

**ROCCOR**



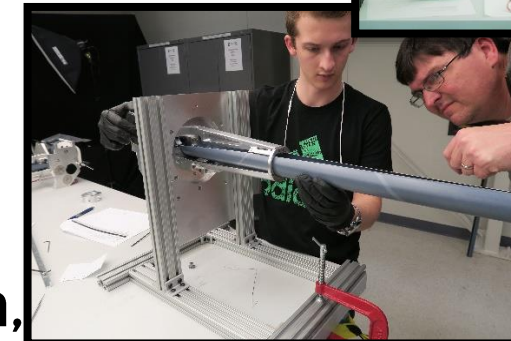
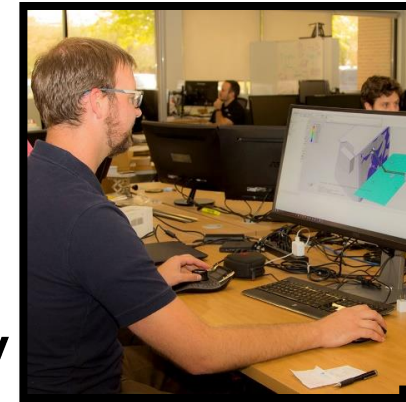
# **Advanced Thermal Architectures for CubeSats (ATACS)**

Mario H. Saldana and Mike Hulse

CubeSat Developers Workshop

April 23<sup>rd</sup> – 25<sup>th</sup> 2019

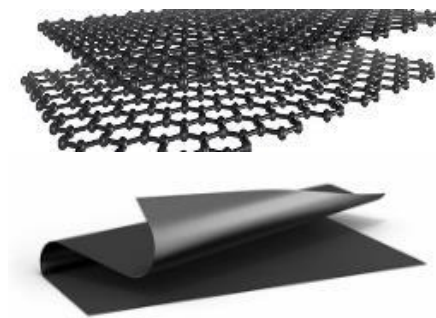
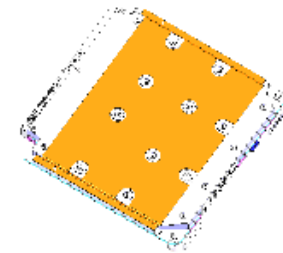
- **Employee owned small business located in Longmont, Colorado**
  - » Active in space, defense and medical sectors
  - » ~50 employees, established production facility
  - » Doubled in size each of the last 3 years
- **Competencies include deployable, power and thermal management systems**
  - » Commercial and US Government customers
  - » Successful track record supplying US and European space primes
  - » In 2018, more than 25 Roccor supplied antenna, solar array and deorbit products were launched



