



# Conformal Ablative Thermal Protection System for Small and Large Scale Missions: Approaching TRL 6 for Planetary and Human Exploration Missions and TRL 9 for Small Probe Missions

**R. A. S. Beck<sup>1</sup>**, M. J. Gasch<sup>1</sup>, F. S. Milos<sup>1</sup>, M. M. Stackpoole<sup>1</sup>, B. P. Smith<sup>1</sup>, M.R. Switzer<sup>1</sup>, E. Venkatapathy<sup>1</sup>, M. C. Wilder<sup>1</sup>, T. Boghhozian<sup>2</sup>, J. F. Chavez-Garcia<sup>2</sup>, T. Gokcen<sup>2</sup>, D. K. Prabhu<sup>2</sup>, G. T. Swanson<sup>2</sup>, C. D. Kazemba<sup>3</sup>, W. Congdon<sup>4</sup>, D. DePasquale<sup>5</sup>, B. A. Woollard<sup>6</sup>, A. Sidor<sup>6</sup>

<sup>1</sup> NASA Ames Research Center, Moffett Field, CA 94035

<sup>2</sup>ERC @ NASA Ames Research Center, Moffett Field, CA 94035

<sup>3</sup>STC @ NASA Ames Research Center, Moffett Field, CA 94035

<sup>4</sup>Applied Research Associates (ARA) Ablatives Laboratory (ABL), 14824 E. Hinsdale Ave., Unit C, Centennial, CO 80112

<sup>5</sup>Terminal Velocity Aerospace, LLC, 75 5<sup>th</sup> Street NW, Suite 244, Atlanta, GA 30308

<sup>6</sup>Georgia Institute of Technology, North Avenue, Atlanta, GA 30332

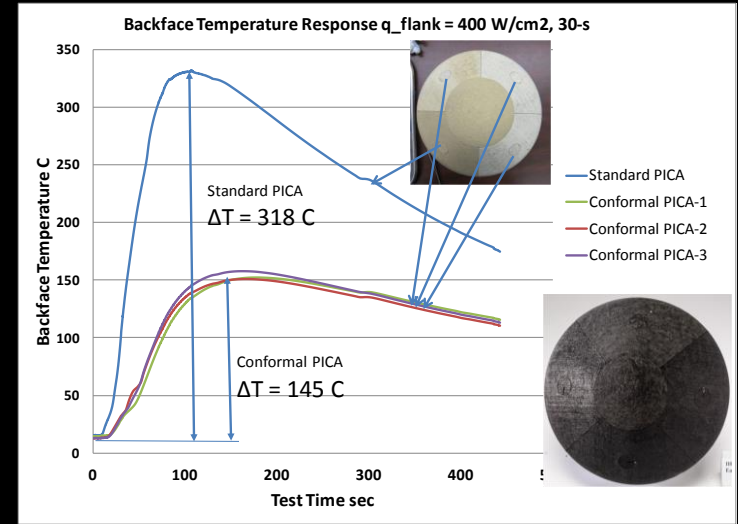
**IPPW-12, Cologne, Germany  
June 2015**

# CA-TPS: The Problem – The Solution



**Problem:** Current SOA materials require complicated installation techniques and/or high touch labor costs (PICA, Avcoat, SLA) and with adequate thermal and poor-to-moderate mechanical performance

