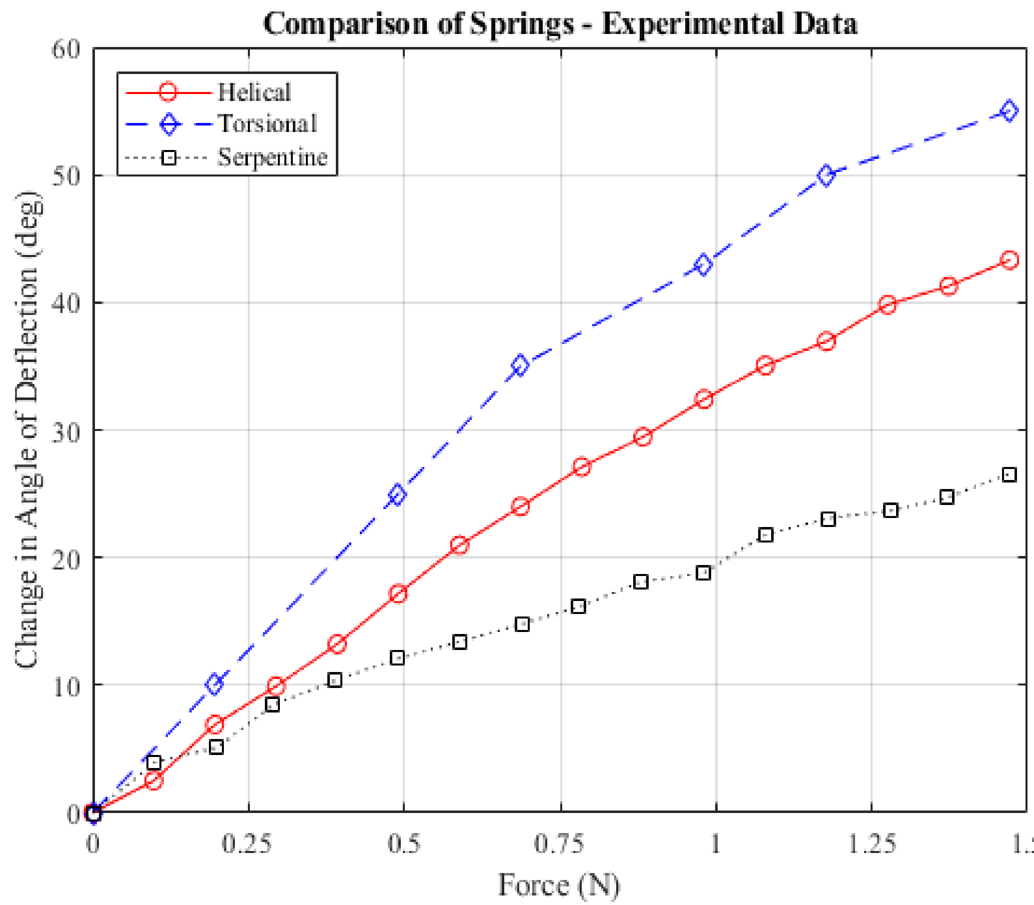
Torsional series

Serpentine structure

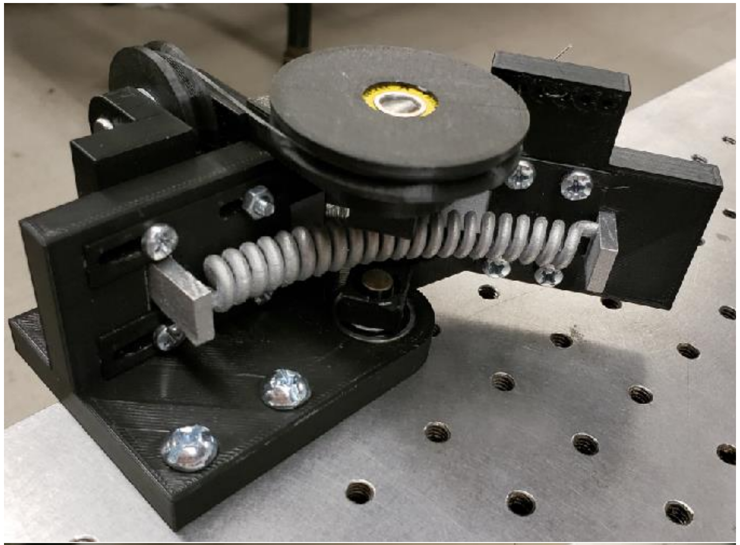
Joint Design – Analysis and Experimentation

