This article is an excerpt from the
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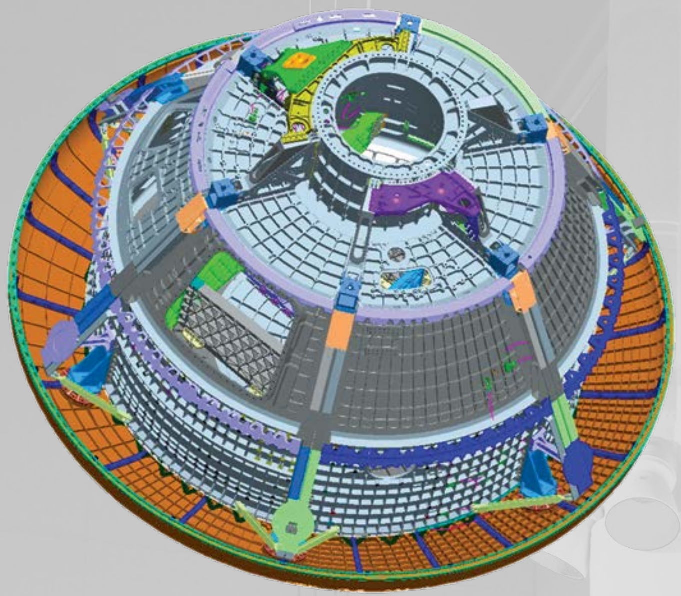

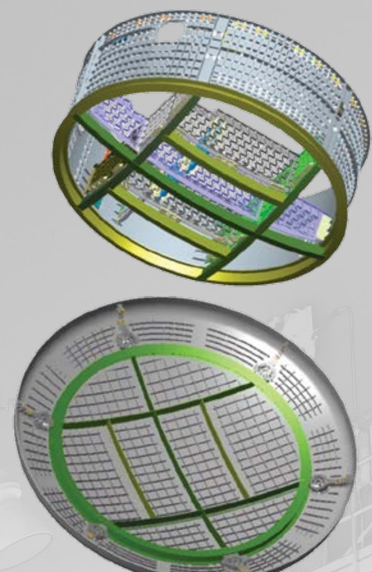

Far Left: Proposed titanium orthogrid heat shield carrier mounted to crew module pressure vessel.
Left: Heat shield carrier structure *(top)* and corresponding lower portion *(bottom)* of pressure vessel with "H-beam" backbone interface structure.

An Alternate Orion Heat Shield Carrier Structural Design

To carry astronauts beyond near Earth orbit to rendezvous with asteroids, the Moon, or Mars, the Orion Multi-Purpose Crew Vehicle (MPCV) must be as light as possible, and spacecraft engineers are always looking for ways to "take mass" out of a design. Weighing in at over 3,000 pounds and just over 16 feet in diameter, the Orion crew module (CM) heat shield carrier structure offered the best opportunity to shave off a bit of weight – about 800 pounds in fact, or 25% of its mass. While the Orion MPCV Team worked hard to reduce mass in this area, the Orion MPCV Chief Engineer requested the NESC study the heat shield carrier and develop alternate designs to the structure.

The carrier structure must hold the thermal protection system heat shield securely to the Orion CM while facing launch, reentry, and splashdown impact loads, including 4,800° F reentry temperatures. Its baseline construction, made of titanium and composite carbon graphite skin to hold the Avcoat ablator thermal protection system, was an agile design that could be easily manipulated and changed, but the Orion MPCV Program needed to know if it was the most mass-optimum design.

Mr. Michael Kirsch, NESC Deputy Director who was then an NESC Principal Engineer, led the NESC assessment team that included members from industry, contractor partners, and NASA Centers including JSC, GSFC, LaRC, and MSFC. The team developed several alternative concepts, including designs that incorporated load sharing with an H-beam configuration, and switched the composite carbon graphite skin to a titanium orthogrid skin. By down-selecting to the titanium orthogrid option, the team had already saved over 1,000 pounds. The design was developed by processing thermal, aerodynamic, and water landing loads through finite element models of the titanium orthogrid structure. The team designed, built, and tested a 20-inch-diameter subscale heat shield orthogrid test article and visited titanium forging facilities, electron beam welding facilities, and large-scale titanium machining facilities to improve confidence that the final design solution could be manufactured.

The final NESC design was estimated to save about 1,600 pounds over the baseline, far exceeding the original goal of 800 pounds. Encouraged by the NESC team's weight savings, the Orion CM baseline design had been undergoing revisions and had significantly reduced its mass, eliminating about 1,100 pounds.

The Orion MPCV Program ultimately stayed with its composite carbon graphite design, versus the titanium option proposed by the NESC for several reasons. While weight savings were a significant factor in design selection, so was schedule. Orion's first exploratory mission is expected in 2017, and the NESC design required financial commitments for material procurement and manufacturing and had a tight schedule for construction. Further, the baseline design had already demonstrated the full-scale manufacturing process, which lowered manufacturing risks, nonrecurring financial commitment, and a shortened delivery timeline.

Even though the NESC's alternative design was not selected by the Orion MPCV Program, it promoted the aggressive redesign of the current baseline and the net result was a significant reduction of overall mass. □