

Structured Hexahedral Mesh Generation for a Biconic Maneuverable Reentry Vehicle

Arda Alpan, Gabe Damiani, Stephen Guzik, Xinfeng Gao

University of Virginia, Department of Mechanical and Aerospace Engineering, CFD & Propulsion Laboratory

Problem of Interest

Predicting hypersonic flow at 40 km around a Maneuverable Reentry Vehicle (MaRV 82) in Chord, a fourth-order explicit finite-volume solver, involves confronting challenges such as accurately simulating shock-wave/boundary-layer interactions due to the flap positioning, capturing steep gradients across cell boundaries, and simulating ablation of the surface material. In order to obtain a stable solution given these complications, the mesh must be well conditioned and suitable for use in Chord, requiring:

- ① Purely hexahedral multiblock mesh
- ② Cells arranged to capture anticipated gradients
- ③ Maximum viable coarseness to allow for AMR to optimize block dimensions

Preliminary Results

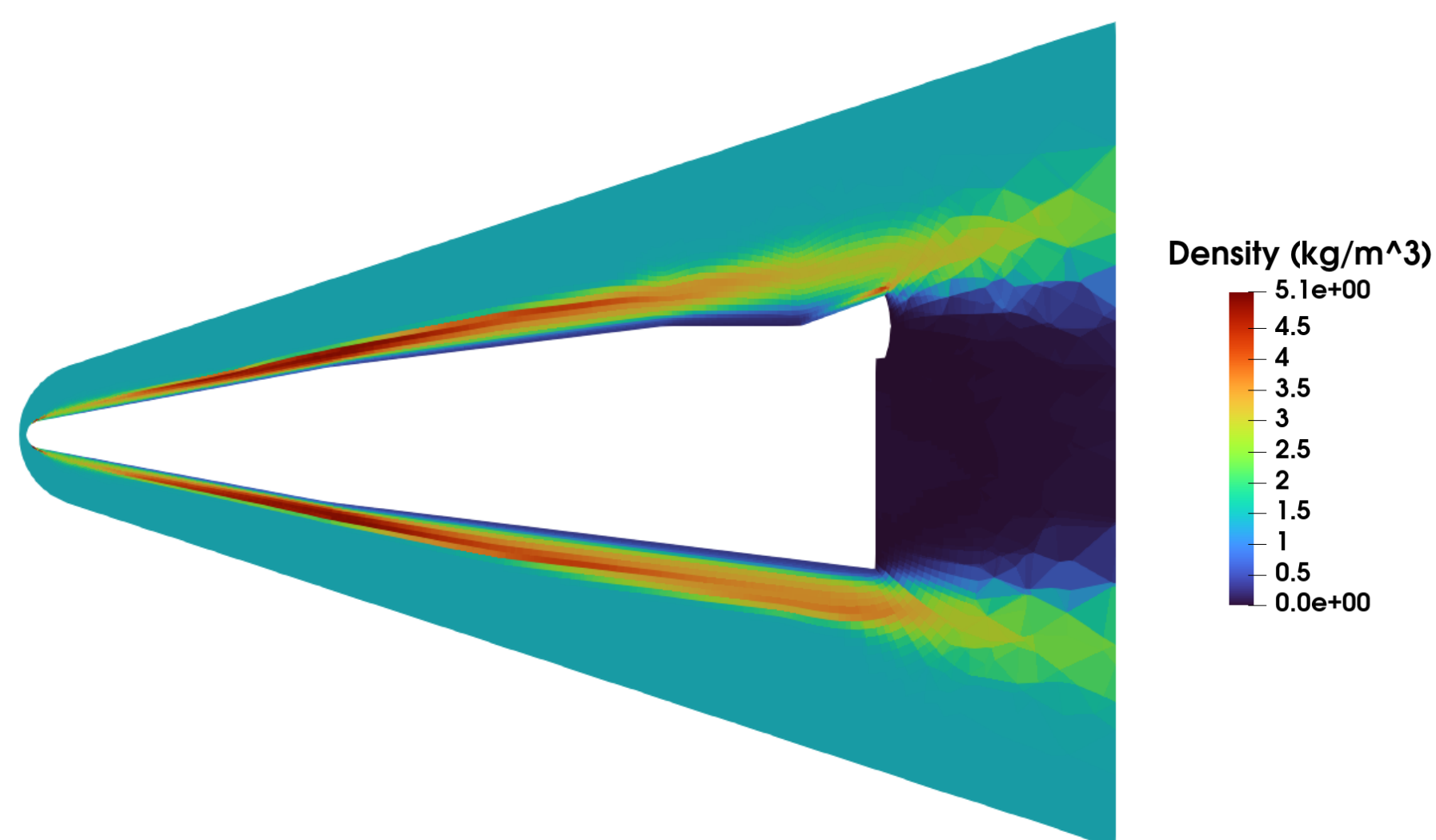


Figure 1: **ANSYS Fluent**; pseudocolor plot of density at centerplane with $M_\infty = 12.6$, $p_\infty = 277.52$ Pa, and $T_\infty = 251.05$ K. Solver is an implicit RANS model and assumes a calorically perfect ideal gas (constant c_p and c_v independent of temperature) with no-slip adiabatic boundary conditions for MaRV surface. Residuals remained constant throughout ~ 2000 iterations. The ANSYS Fluent simulation is used primarily to motivate the meshing strategy by identifying high-gradient regions at high freestream Mach number.

