An Update to a Conformal Ablative Thermal Protection System for Planetary and Human Exploration Missions

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CONTEX & OBJECTIVE

Nasa Stmd Game Changing Development Program

What is our Mission?

To focus on transformative space technologies that will lead to advances in space and terrestrial capabilities

Goals

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

Vision

• Focus of the spacecraft design community has been on “heritage” ablative materials for TPS
• Lessons learned during recent builds:
  - Rigid-lightweight TPS heritage alternatives (PICA and AVCOAT) have been having significant integration issues
  - Low strain-to-failure of PICA makes direct bonding problematic and requires small link sizes and gap fillers for large heatshield panels
  - High touch labor requirements for AVCOAT results in large costs and long schedules, high CTE limits choice of structure materials
• Work was initiated under ETTO and ARMID and continued under STMD/GCDP to develop improved TPS to solve these issues

The Vision is to develop and deliver a high strain-to-failure conformal TPS to TRL 5-6 capable of reducing the cost and complexity of protecting an flight aeroshell

Why Conformal?

• 125% of the weight of conventional TPS
• Improved heat shield design
• Decreased cost of launch

CA-TPS Key Performance Parameters

<table>
<thead>
<tr>
<th>Conformal Ablator Key Performance Parameters</th>
<th>Category</th>
<th>Definition</th>
<th>State-of-the-Art Values</th>
<th>TRL 5 Threshold Goal</th>
<th>Justification</th>
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</thead>
<tbody>
<tr>
<td>KPP-C1</td>
<td></td>
<td></td>
<td></td>
<td>200°C/500°C</td>
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<tr>
<td>KPP-C2</td>
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<td>300°C/650°C</td>
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<td>KPP-C4</td>
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<td>400°C/800°C</td>
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CA-TPS Schedule

Continued Systems Engineering Approach to Material Development

Technical Requirements Definition

• Stakeholder expectations understood to understand the technical problem and establish the design boundary

Continuous Risk Management (CRM)

• CRM utilized to provide systematic method for identifying, analyzing, tracking, and communicating risks on a continuous basis
• Embed risk management into normal day-to-day activities to identify and manage risks
• Delegate risk management responsibility to lowest possible organization to mitigate or accept risk
• Delegate Risk Management Officer to lead risk management

Testing, Results & Modeling

Testing, Results, and Modeling

Conformal TPS Manufacturing Scale-Up

• Vendor is required to supply for 1-m or larger MDU
  - Small-scale samples for mat props and SPRITE following by large-scale materials for application to the MDU
  - Manufacturing Plan for C-PICA at least 1.5-m wide
  - Non-destructive methodologies necessary to examine variations in the fuel structure and the resulting conformal ablator and for bond verification
  - Design support and manufacture of a large manufacturing demonstration unit (MDU)

Small Probe Vendor

• Technology transfer TPS manufacturing to Small Probe Provider Terminal Velocity Aerospace (TPA) and provide flight test article
• Performed a successfully demonstration Conformal PICA and Conformal TPS over the technology development phase
• Developed a successful TPS design for a future Small Probe Provider Terminal Velocity
• Developed and delivered flight test article (ETTO- EDR) for ground testing
• Includes
  - Plant and test activities
  - Pre-flight activities
  - Post-flight analysis and testing

Establish Industry Partnerships

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CONCLUSION & OUTLOOK

Game Changing: we have created a high strain-to-failure TPS with a dramatic reduction in complexity and should result in lower cost heatshield manufacturing