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

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www.nasa.gov/directorates/spacetech/game_changing_development
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 – $\Delta T = \Delta T_{\text{PICA}}/2$

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

- **Conformal PICA (C-PICA) Small Scale**
- **Conformal PICA (C-PICA) Large Scale**
- **Conformal Silica/Silicone (C-SIRCA) RF-transparent matl**

**FY12**
- Complete materials screening arc jet testing
- Downselect Conformal Ablator

**FY13**
- Complete arc jet testing
- Complete vendor under contract
- Scale up thermal response model complete

**FY14**
- Mid-fidelity thermal response model complete
- Industry outreach workshop

**FY15**
- Complete all arc jet testing
- Deliver Flight Test Articles
- Complete seam and thermal response arc jet testing
- Controlled Milestone

**FY16**
- Deliver MDU
- Deliver PDU
- Mission Infusion KDP (Small Scale)
- Mission Infusion KDP (Large Scale)
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
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
• 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”