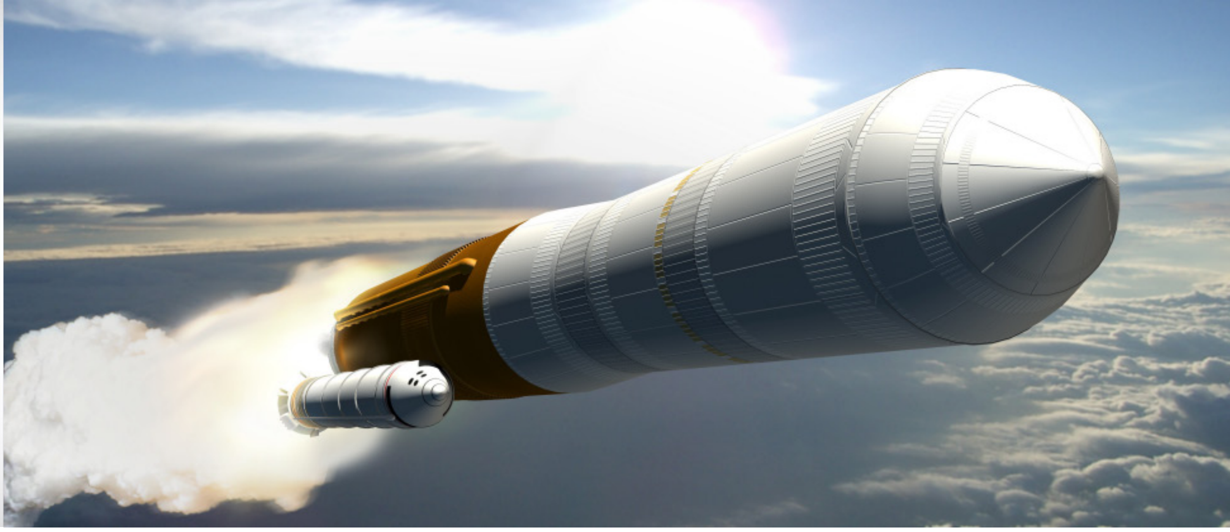
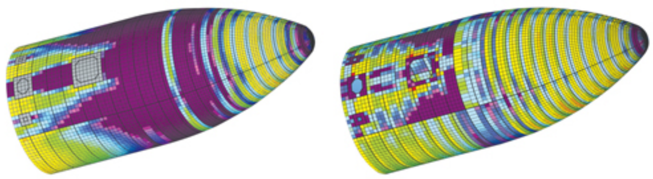
DESIGN | ANALYZE | OPTIMIZE



