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

CONCLUSION & OUTLOOK

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

NASA OCT Game Changing Development Program

What is our Mission?

To focus on transformative space technologies that will lead to advances in space and aerofoil capabilities, serve as a stimulus to the US economy while providing inspiration and opportunity to our nation's youth.

Goals

- Develop Game Changing technologies that produce dramatic impacts for NASA's Space Exploration and Science Missions
- Capitalize on opportunities to leverage funding and resources from external organizations in technology areas mutually benefiting NASA and the other organizations.
- Formulate and implement technology projects that deliver the required performance to schedule and within cost
- Develop technology knowledge, identified internally for NASA missions as well as externally throughout the aerospace community.

Vision

- Recent focus of the TPS community has been on ablative solutions.
- Lessons learned:
  - Only 2 rigid TPS alternatives (PICPA and ACEVOS) had been maturing each having significant integration issues
  - Use of strain-to-failure makes direct bonding problematic
  - Existing systems are expensive and time consuming to install
  - Work was initiated under ETDO and ARMD to develop improved TPS

The Vision is to develop and deliver a high strain-to-failure conformal TPS to TRL 5 capable of reducing the cost and complexity of protecting an flight aerocraft.

Systems Engineering Approach to Material Development

Mission Application Assessment

- 4.5 m diameter composite heatshield
  - Peak heat rate 726 W/m², peak shear 400 Pa, peak pressure 33 atm (91 sigma design values)

COTS LOI entry

- Generic environments include 25% margin
- Highest heat flux for a capsule shallow trajectory (28,480 J/m²)
- Heat rates for capsule and lifting -150 W/m², Max shear -352 Pa (lifting)/Max pressure 0.3 atm (lifting)

Performance Goals

- Demonstrate performance capability of conformal ablator under relevant aerospace heating conditions
- Goals: survive MLS-like heating, pressure, and strain environments
- Goals to survive COTS-like heating loads

Key Performance Parameters

- Conformal Ablative Key Performance Parameters
  - Conformal Ablative
    - Category: Key Performance Parameters
      - Conformal Ablative
    - Category: Performance Parameters
      - Conformal Ablative
    - Category: Performance Parameters
      - Conformal Ablative

- Key Decision Gates
  - Key Decision Gates
    - Systems Engineering
    - Engineering
    - Develop Industry
    - identifies the high strain-to-failure TPS need and seeks to:
    - Identify and prioritize technology development efforts
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Perform Arc Jet Testing and Materials Properties Testing to Downselect Best Material

Establish Industry Partnerships for Scale-Up

- Industry Request for Information: Conformal TPS Manufacturing Scale-Up
  - Objective
    - Manufacturing Plan for felt-based conformal ablator 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 felt structure and the resulting conformal ablator and for bond 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 samples 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 TRL 5 in 2 years
  - Technology transfer for scale-up, and evaluation of Industry materials
  - Development of attachment and seams techniques
  - Perform further arc jet tests and thermal properties tests to provide data for development of a mid fidelity material response model
  - Develop mid fidelity material response model
  - manufacture and MDU
  - Develop NDE techniques to evaluate material and bond conformance
  - Develop material specifications
  - Begin technology push to new missions