# Thermal Technology Overview

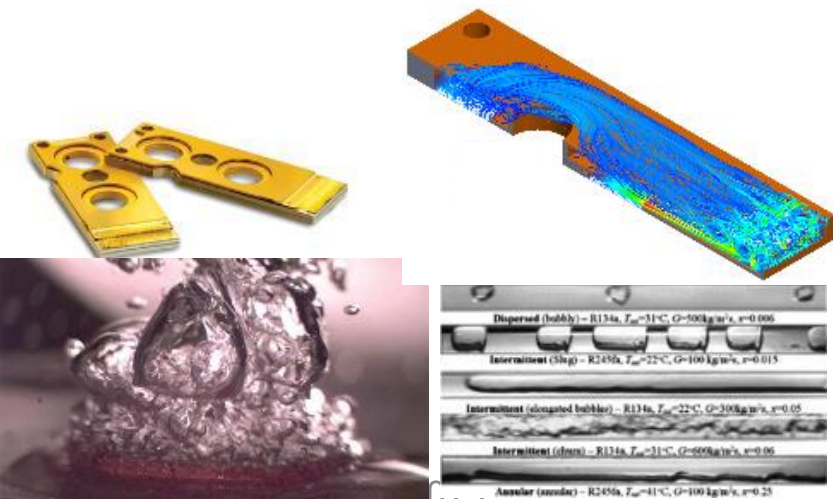
## FlexCool™

Thin, flat and bendable heat pipes



## SMARTCool™

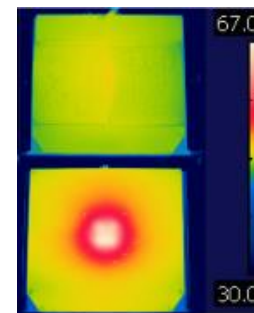
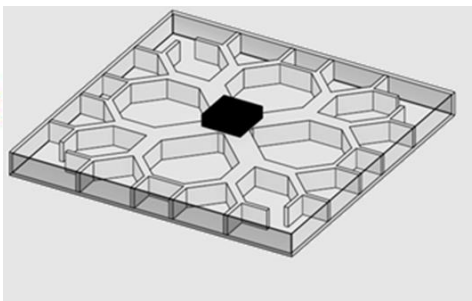
Flow boiling for high energy tactical systems



Dispersed (bubbly) - R134a, T <sub>sat</sub> =31°C, G=500 kg/m <sup>2</sup> s, x=0.006
Intermittent (slug) - R245fa, T <sub>sat</sub> =22°C, G=100 kg/m <sup>2</sup> s, x=0.015
Intermittent (elongated bubble) - R134a, T <sub>sat</sub> =22°C, G=300 kg/m <sup>2</sup> s, x=0.05
Intermittent (column) - R134a, T <sub>sat</sub> =31°C, G=600 kg/m <sup>2</sup> s, x=0.06
Ancillary (annular) - R245fa, T <sub>sat</sub> =41°C, G=100 kg/m <sup>2</sup> s, x=0.25