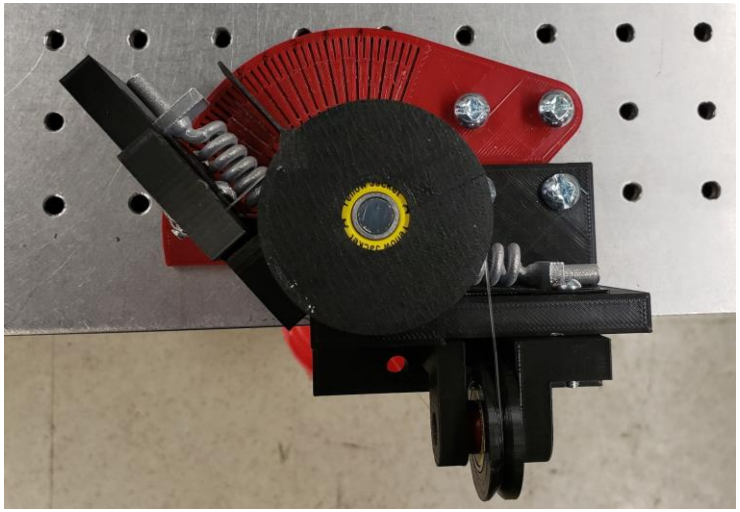


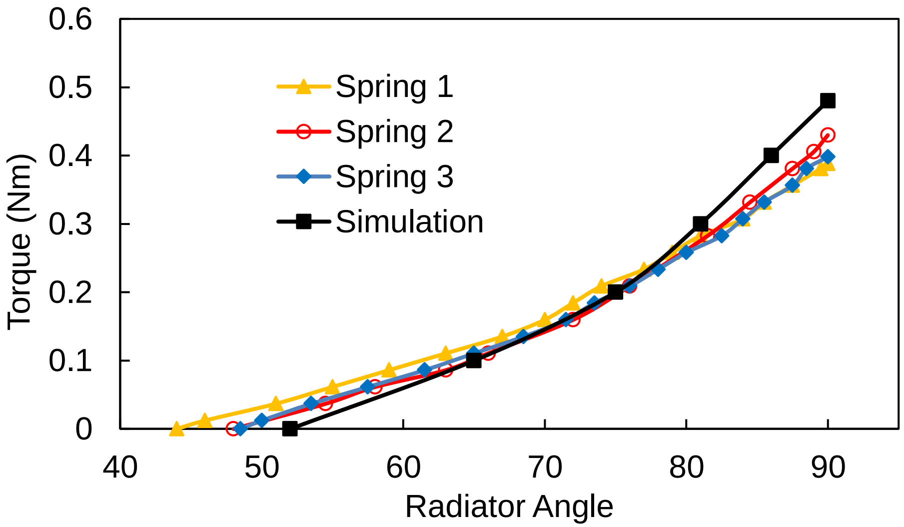




Joint Design – Analysis and Experimentation



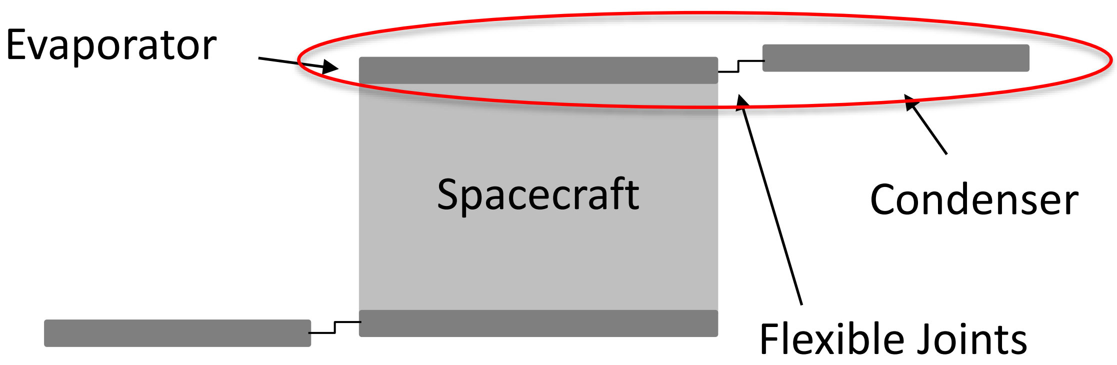




Radiator

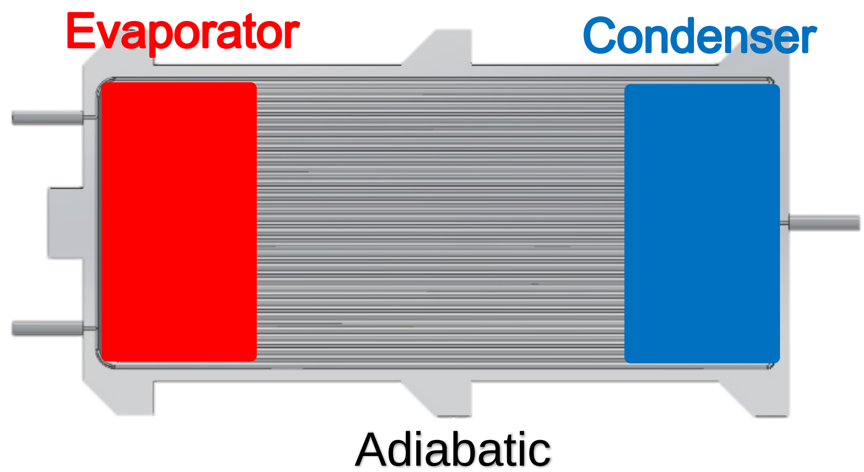
Topics:

- Oscillating heat pipes design considerations
- Additive manufacturing
- Radiator design
- Current design



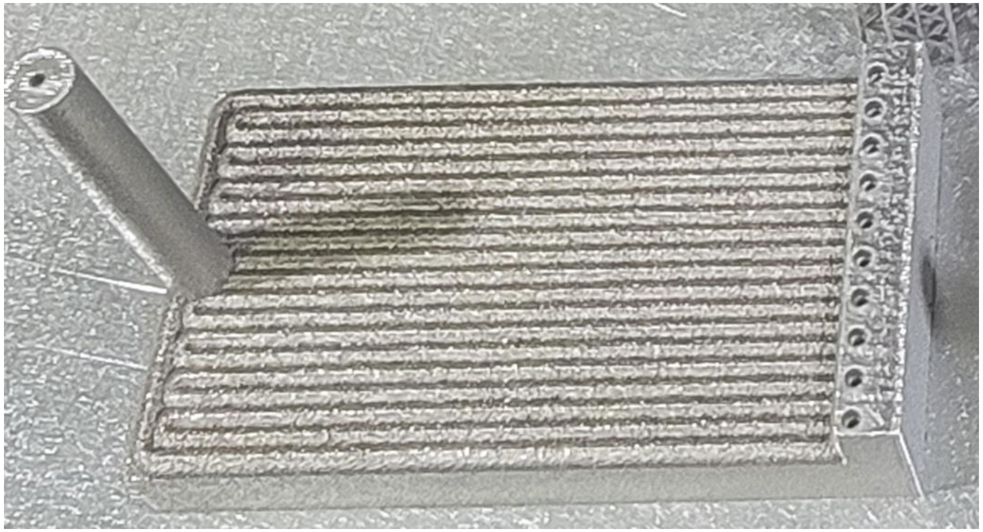
Radiator – OHP Design Considerations

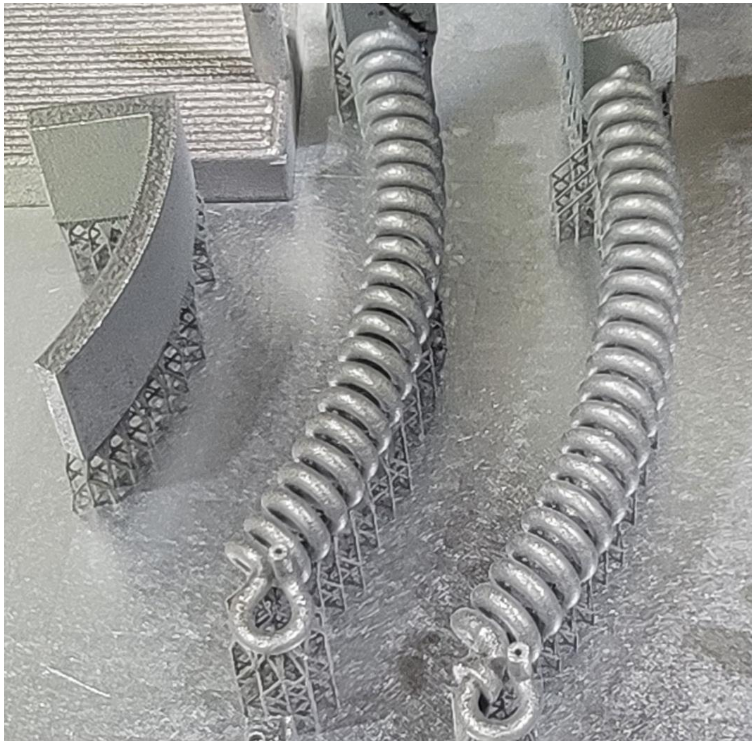
- Channel Diameter
- Turn Radius
- Working Fluid
- Number of turns
- Heat input
- Condenser temperature
- Relative size of evaporator, condenser and adiabatic regions
- Expected performance: ~4-6 W/C