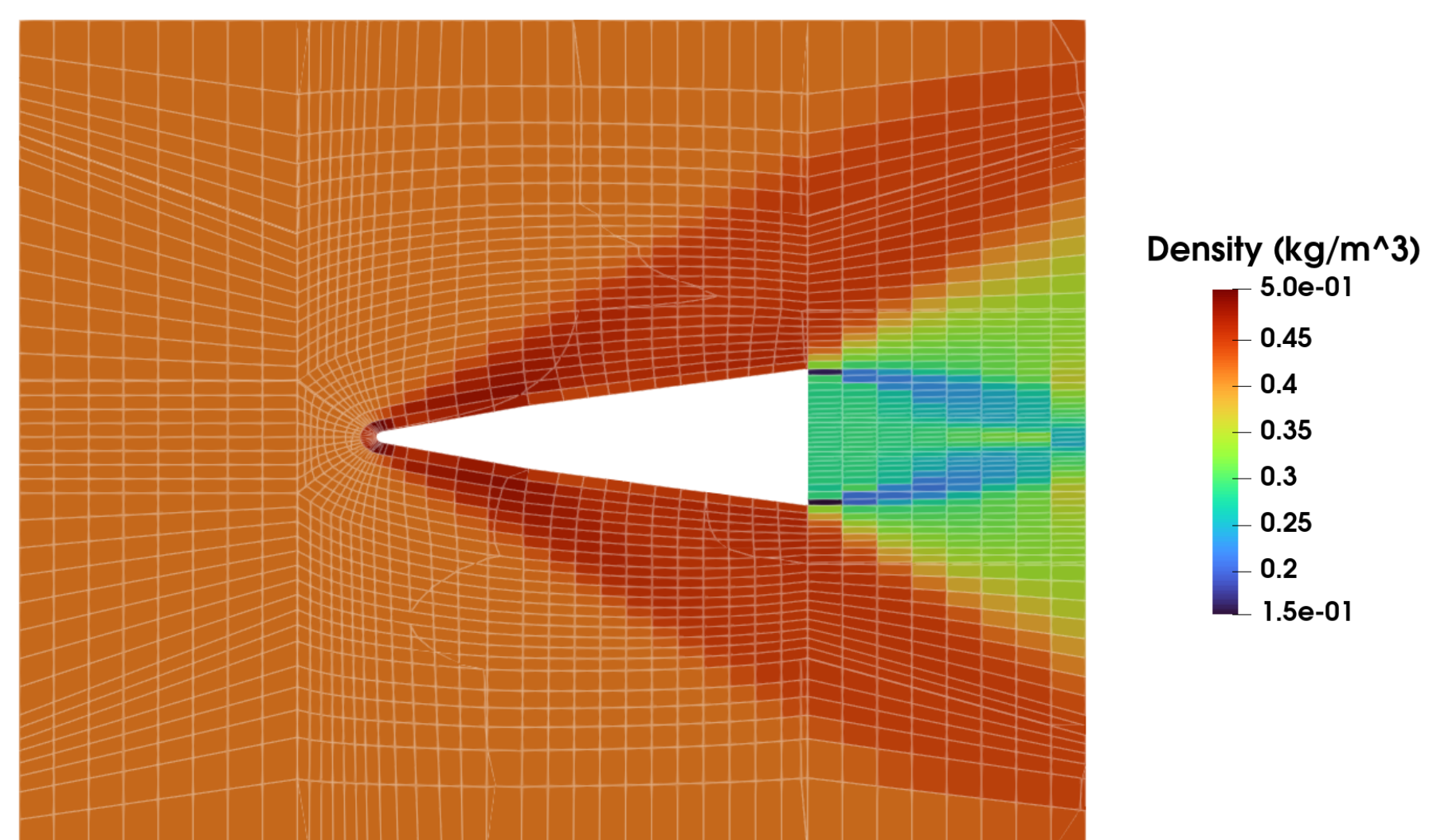


Figure 2: **Chord**; pseudocolor plot of density at centerplane with $M_\infty = 2$, $p_\infty = 287.1$ Pa, and $T_\infty = 250.4$ K. Solver is an explicit Euler model and assumes ideal gas law with slip adiabatic boundary conditions for MaRV surface. Simulation ran for 5000 timesteps. The simplified geometry is used to ensure the mapped multiblock mesh functions with the solver disregarding the complications of the flap geometry.