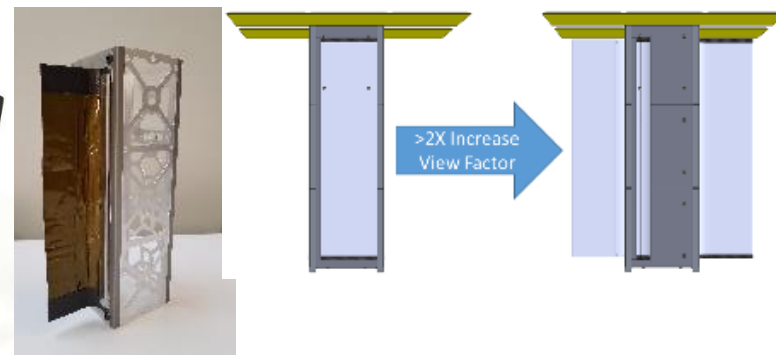
## JouleCool™

Load bearing thermal capacitor



## ROCool™

Heat Spreading and Deployable Radiators

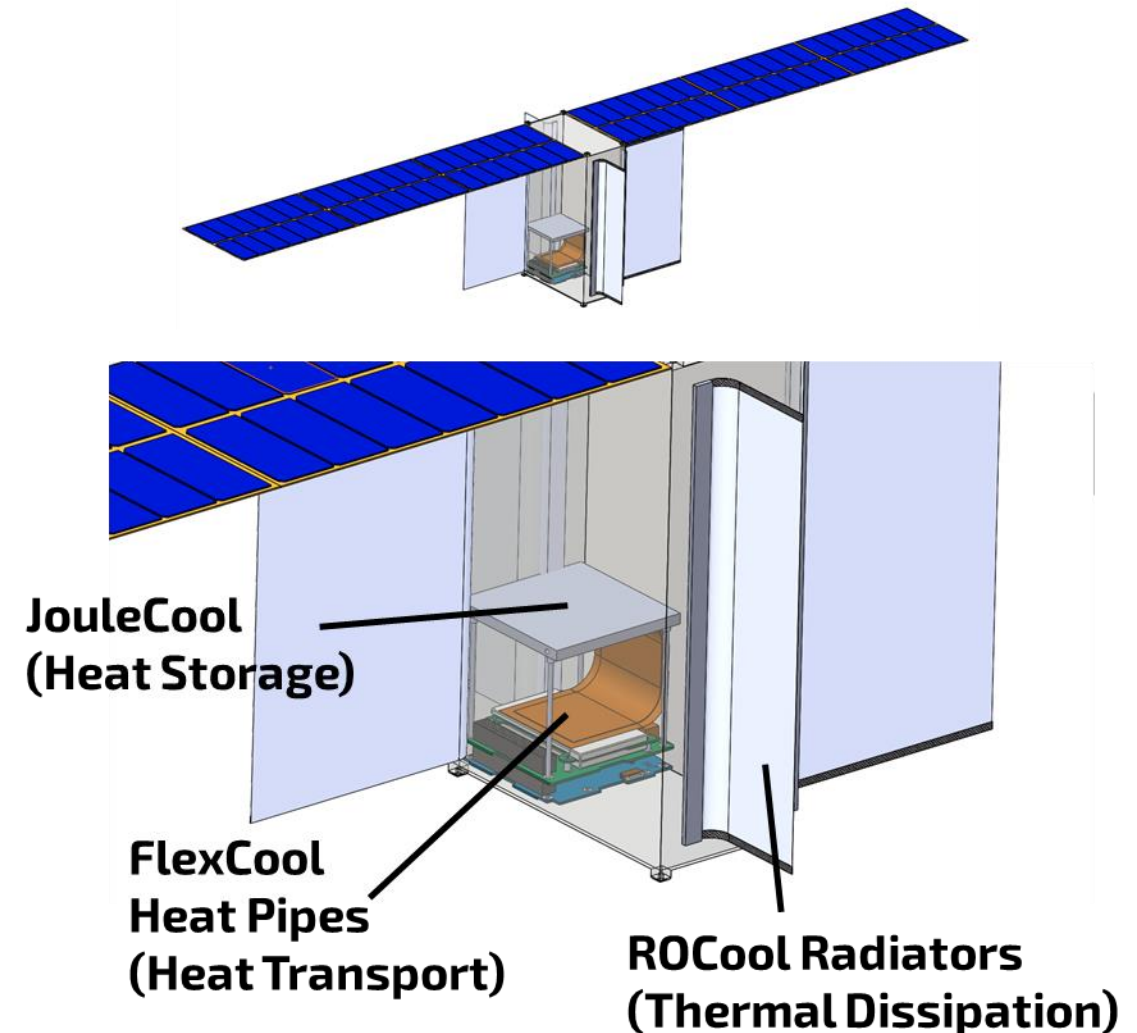


## **Modular approach to CubeSats is plagued by thermal management issues late in their design cycles**

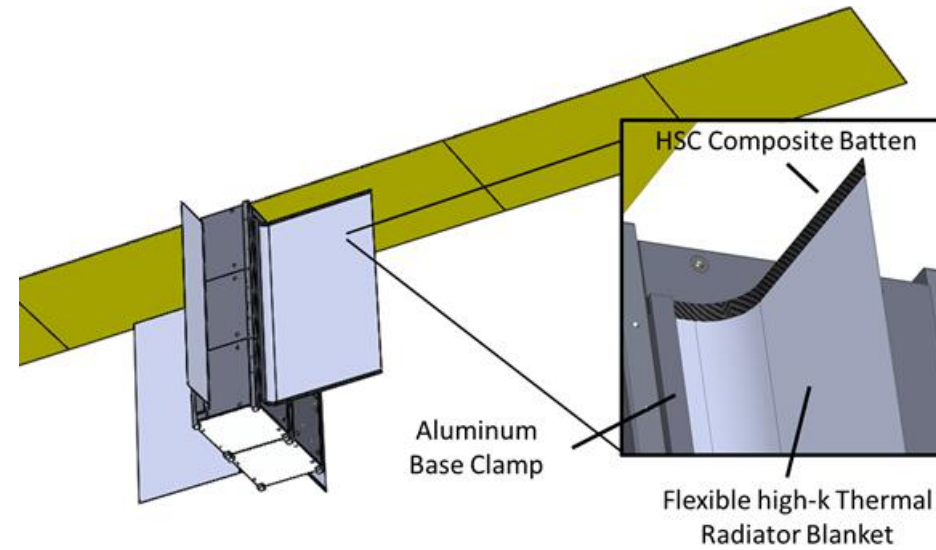
- » Drastic de-rating
- » Or failure to meet original performance objectives

## ATACS

- » Produce a “one-size-fits-most” approach to thermal management across a range of CubeSats
- » Utilize Roccor’s suite of thermal management products