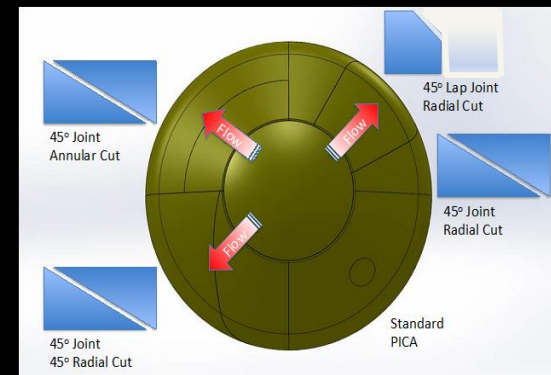
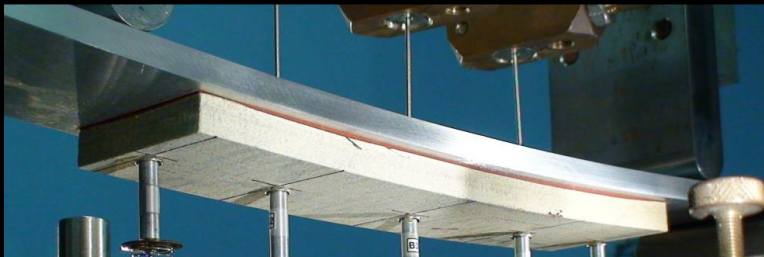
**Solution:** Develop a conformal TPS ablator with a significantly lower areal mass and more compliant for ease of integration (direct bonding, no gap fill)



Materials response models tested –  $\Delta T = \Delta T_{PICA}/2$   
 Seam development models tested – no gap filler