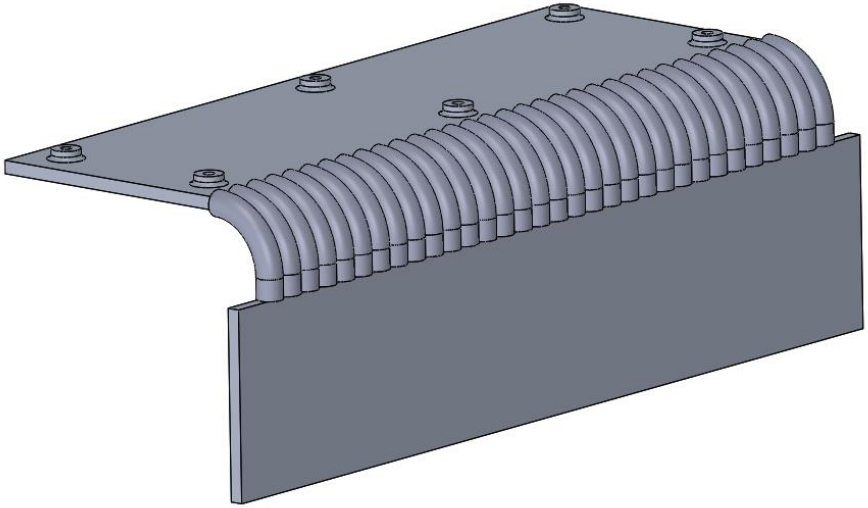
Radiator – Additive manufacturing

- Broadens design space
- Complex geometries
- Rapid prototyping

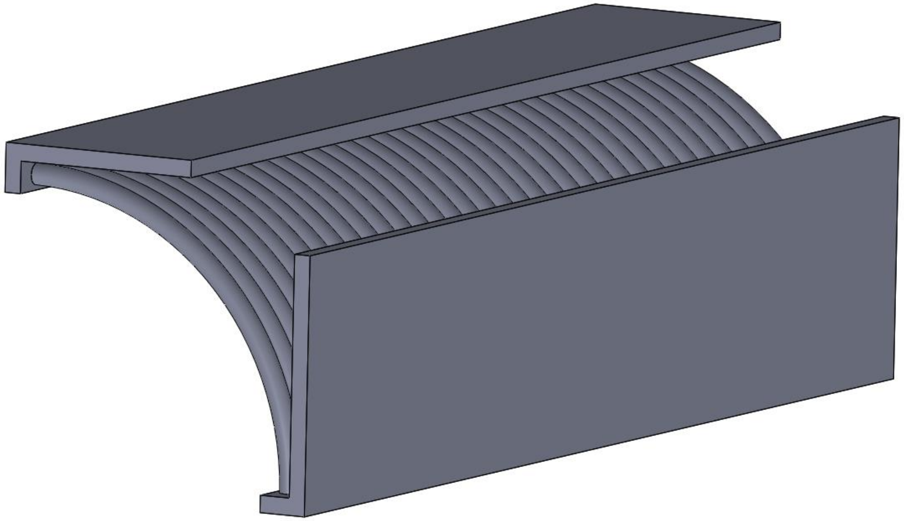




