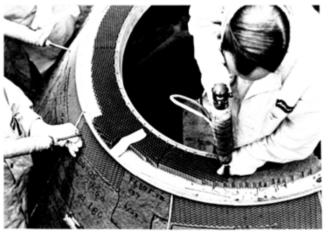
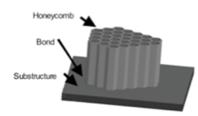
The Block-Ablator-in-a-Honeycomb Heat Shield Architecture* Overview

Peter Zell, Ethiraj Venkatapathy & James Arnold
NASA Ames Research Center, Moffett Field, California

Heritage Ablative Heat Shield Architecture #1



Technicians injecting ablator into honeycomb
Apollo CM (above) had 300,000 cells

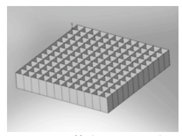


Traditional insertion of uncured ablator material into a relatively small (~1 cm) diameter honeycomb lattice prior to oven curing

Abstract

An atmospheric-entry heat shield architecture is presented that employs cured ablator blocks bonded into a structural honeycomb lattice. This architectural approach provides the flexibility to tailor the distribution of thermal protection materials; both, over the surface area of the vehicle, and at depth. This approach may provide higher atmospheric entry reliability due to the structural attachment integrity provided by the honeycomb lattice in the ablative material layer. The architecture is described using the NASA Orion Crew Module's 5.0m diameter heat shield configuration as an example case. In general, this architecture has broad potential application for future missions that involve large-vehicle entries into planetary atmospheres.

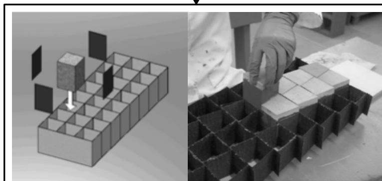
Block-Ablator-in-a-Honeycomb Heat Shield Architecture Concept



Large-cell (~ 5x5 cm) structural honeycomb

+

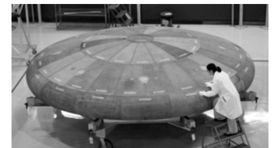
Mass-produced, standard-sized, cured-ablator blocks



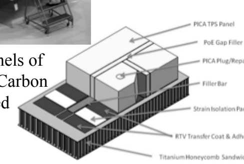
Bond blocks into the honeycomb with adhesive

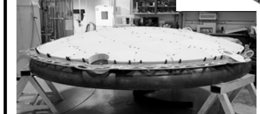
Combine the structural lattice provided by honeycomb, with pre-inspected ablator blocks, to produce a robust thermal protection system layer

Ablative Heat Shield Architecture #2



Technician inspects panels of Phenolic Impregnated Carbon Ablator (PICA) attached to a metal substrate

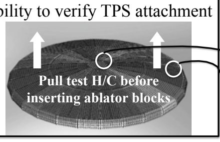




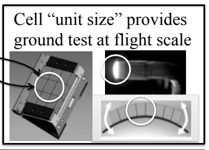
Room-temperature bonding of cured ablator panels (PICA) to a heat shield surface using RTV adhesive alone, or, RTV adhesive and strain isolation pads/gap fillers

Key Potential System Advantages

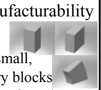
Ability to verify TPS attachment



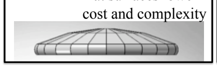
Cell "unit size" provides ground test at flight scale



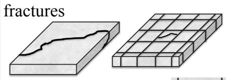
Improved manufacturability and inspection



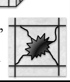
- mass-produce small, simple-geometry blocks
  - flat surfaces lower cost and complexity