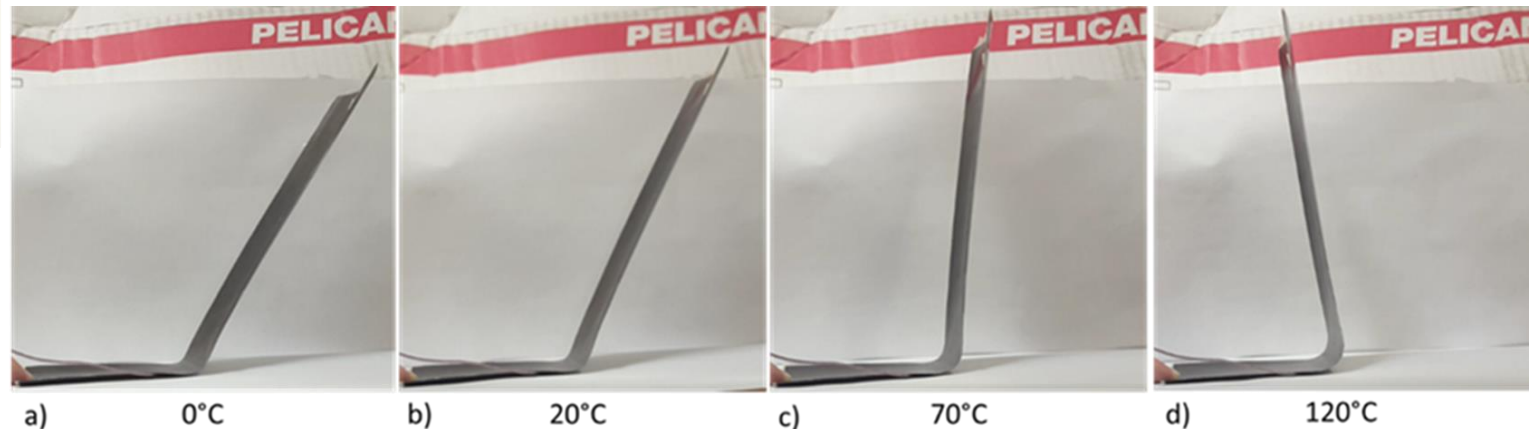
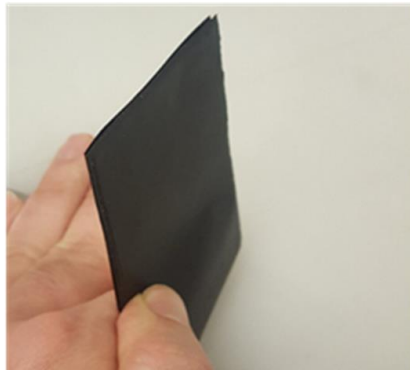


- **Thermally activated hinges**
- **High thermal conductivity radiator blanket**
- **21:1 Turndown Ratio**