Optimizing the Ares V Payload Shroud

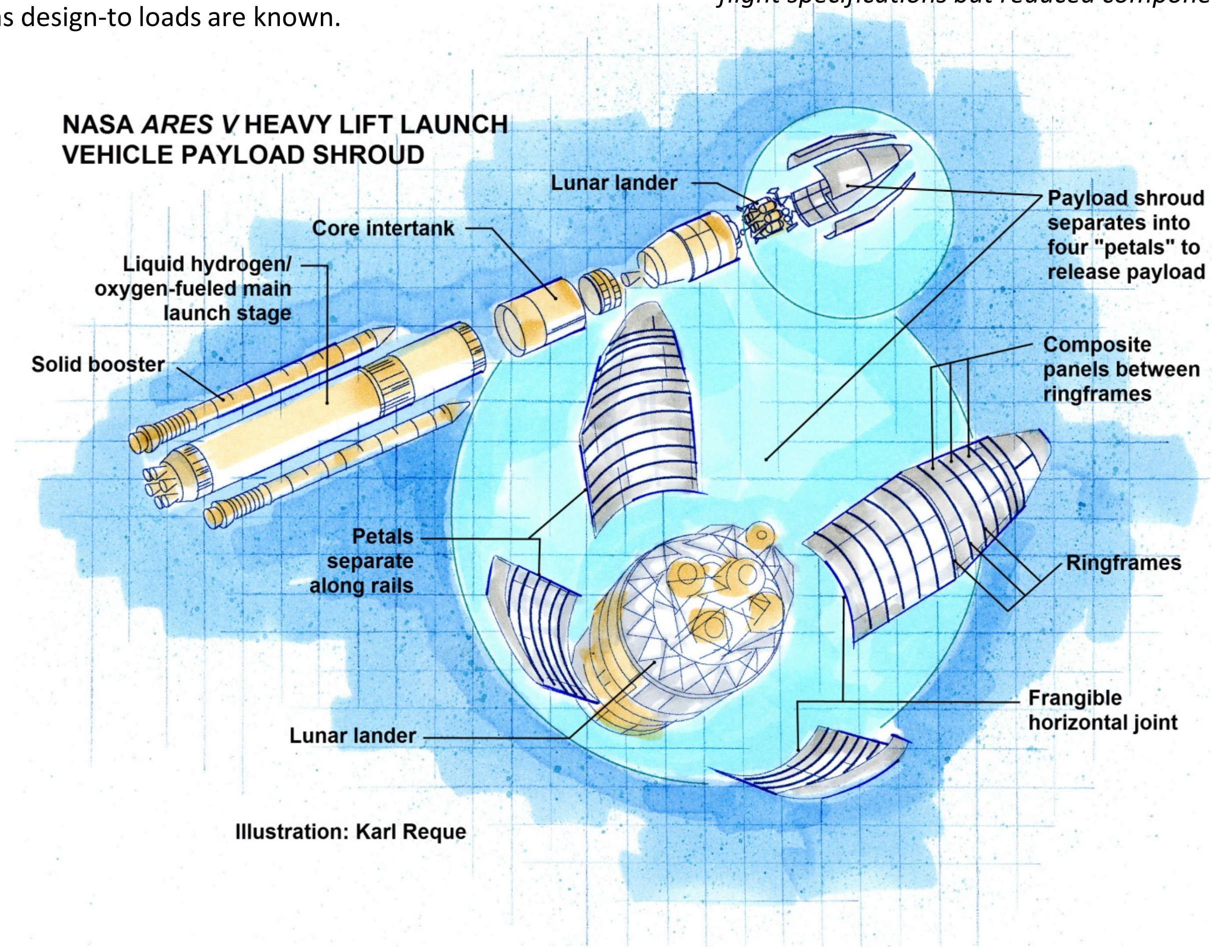
The Project

The NASA Ares V Shroud was envisioned as a four-petal, ogive-shaped enclosure that, at the appointed time in flight, would explosively separate along a frangible horizontal joint above the interstage and along four "rails," jettisoning the four petal segments to release the lunar lander. For this component, Collier and the NASA team first developed a finite element (FE) model, using Nastran and Abaqus. The external dynamic flight pressures were resolved through the FE model mesh to determine the internal "design-to" loads for HyperSizer, noting that the software also works without FEA, as long as design-to loads are known.



Overdesigned **Optimized**

When "large acreage" design was employed, that is, large areas of stiffened panels that had identical layups (left), the dark purple color indicates that many panels were overdesigned, with margins of safety well over 1.0. The optimized design (right) featured tailored layups that met flight specifications but reduced component weight.



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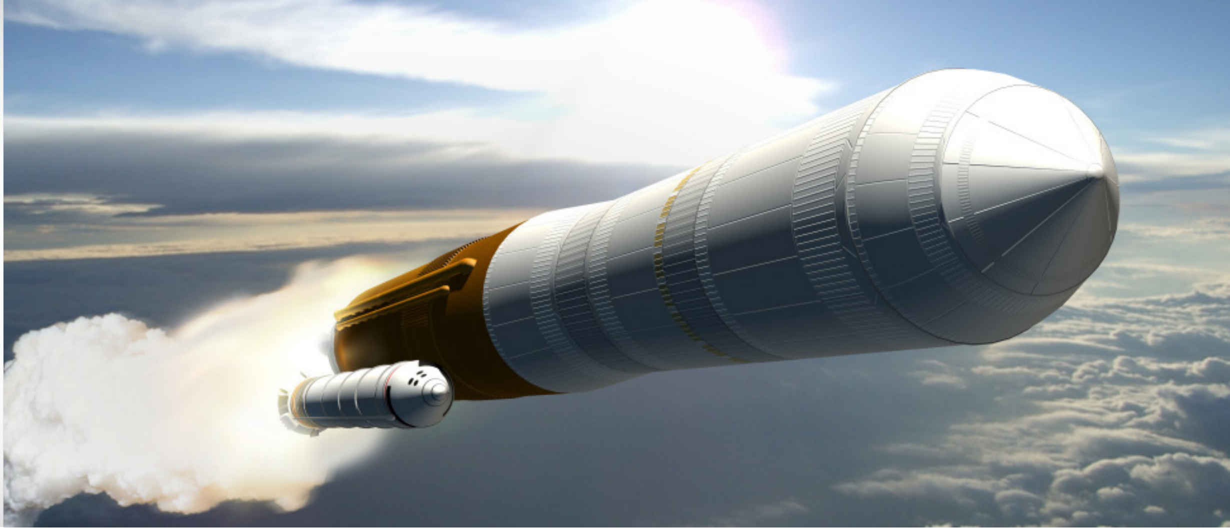