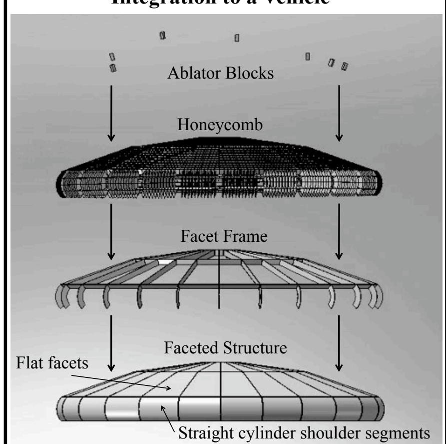
Honeycomb resists large ablator fractures



& may contain "small" MMOD to a single cell



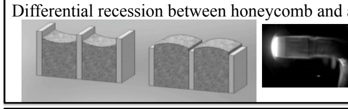
Integration to a Vehicle



The block-ablator architecture application approach as envisioned for the Orion 5-m diameter heat shield

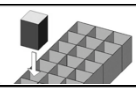
Technical Challenges / Future Work

Differential recession between honeycomb and ablator — feasibility tests +

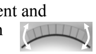


Precision "large cell" honeycomb (~ 5x5 cm) — feasibility build +

Ablator block fabrication and bonding into honeycomb — feasibility build +



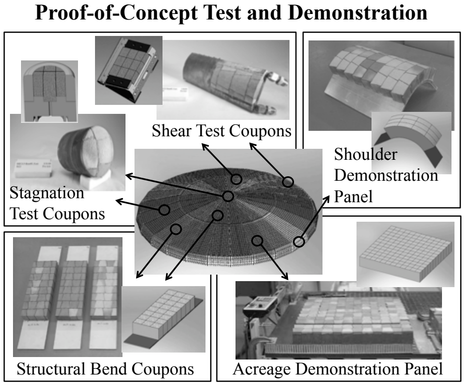
Honeycomb to substrate attachment and structural strength determination — feasibility tests ?



Will this architecture provide advantages that enable a future atmospheric entry vehicle (mass, thermal-structural performance & reliability)? — analytical studies +

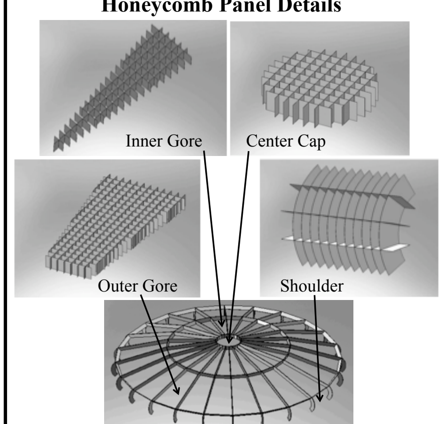
More technical evidence is required to raise the readiness level of this architecture prior to a flight application

Proof-of-Concept Test and Demonstration



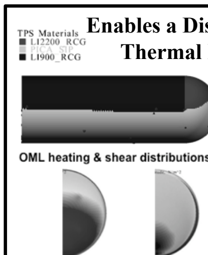
Architecture test coupons and demonstration panels

Honeycomb Panel Details



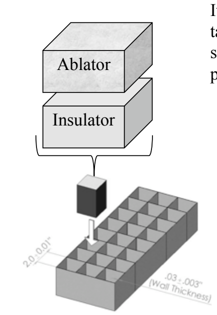
Honeycomb panel configuration details as envisioned for the Orion 5-m diameter heat shield

Enables a Distributed and Dual-Layer Thermal Protection System

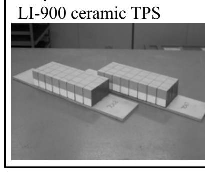


This architecture allows for the tailored application of TPS materials, with varying degrees of thermal protection capability, and structural strength, to be applied as required to meet surface environment predictions.

It also allows for in-depth tailoring that may result in significant system mass and performance advantages.



Dual-layer structural bend coupons with PICA over LI-900 ceramic TPS



Illustrations of surface and in-depth tailoring of the thermal protection material layer that is enabled

* U.S. Patent #7662459 awarded February 16, 2010