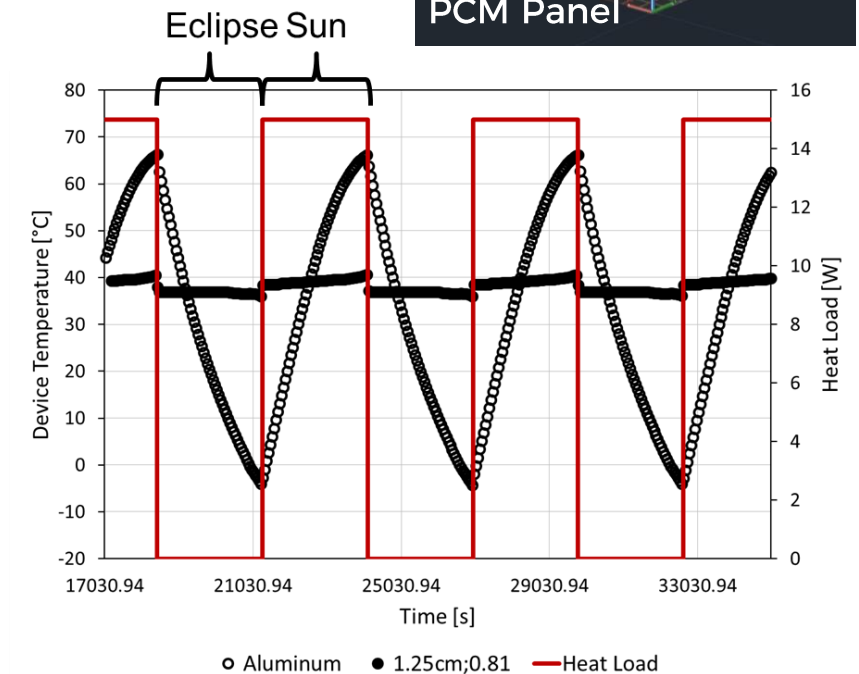
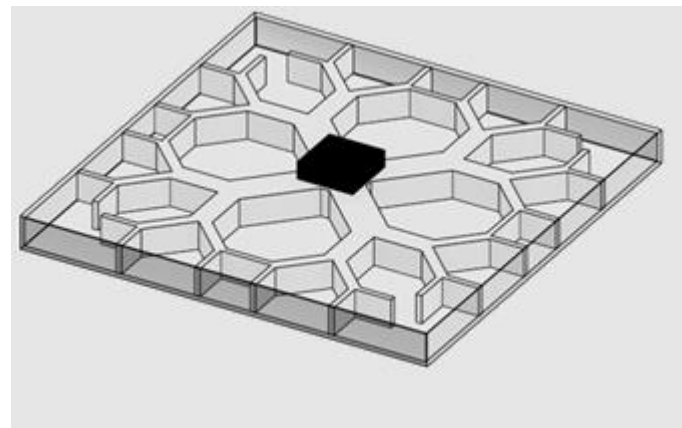
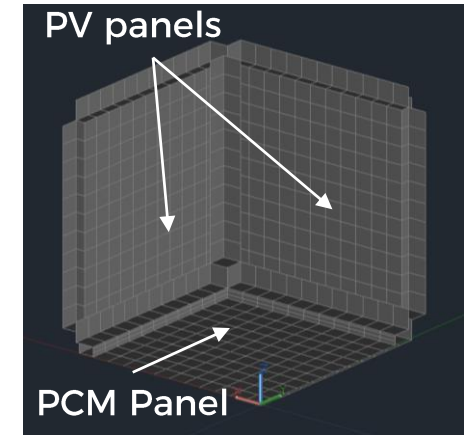