Radiator Design

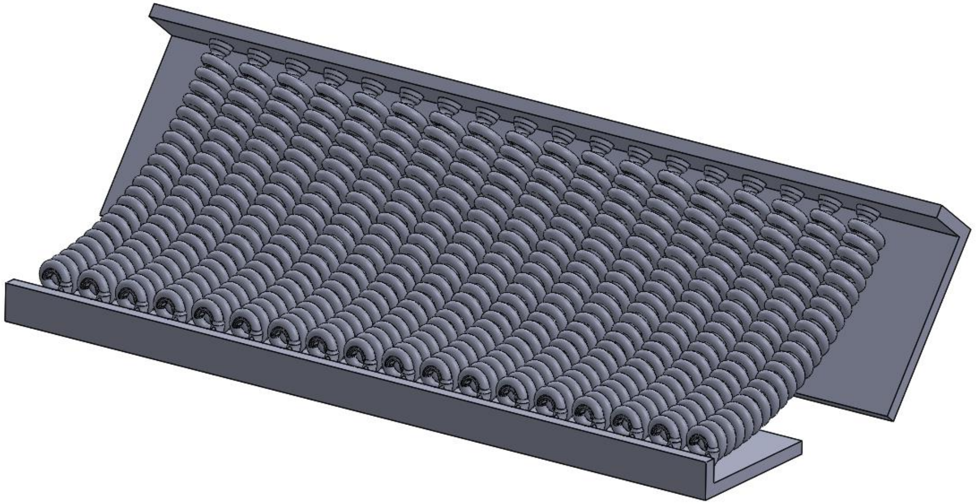


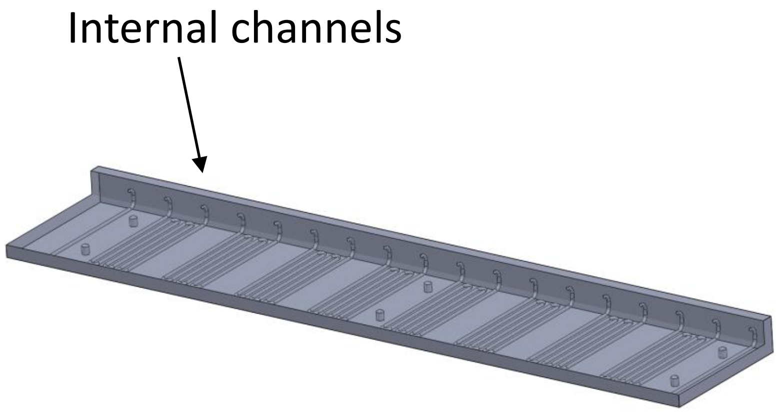
External Design



Internal Design

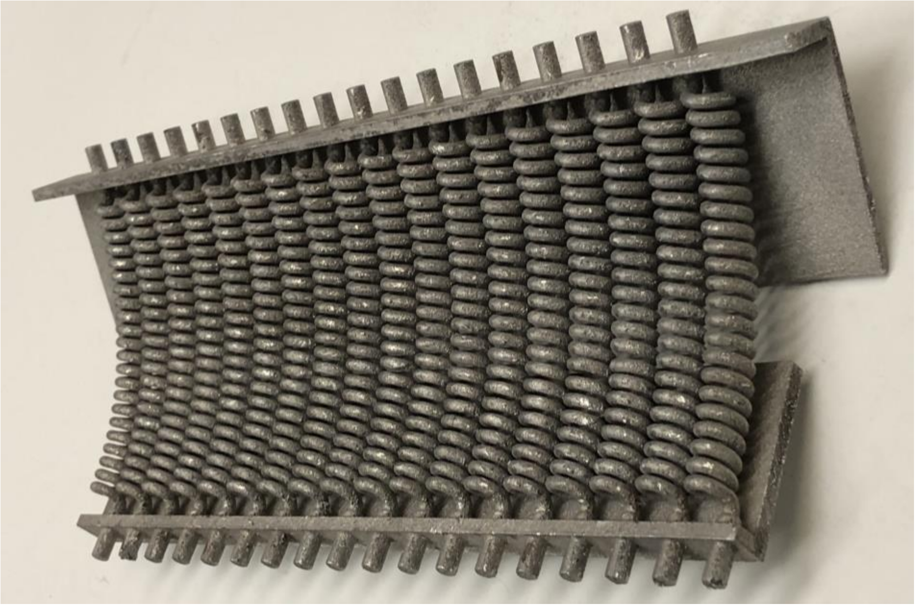