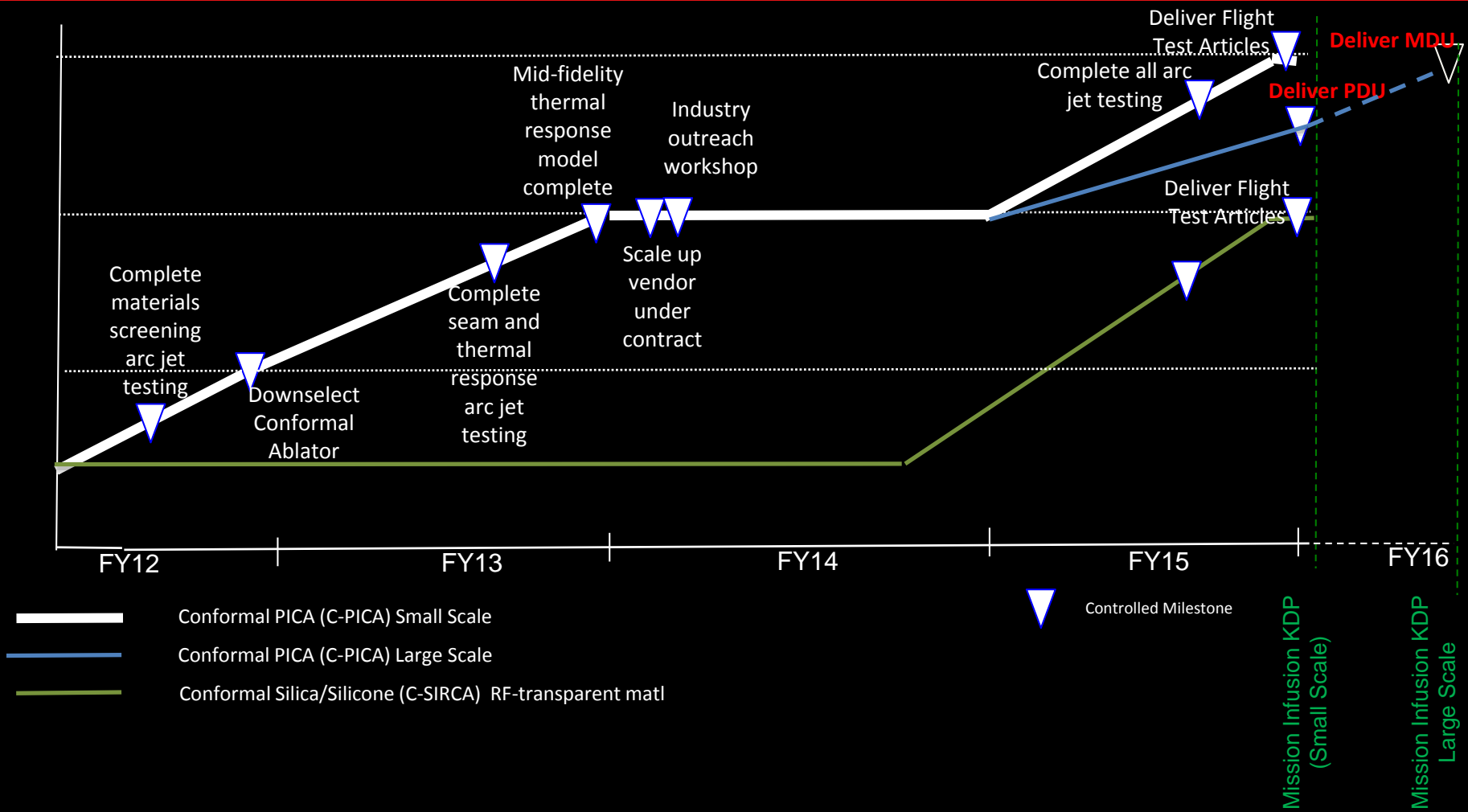


PICA failure <750 lb, ROC ~145"  
 C-PICA no failure at 1500 lb, ROC <65"





# CA-TPS TRL Progression



# CA-TPS Mission Infusion Efforts

## Small Probe Development with Terminal Velocity Aerospace Design and Hardware Roles and Responsibilities



- Small probe vehicle designed for break-up evaluation
- TVA responsible for entire design
  - Ames responsible for TPS selection and sizing
- Ames hardware
  - Backshell TPS bonded to carrier structure
    - RF transparent Silica/silicone (C-SIRCA)
    - In-depth instrumentation included
  - Heatshield TPS bonded to carrier structure
    - C-PICA
    - In-depth instrumentation included
- Remaining hardware is TVA's responsibility

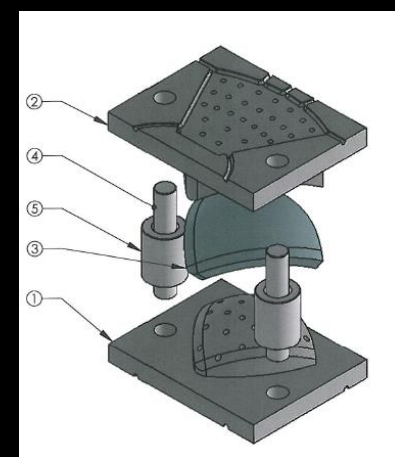
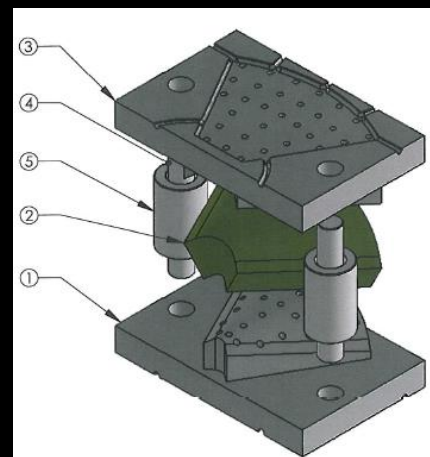
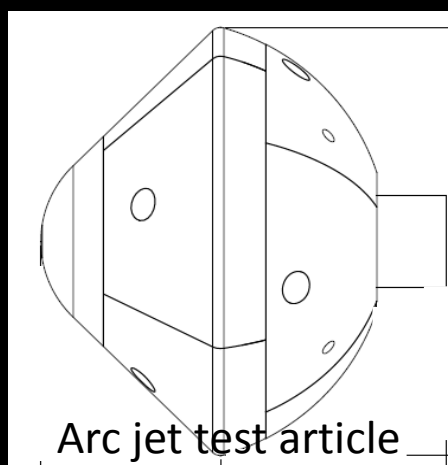
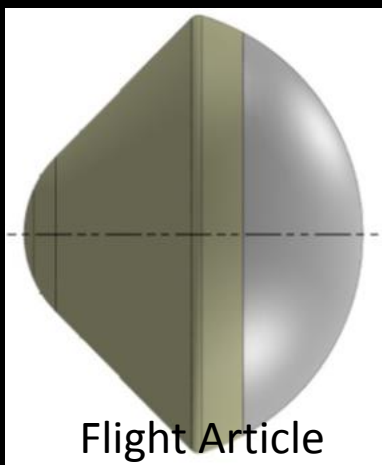