Optimizing for Manufacturability

HyperSizer optimized the panels for strength and positive margins of safety for all potential failure modes, then HyperSizer optimized the entire structure for manufacturing “**ply compatibility**.” That is, the software determined not only the best design, but the most practical layup as well. This capability proves manufacturability by determining the most efficient layup sequence, and can help develop programs for automated processes as well.

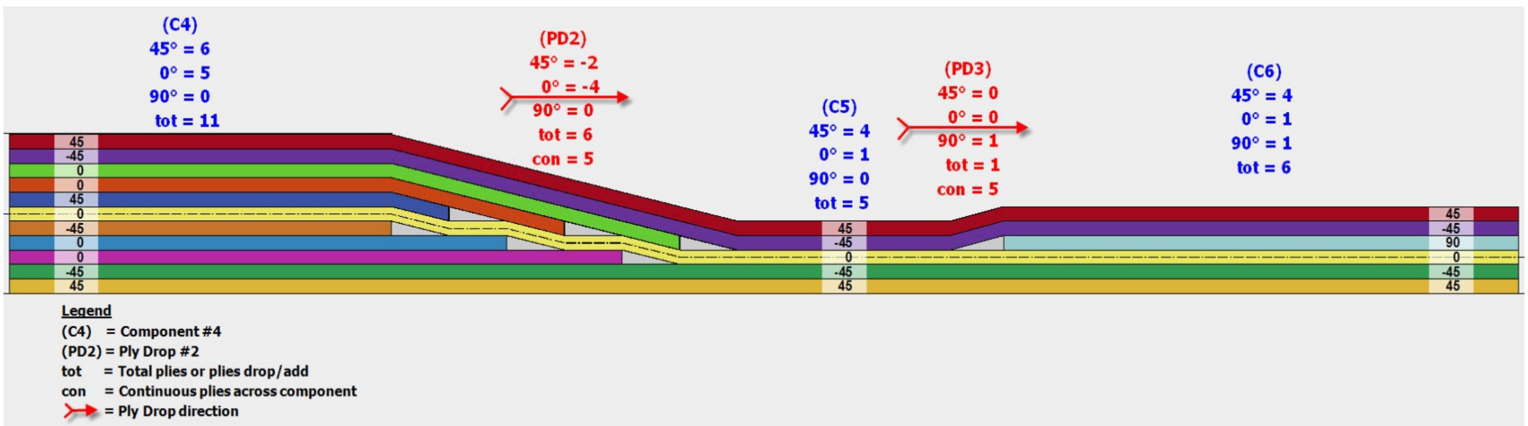
The software generates a series of global sublaminate stacks (GSS) within which all plies are continuous throughout the entire panel or part. These are placed on the tool side (either OML or IML). If ply drop-offs or ply-adds are required, they are placed near the laminate midplane, between GSS. This minimizes drop-offs on the tool, making it much easier to manufacture the part.

The software also prioritizes ply drop-off order, avoiding “stair step” drops that can greatly diminish laminate performance. Well over a million candidate layup arrangements across each panel surface were evaluated so that the lightest design was also the most manufacturable.

Finally, HyperSizer’s PC-compatibility enabled multiple team members to run the program on different computers, all with access to the same database. Each engineer’s results were documented and maintained, and complete stress reports were available for later airworthiness documentation.

NASA conducted a rigorous “figure of merit” (FOM) process to score the candidate shroud concepts, with weight savings as the most important metric. The team conceived an initial design of composite panels between each ringframe and spanning the distance between the four petal separation rails. Panel candidates included cored sandwich panels and stiffened panels, the latter featuring uncored, monolithic laminates with hat stiffeners bonded or comolded with the panel to prevent buckling. HyperSizer provided a means to quickly establish the best — i.e., the lightest — panel concept.

The fact that composites were used for the *Ares V Shroud* indicates that the technology is maturing. The composites optimization process for *Ares V* has shown **potential to reduce the weight of traditionally accepted launch vehicle designs by 30 percent.**



HyperSizer’s ply compatibility function, where the software optimizes ply drop-offs and ply adds to arrive at the most manufacturable design.

www.HyperSizer.com
Phone:(757) 825-0000