Current Design

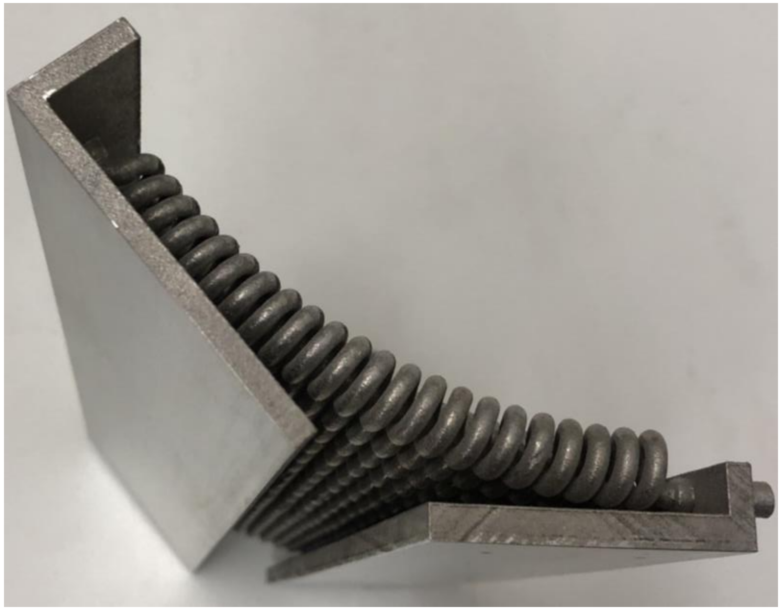


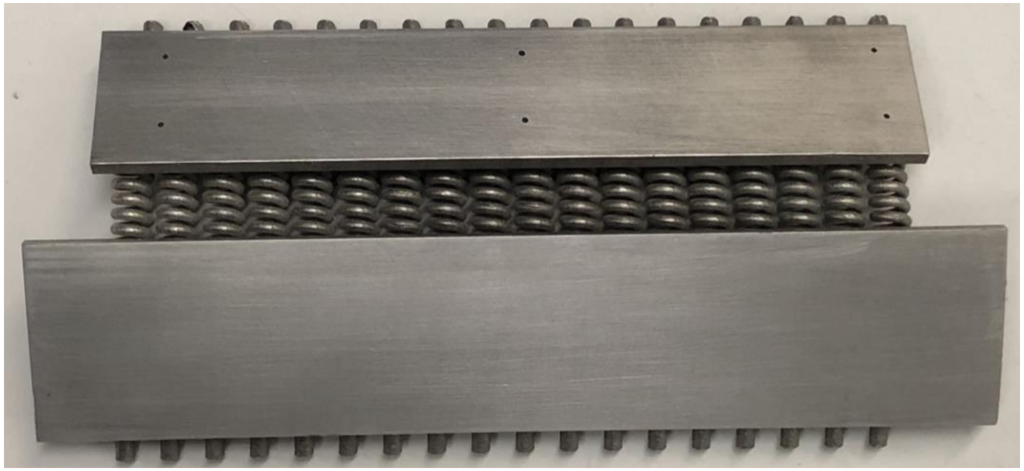


- 18 Joints/Turns
- Aluminum 6061-T6
- Assumed Working Fluid: R123

