Conformal Ablative Thermal Protection System for Planetary and Human Exploration Missions


NASA Ames Research Center, ERC Corporation, Jet Propulsion Laboratory

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Context & Objective

Game Changing: we are looking to create a high strain-to-failure TPS with dramatic reduction in cost and complexity

Why Conformal?

Conformal Solutions

 MODULE: Conformal Ablator

Why Conformal?

- High strain to failure
- Low cost
- Lightweight
- High heat flux capability

The Vision is to develop and deliver a high-strain-to-failure conformal TPS to meet the cost and complexity of protecting an air-breathing vehicle

Systems Engineering Approach to Material Development

Mission Application Requirements

- MSL-like entry
  - 4.5 m diameter composite heatshield structure
  - Peak heat rate 726 W/cm², peak shear 440 Pa, peak pressure 33 atm (9 σ design basis)

- COTS LED entry
  - Generic environments include 25% margin
  - Highest heat load for a capsule shallow trajectory (28,400 W/m²)
  - Heat rates for capsule and lifting 150 W/cm², Max shear ~325 Pa (lifting), Max pressure ~0.2 atm (lifting)

Material Performance Goals

- Demonstrate performance capability of conformal ablators under relevant aerothermoheating conditions
- Goal: Survive MSL-like heating, pressure, and their environments
- Goal: Survive COTS-like heating loads

Perform Arc Jet Testing and Materials Properties Testing to Downselect Best Material

CA250 Project Schedule

Key Performance Parameters

Conformal Ablator

- Key Performance Parameters
  - Key: Performance
  - Conformally Ablator
    - Category: Key Performance
    - Performance: Ablator
    - Parameter: Conformal
    - Value: Ablator
    - Justification: Ablator is a conformal ablative material that can be tailored to meet specific mission requirements

Establish Industry Partnerships for Scale-Up

- Industry Request for Information – Conformal TPS Manufacturing Scale-Up
  - Objective
    - Manufacturing Plan for field-based conformal ablative materials at least 1-m diameter – which includes the necessary processes, procedures, equipment, and any services required
    - Non-destructive methodologies necessary to examine variations in the field structure and the resulting conformal ablative and for bonding verification
    - Proposed specifications for certified TPS processing and NDE evaluation of the ablative materials
    - Design support and manufacture of a 1-meter class manufacturing demonstration unit (MDU)
    - Vendor will be required to supply small-scale materials for testing followed by large-scale materials for application to the 1-meter diameter MDU
    - Current maximum available thicknesses of carbon felt is ~2 cm, the Project is working to develop thicker felt (~6-7 cm) with industry partners
    - Work-to-go: planned to reach TRLs in 2 years
      - Technology transfer for scale-up and qualification of the materials
      - Development of attachment and bounding techniques
      - Perform further arc jet tests and thermal tests to provide data for development of a mid-fidelity material response model
      - Develop mid-fidelity material response model
      - Manufacture MDU
      - Develop NDE techniques to evaluate material and bond conformance
      - Develop material specifications
      - Begin technology push to new missions

Conclusion & Outlook

Work-to-date shows promise that we can achieve our TRL 5 goal for conformal ablator with industry partnerships and focused testing