Geometry

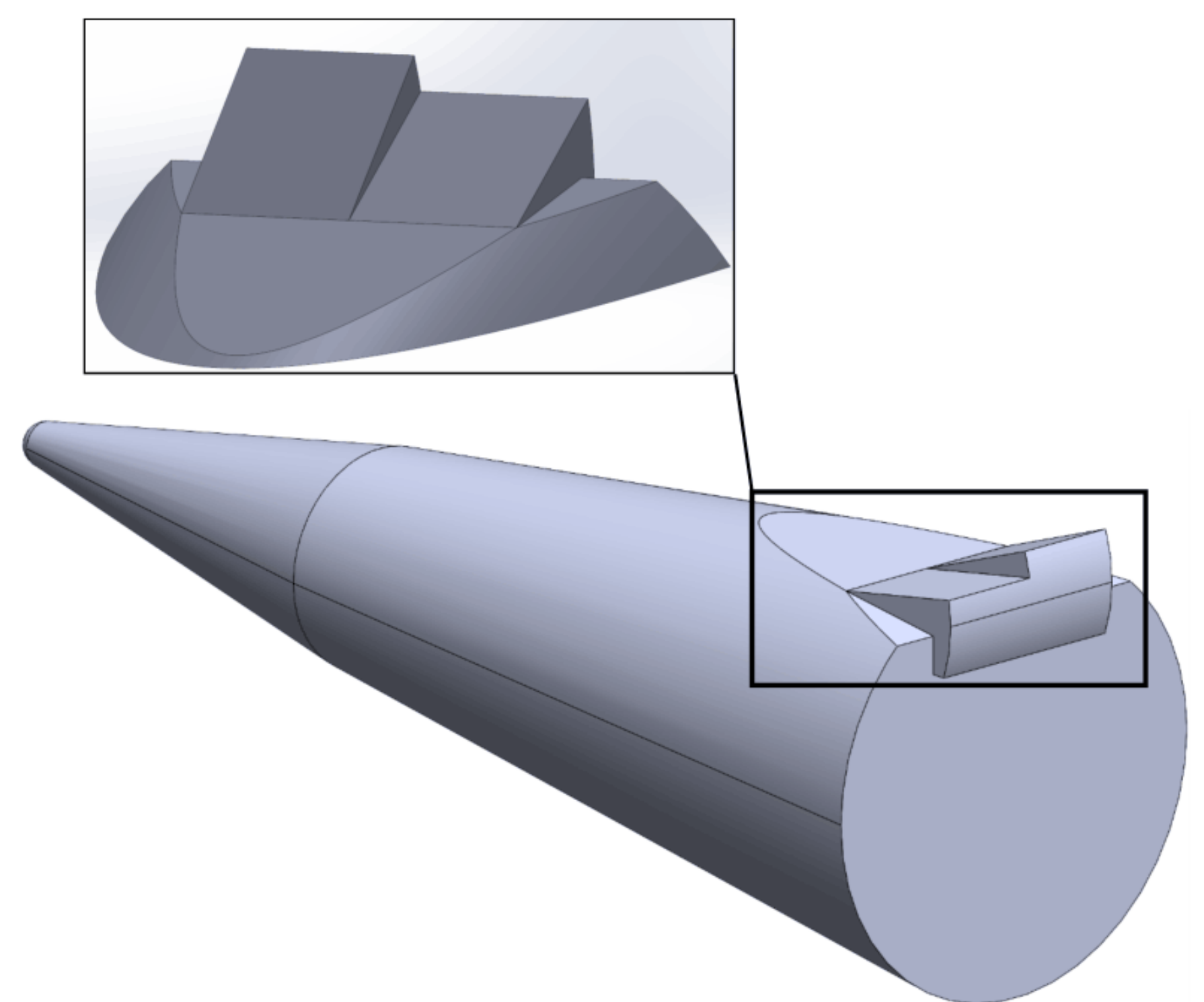


Figure 3: MaRV body with rotated detail view of flaps. Geometry consists of a fore 10.5° cone and an aft 7° cone, a slice plane through the 7° cone, and a two-panel split flap (10° , 20°). The slice and flap intersect the cone in point-terminated triangular faces, which admit no valid hexahedral topology.