Current Design



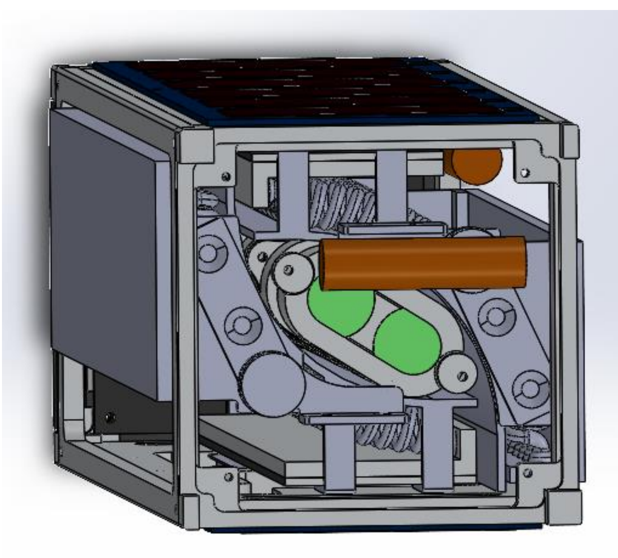


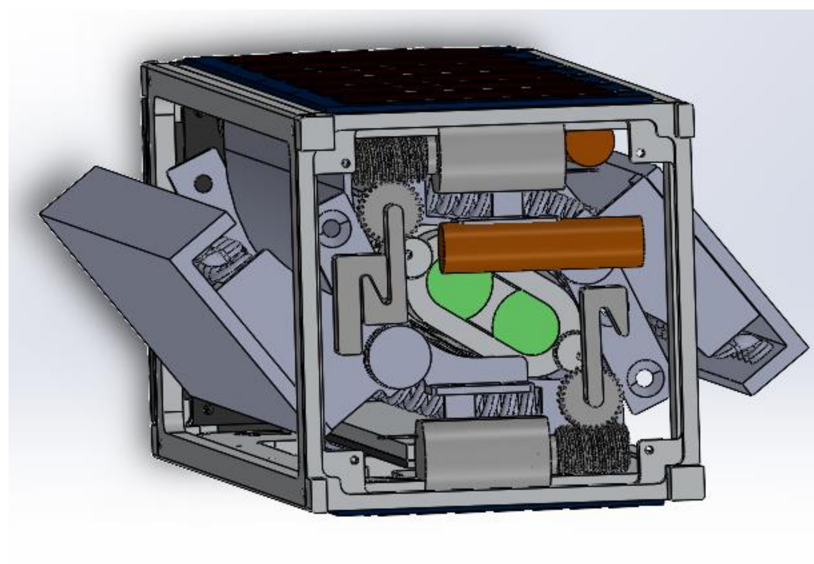


Spacecraft

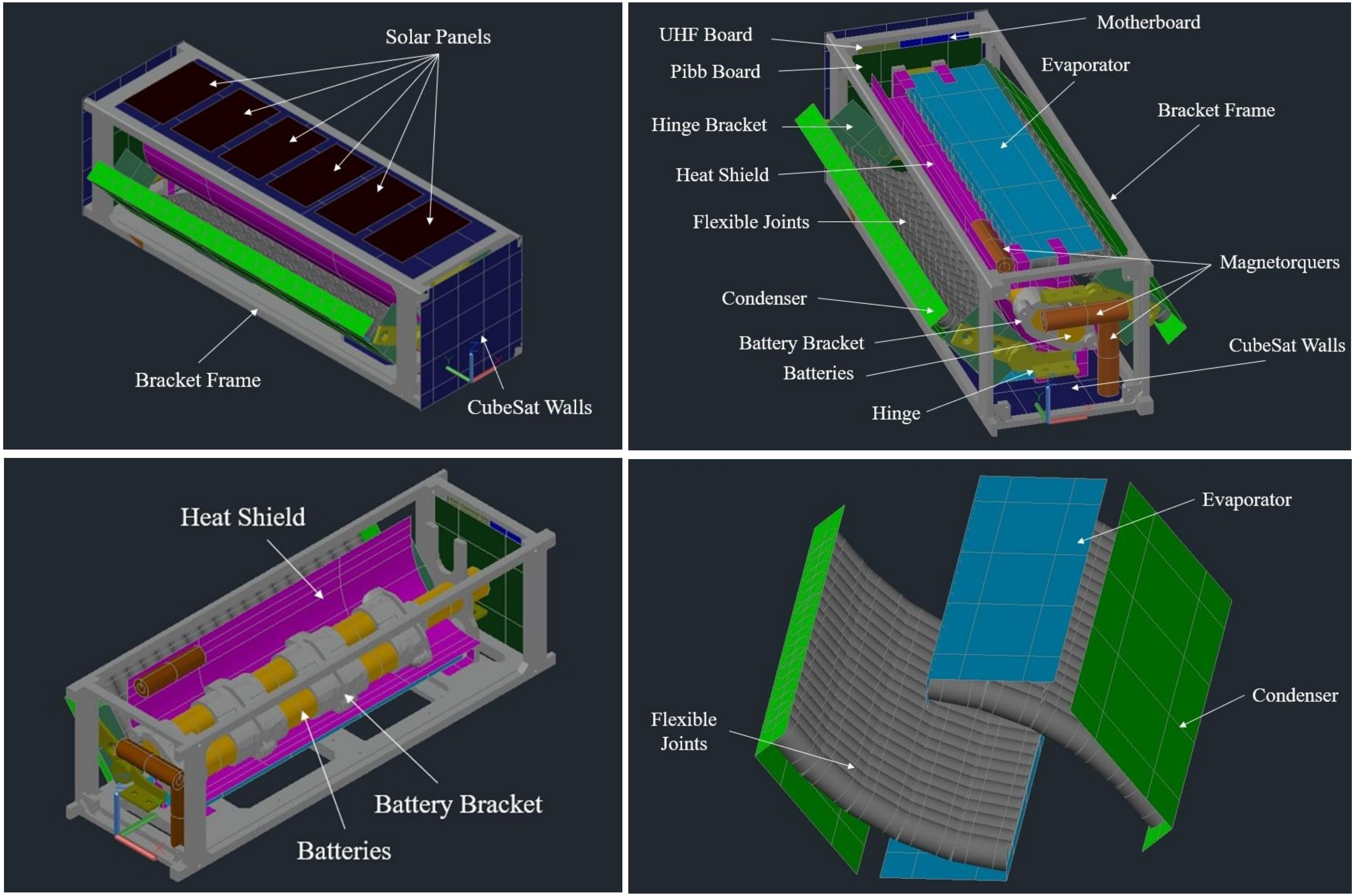
Topics:

