Advanced Ablative TPS

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Introduction

1

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

SOA rigid ablators require many tiles to cover large heat shields and require gap fillers

Objectives

2

- This poster summarizes some recent progress at NASA in developing families of advanced rigid/conformable and flexible ablators that could potentially be used for thermal protection in planetary entry missions
- In particular the effort focuses technologies required to land heavy (~40 metric ton) masses on Mars to facilitate future exploration plans

Mars Exploration Architectures

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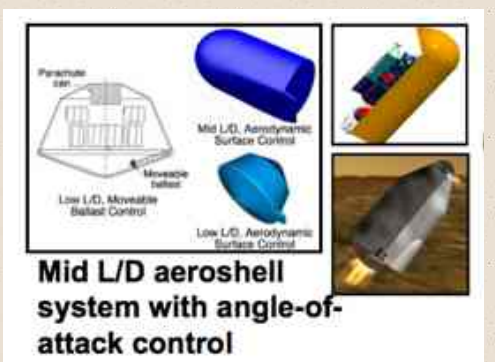
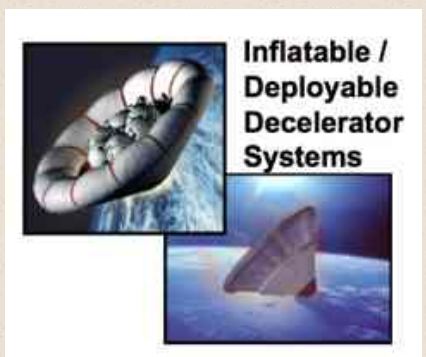
- In May 2008 NASA senior leadership commissioned a 2-year Entry, Descent, and Landing Systems Analysis study to establish EDL technology needs





Rigid TPS Heating Environments

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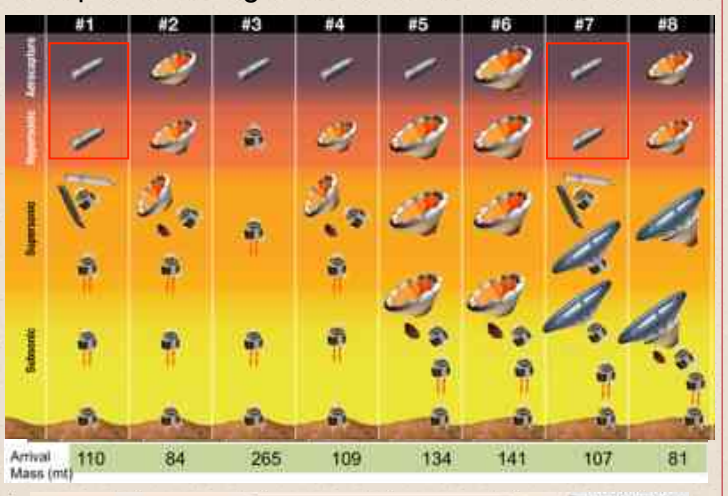
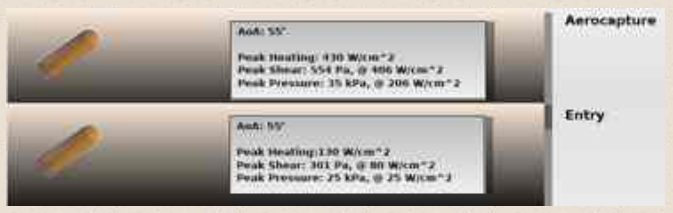
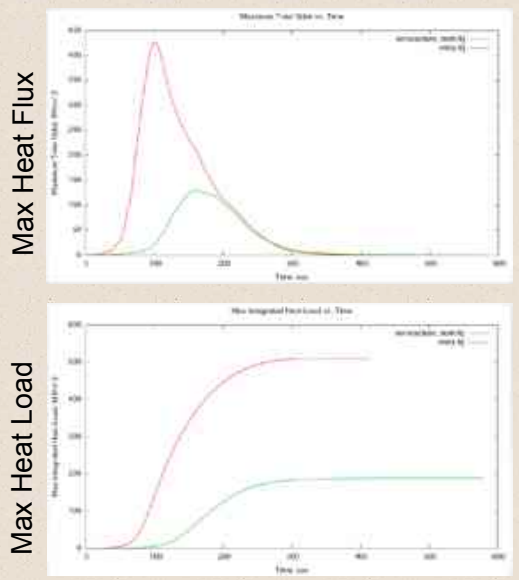
- 8 exploration architectures identified
  - 5 require Rigid TPS
  - 2 require Rigid TPS that can handle dual pulse heating







Material Advancement Required

5

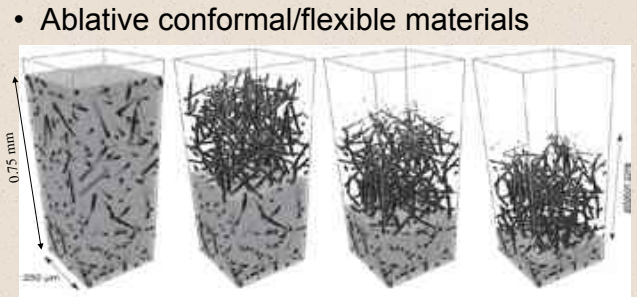
Materials Research

- 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)

Currently 2 NASA programs supporting EDL/TPS
1) ETDD EDL TDP
2) Fundamental Aero, 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



Microscopic scale simulation of the ablation of fibrous materials. J Lachaud, N. N. Mansour. 48th AIAA Aerospace Sciences Meeting, 4-7 January 2010, Orlando, Florida – Paper 2010-984.

Advanced Ablator Concepts

6

- **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


Multi-Purpose Crew Vehicle


Mid L/D Vehicle

EDL ETDD Efforts

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


Dual-layer Graded Ablator


Integrated Composite

NASA Hypersonics Work

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


Graded Ablator/Insulator

Conformal Ablator

Conclusions

7

- 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

8

- 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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