Conformal Ablative Thermal Protection System for Planetary and Human Exploration Missions

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Systems Engineering Approach to Material Development

Mission Application Assessment
- • 4.5 m diameter composite heatshield structure
  - Peak heat rate 7260 W/m², peak shear 440 Pa, peak pressure 4.2 atm (9 sigma design values)
- • COTS LCD entry
  - Generic environments include 20% margin
  - Highest heat load for a capsule shallow trajectory (79,440 W/m²)
  - Heat tubes for capo and lift (190 W/m²), Max shear 101 Psa (liftoff), Max pressure 0.25 atm (liftoff)

Performance Goals
- Demonstrate performance capability of conformal ablator under relevant aerothermal heating conditions
- Go to survive MSL-like heating, pressure, and their environments
- Go to survive COTS-like heating loads

Key Performance Parameters

Table: Conformal Ablative Key Performance Parameters

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>KPI-1</td>
<td>Scalable to MSL, other COTS environments, and other future missions</td>
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<tr>
<td>KPI-2</td>
<td>High heat loading on the 35° cone</td>
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<tr>
<td>KPI-3</td>
<td>Low heat loading on the 35° cone</td>
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<tr>
<td>KPI-4</td>
<td>Area efficiency and structural strength</td>
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</tbody>
</table>

CA250 Project Schedule

- FY2012 1st Half
- FY2012 2nd Half
- FY2013 1st Half
- FY2013 2nd Half

Conclusions & Outlook

Vision
- Recent focus of the TPS community has been on ablatives
- Lessons learned:
  - Only 2 rigid TPS alternatives (PICA and ABOAT) have been maturing each having significant integration issues
  - Use ablative-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 aerodynamically

Why Conformal?
- Larger TPS per kit reduces overall cost and weight and reduces assembly and integration needs
- Can be flown before TPS allows broader structure design options for rapid assembly structures

Ablative TPS - Conformal TPS

Conformal Ablation

- PIKA - PIKATM Ablator
- High heat loading on the 35° cone
- Low heat loading on the 35° cone
- Area efficiency and structural strength

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 full-scale conformal ablative materials at least 1 m diameter which includes the necessary processes, procedures, equipment, and services required
    - Non-destructive methodologies necessary to examine variations in the casted structure and the resulting conformal ablative and bond verification
    - Proposed specifications for certified TPS processing and R&D evaluation of the ablative materials
    - Design 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 be done in projects TRU 1 in 2 years
    - Technology transfer for scale up and evaluation of industry materials
    - Development of attachment and seal techniques
    - Further Arc jet tests and thermal properties tests to provide data for development of a mid-life material response model
    - Develop mid-life material response model
    - Manufacturing MDU
    - Develop NDE techniques to evaluate material and bond conformance
    - Develop material specifications
    - Begin technology push to new missions

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

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