National Aeronautics and Space Administration

NASAfacts

Space Technology
Game Changing Development

3-Dimensional Multifunctional Ablative Thermal Protection System (3D-MAT)

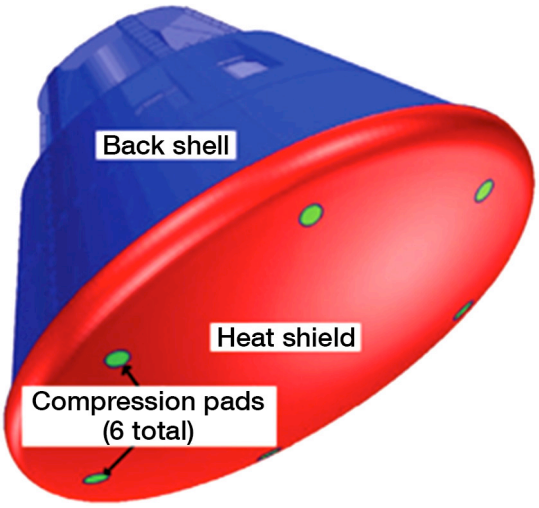
Overview

The 3-Dimensional Multifunctional Ablative Thermal (3D-MAT) Protection System project seeks to design and develop a game changing woven thermal protection system (TPS) technology tailored to the needs of the Orion Multi-Purpose Crew Vehicle (MPCV) compression pad for the lunar return mission, EM-1, and beyond.

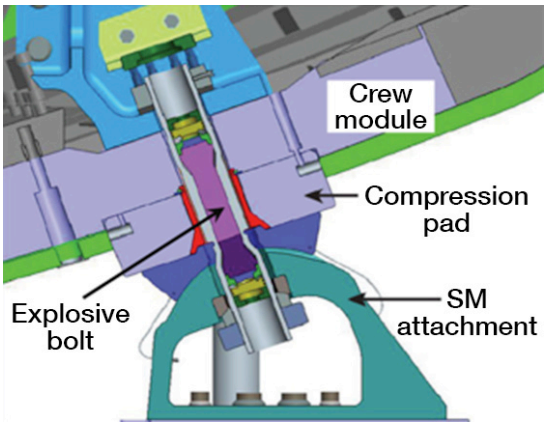
Background

The Orion compression pads serve as the interface between the crew module and service module. The compression pads must carry the structural loads generated during launch, space operations and pyroshock separation of the two modules, and then must serve as an ablative TPS withstanding the high heating of Earth reentry.

The current compression pad design for Orion is complex and limited to Earth orbit return missions such as the Exploration Flight Test-1 (EFT-1).The 2D carbon phenolic material being used for EFT-1 has relatively low interlaminar strength and requires a metallic shear insert to handle structural loads. There are few options for materials that can meet the load demands of lunar return missions due to performance or part size limitations.



Orion crew module highlighting the compression pads in the heat shield.



Expanded view of the compression pad interface with the service module (SM).

Project Description

3D-MAT is leveraging the efforts of NASA's Space Technology Mission Directorate's investment in Woven TPS to design, manufacture, test, and demonstrate a prototype material for Orion compression pads. The project combines the 3D weaving of quartz yarns with resin transfer molding to develop a robust multifunctional material architecture capable of meeting both structural and thermal performance needs for lunar return and beyond. The goal of 3D-MAT is to deliver a prototype compression pad material at technology readiness level 4 in 2014 to enable Orion's further development and use of the material on the MPCV flight in 2017.

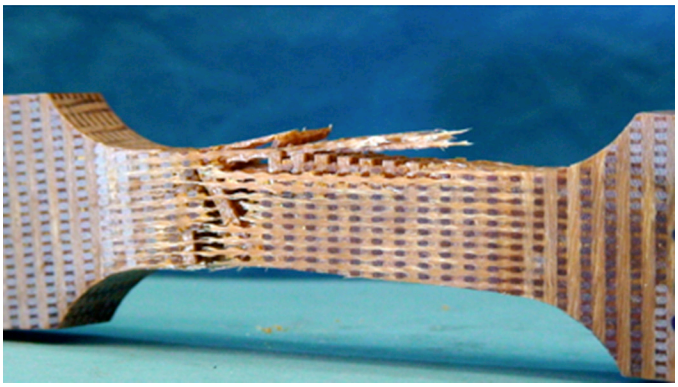
Partnerships

The 3D-MAT project is led by NASA'S Ames Research Center with many partnerships, including industrial weaver Bally Ribbon Mills and NASA's Johnson Space Center (JSC), where the resin infusion takes place. Mechanical testing of the 3D composite is taking place at Southern Research Institute, NASA's Langley Research Center and JSC. The Game Changing Development Program is the primary funding source for the project, with significant support from Orion. The 3D-MAT project team is well integrated with the NASA and Lockheed Martin Orion teams to assure development meets the MPCV needs.

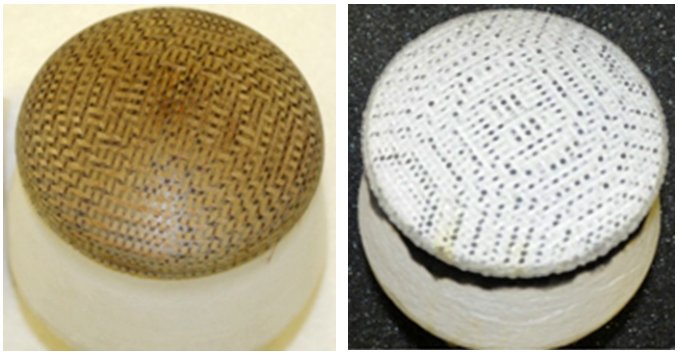
The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit http://gameon.nasa.gov/

3D woven, quartz-fiber preform (12 x 10.5 x 2.7 in.) prior to resin infusion.



3D-MAT posttest tensile coupon; the 3D composite has superior mechanical performance compared with the current 2D pad material.



3D quartz cyanate ester arc-jet samples before (left) and after (right) exposure to lunar return-relevant conditions of 750 W/cm^2.

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