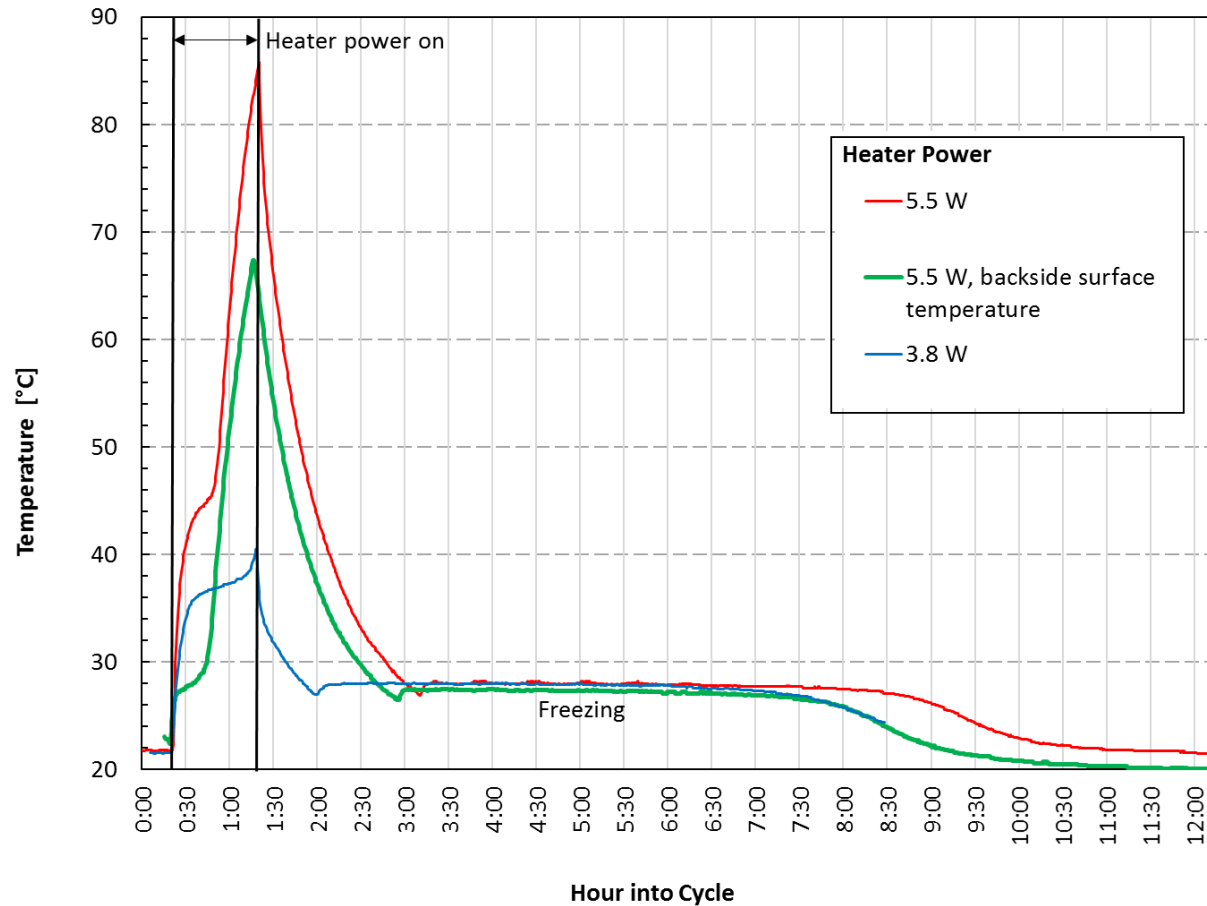
Aluminized outer surface

High emissivity inner surface



- **A Thermal Capacitor using Phase Change material:**
  - » Can dampen temperature fluctuations to maintain components within a tolerable range
