3D Printed Structural Core with MMOD Protection

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OVERVIEW

Deep space exploration requires large habitats for both orbital and surface missions. The weight of a habitat is driven largely by its structure and future vehicles require lighter weight structures to minimize launch mass and cost. Unlike honeycomb core materials used in the past, a 3D printed core can be analyzed and optimized for specific load environments, further cutting down mass of the vehicle. Multi-functional structures can integrate features into the primary structure that are traditionally added mass. MMOD (Micro Meteor and Orbital Debris) protection, for example, can be integrated directly into the primary structure of a habitat. This minimizes the mass of the structure and eliminates the need for additional MMOD layers and attachment hardware. This project seeks to develop 3D printed structural core that can be optimized for flights loads and provide integrated MMOD protection.

INNOVATION

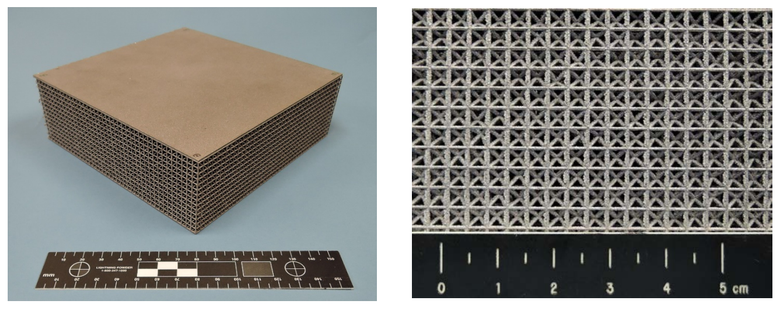
This technology will reduce the structural weight of crewed vehicles by combining several necessary elements of the vehicle, which are typically layered as serial components, into a single integrated structure, eliminating connecting fasteners and attachment hardware. These elements include a composite pressure shell, an optimized structural sandwich core, and MMOD protection.

OUTCOME

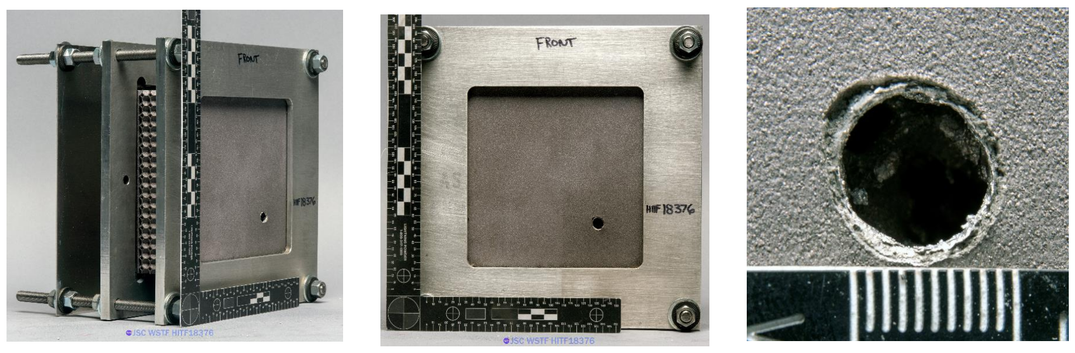
The MMOD capability of the 3D printed core was tested with a hyper-velocity impact test, which resulted in a successful outcome, proving the system can be a feasible MMOD shield. A 3.4 mm Aluminum sphere was fired at the structural test articles at 6.8 km/s with no penetrations of the second sheet. Three body centric lattice structures of different densities were tested along with a Kelvin cell structural panel.

INFUSION SPACE / EARTH

This technology can be used on future crewed space crafts and habitats including the Deep Space Gateway, Lunar surface habitats, and the Mars Transport vehicle.



Body Centric Cubic Lattice Structure Photo: NASA



Kelvin Cell Structure Test #2 Photo: NASA

PARTNERSHIPS / COLLABORATIONS

Primary collaborators are Douglas Litteken and Jasen Raboin in ES.

Testing was conducted at WSTF with special thanks to Alan Davis, Eric Christiansen, Robert McCandless, and Dana Lear.

Test specimen models generated by Drew Burkhalter using Altair Software per NASA specifications.

Test specimens where printed by Volunteer Aerospace out of Knoxville, Tennessee.

PAPERS / PRESENTATIONS

Future presentations and publications are planned after additional MMOD and structural testing of the panels is completed.

FUTURE WORK

Materials advancement will continue with the production of additional test panels made from plastic core material and carbon composite face sheets for pressure test and structural evaluation.

The core lattice design will also be refined for flight load cases, which requires the selection and use of a mass optimization software package.