# CA-TPS Mission Infusion Efforts

## Small Probe Development with Terminal Velocity Aerospace Arc Jet Test Article Design and Build



- **Vehicle and arc jet test article configuration iterations completed**
  - Trajectory analyses performed, environments defined, TPS sizing completed
- **TPS parts designed**
- **TPS processing molds designed and manufactured**
- **Segments processed and machined**



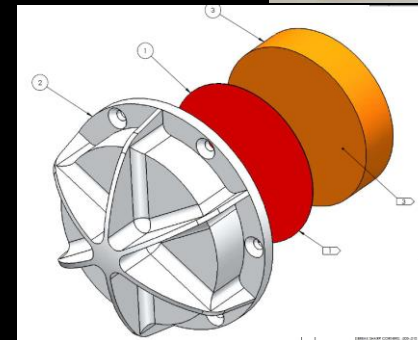
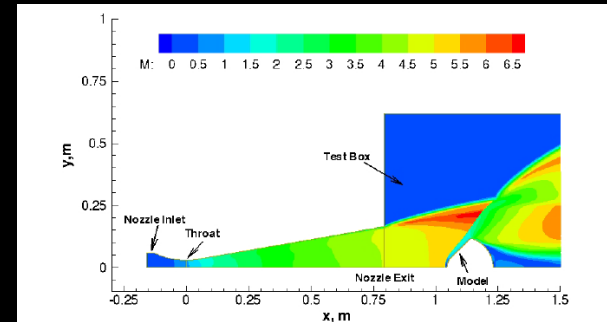
- **TVA tested their mock-up in balloon-drop out of Tillamook, Oregon**
  - Charred RF transparent conformal ablator flew

# CA-TPS Mission Infusion Efforts

## Small Probe Development with Terminal Velocity Aerospace Arc Jet and Vibe Testing Efforts



- Arc jet test planning completed
  - Arc jet environments defined
  - Arc jet aeroshells received from TVA
  - Test article assembly nearly complete
  - Testing scheduled Aug 3-7
- Vibe test planning underway
  - Testing PICA, C-PICA and C-SIRCA
  - Test fixture
  - Fixtures and specimens in manufacturing
  - Testing scheduled in July



**TVA RED-Data2 has a flight manifest – late CY17**

# CA-TPS Scale-Up – Step 1

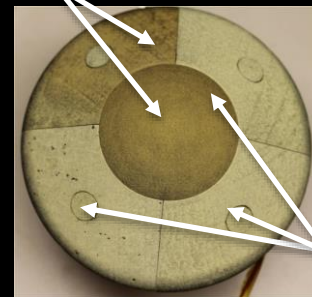
## Vendor Demonstration of C-PICA Processing (Small articles)



- Material processing duplicated on small scale by Applied Research Associates, Ablative Laboratory (ARA-ABL)
- NASA provided molds and process descriptions used and first parts produced
  - Flat panels for characterization
  - Molded parts for use on arc jet test models
- NASA process duplicated with no changes provided delivered parts
- Testing to occur June 24-25



NASA C-PICA



Vendor



# CA-TPS Scale-Up – Step 2

## C-PICA Pathfinder Unit Leading to a MDU



- Pathfinder Demonstration Unit for delivery this year
  - Design new metallic molds for large-scale parts
  - Infiltrate thin and thick felt to demonstrate uniform infiltration and evaluate extent of warping (parts ~0.6m x 0.7m)
  - Install on foam “body”
- Manufacturing Demonstration Unit for delivery mid FY16 (if funded)
  - ~1-m length mid L/D vehicle design
  - Build 3-4 panels
  - Side panel(s) demonstrates complex curvature
  - Install on foam “body”