  - » Can reduce large temperature swings that could lead to undesirable thermal stresses



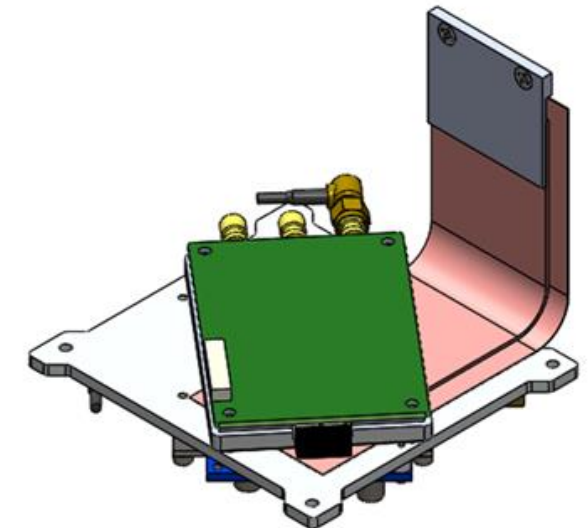
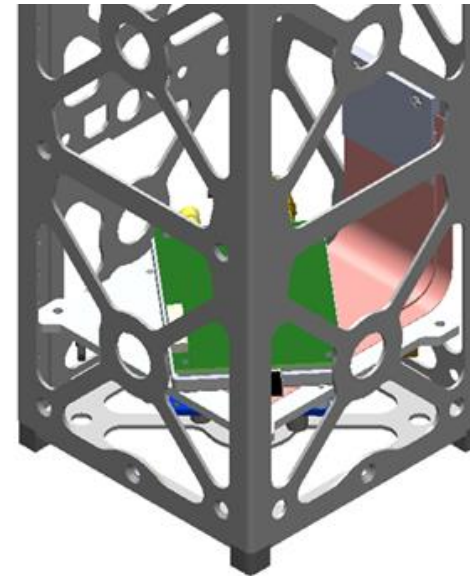
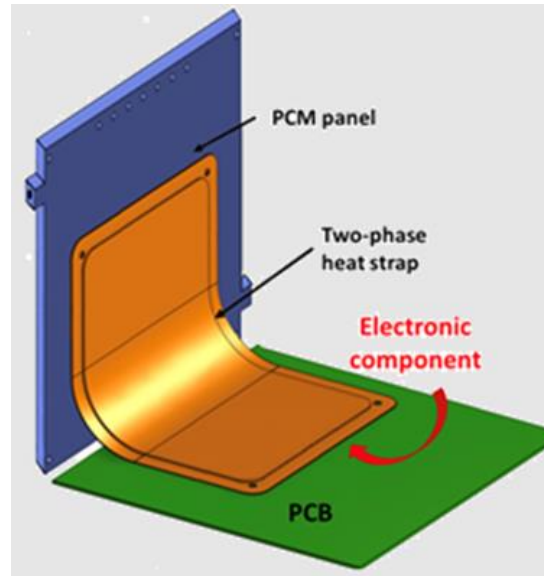
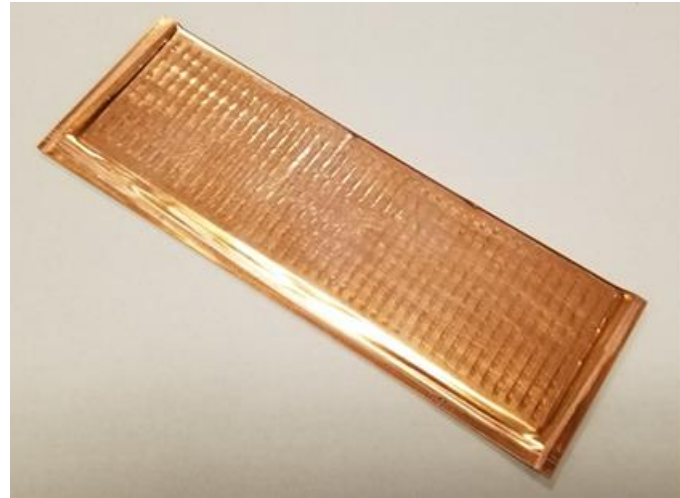


