**Introduction**

**Importance of Research**
- Early NASA missions (Gemini, Apollo, Mars Viking) employed new ablative TPS that were tailored for the entry environment.
- After 40 years, heritage ablative TPS materials using Viking or Pathfinder era materials are at or near their performance limits and will be inadequate for future exploration missions.
- Significant advances in TPS materials technology are needed in order to enable any subsequent human exploration missions beyond Low Earth Orbit.

**Objectives**
- This poster summarizes some recent progress on Mars to facilitate future exploration plans.
- Technological advancements in TPS materials are required to land heavy (~40 metric ton) masses in planetary entry missions.
- Rigid/conformable and flexible ablators that are tailored for the entry environment could potentially be used for thermal protection in planetary entry missions.

**Mars Exploration Architectures**
- In May 2008 NASA senior leadership commissioned a 2-year Entry, Descent, and Landing Systems Analysis study to establish EDL technology needs.

**Advanced Ablative TPS**

**Rigid TPS Heating Environments**
- 8 exploration architectures identified.
- 5 require Rigid TPS.
- 2 require Rigid TPS that can handle dual pulse heating.

**Advanced Ablator Concepts**
- Goal: Enable thermally optimized TPS systems that offer ability to cover large surfaces without gaps/seams.
- Infusion Plan – Block upgrade option for NASA or COTS Multi Purpose Crew Vehicle with eventual use to enable large mid L/D concept for human Mars exploration.

**EDL ETDD Efforts**
- Commercially supplied TPS concepts.
- Multi-layer/graded materials.
- Integrated ablator/composite structures.
- Screening and development through NASA EDL ETDD Program.

**NASA Hypersonics Work**
- In-house TPS research and development.
- Multi-layer/graded ablator/insulator.
- Conformal/flexible ablators without seams.
- Low TRL R&D through Fundamental Aeronautics Hypersonics Program.

**Material Advancement Required**

**Materials Research**
- Development of lighter weight thermal protection material systems is required to support either mid L/D rigid systems or hypersonic inflatable/deployable aerodynamic decelerators.
- Architectures require ablative materials for aerocapture based on original geometric limitations.
- Studies of much larger HiADs allow for insulative flexible materials currently being studied under Fundamental Aerodynamics (Hypersonics).

**Materials Modeling**
- Advancement in materials modeling is also required to support new TPS concepts.
- Multi-layer or graded rigid ablators with varying resins.
- Multi-layer ablative/insulative materials.
- Ablative conformal/flexible materials.

**Conclusions**
- NASA has the need for new TPS and TPS architectures to enable future exploration missions.
- NASA is working with industry and in-house to develop new, more complex materials and systems.
- Modeling these new material and their unique behaviors will be challenging due to:
  - Varying resin systems (fiber/resin interactions).
  - Varying materials with depth.
  - FSI (fluid/surface interactions).

**Future Work**
- Support for rigid TPS development of commercially supplied materials through the EDL ETDD Program is ending FY11.
- NASA in-house development of will continue with focus on varying resin systems and the fiber/resin interaction.

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