- Spacecraft thermal model
- Spacecraft thermal performance

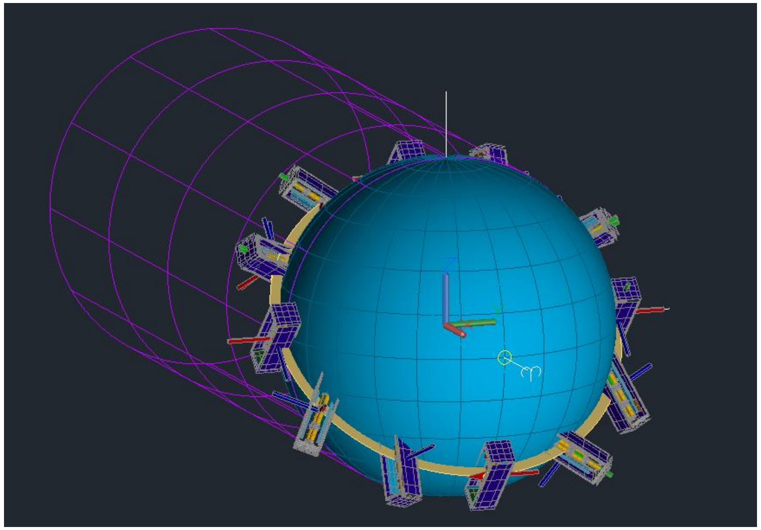


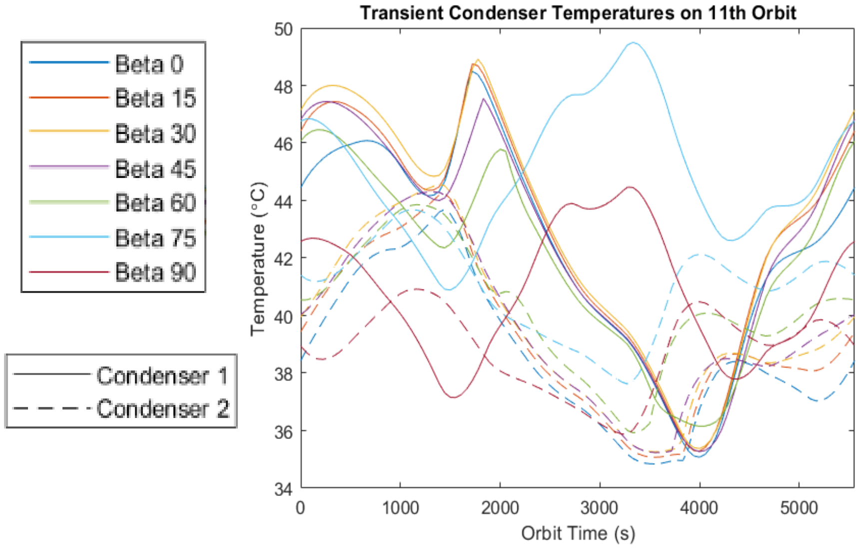


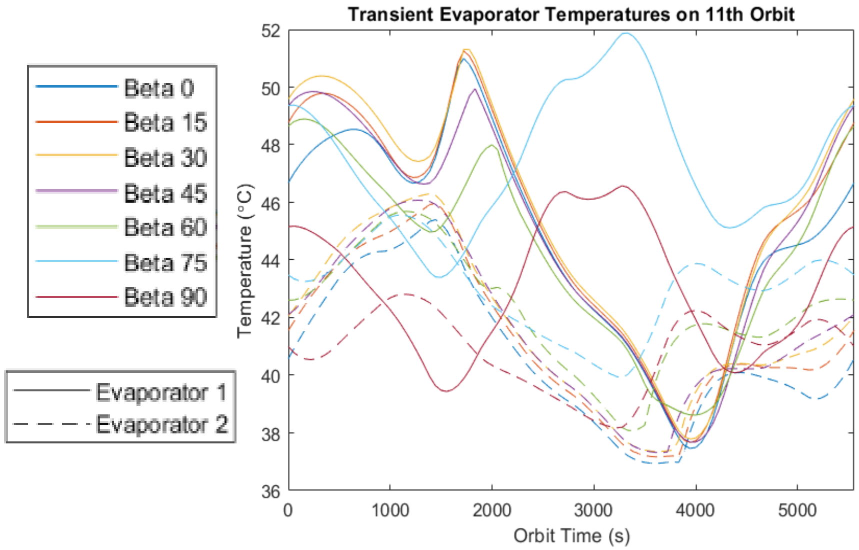
Spacecraft Thermal Model

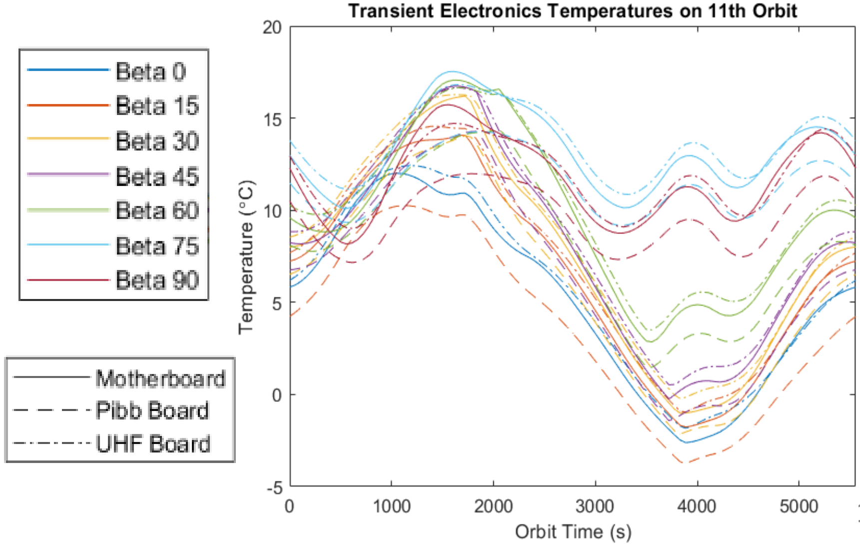


Spacecraft Thermal Performance









Summary of Design

- Volume: ~220 cm^3/radiator
- Mass: ~650 g/radiator
- Power: Passive
- Cost: N/A
- Heat Rejection:
  - 25 W per radiator (50 W total) → <53°C at evaporator
  - 50 W for one radiator → ~65°C at evaporator
- Expected conductance: ~4-6 W/K

Next Steps

- CubeSat-radiator integration
- OHP performance testing
- Further mechanical testing
- TVAC testing
- Follow-on project
- CSLI launch

Thank You!

SMALL SPACECRAFT TECHNOLOGY PROGRAM

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Jet Propulsion Laboratory
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