- **Panel was filled with PCM and sealed**
- **Performed thermal testing under vacuum**
- **Completed 25 freeze/thaw tests**
- **No degradation was observed (no panel deformation, melt temperature or mass change)**



## Ultra Thin Heat Pipe

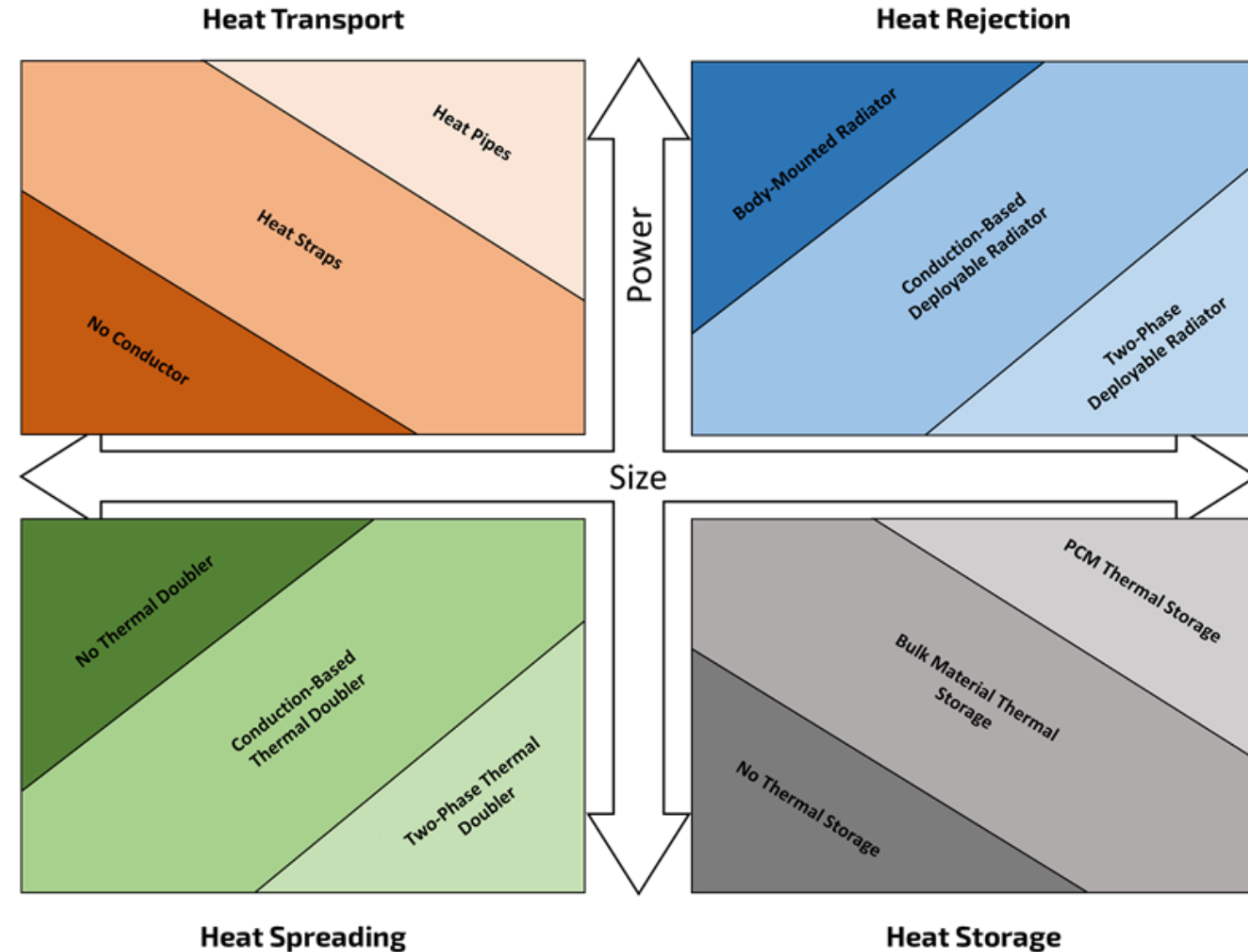
- » Under 1.5 mm
- » Water/Copper



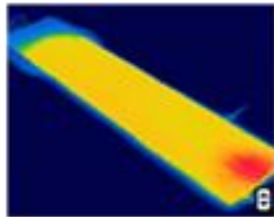
# Technology Identification from Thermal Analysis (TITAN)

## Mapping tool

- » Consider current thermal control technologies
- » Identify key technology transitions in the Thermal Control System (TCS)



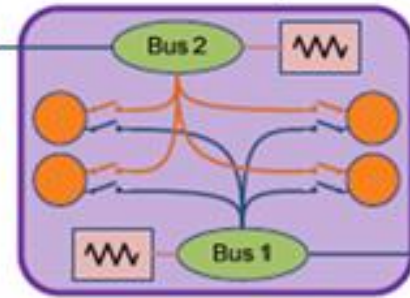
FlexCool™ Two-phase heat pipes



JouleCool PCM Panel



ROCool™ Deployable Radiator

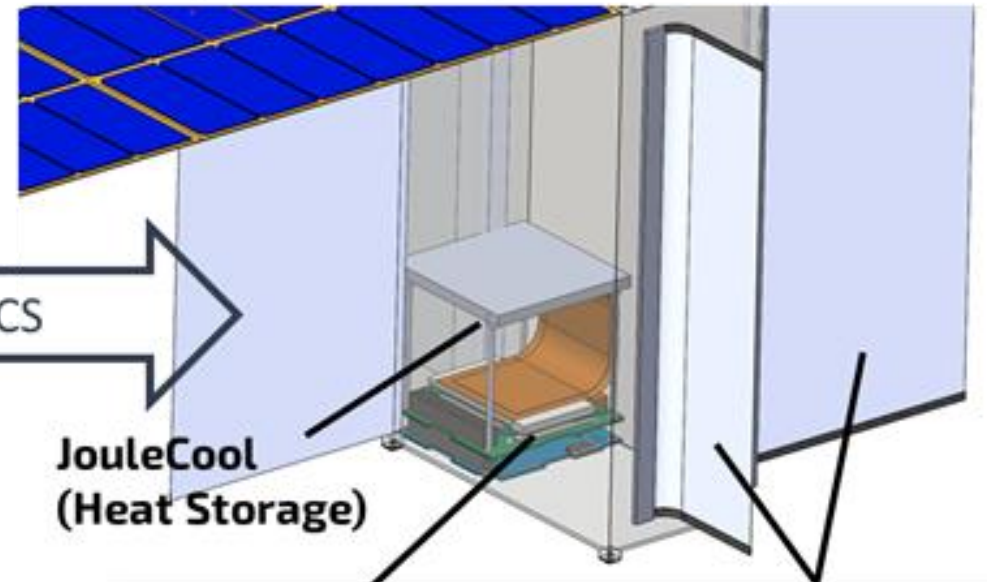


ATACS

JouleCool (Heat Storage)

FlexCool Heat Pipes (Heat Transport)

ROCool Radiators (Thermal Dissipation)



# Questions?

## Thank You and Stay Cool

# ROCCOR