Structured Mesh

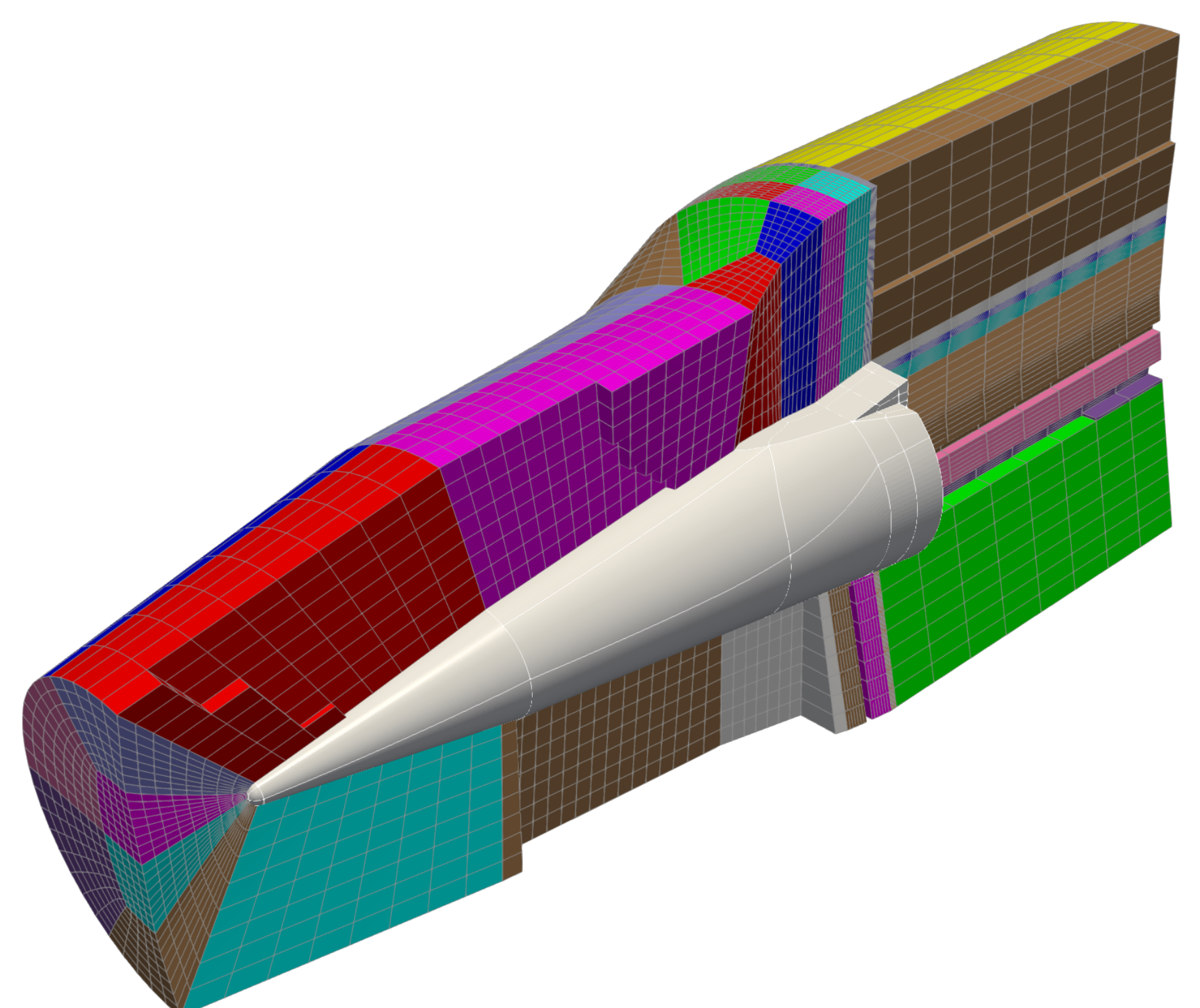


Figure 4: Structured mesh of full MaRV geometry created in Fidelity Pointwise, colored by blocks. Due to Chord's requirements, the mesh must have $8n$ edge dimensions for all blocks, 1:1 conformal cell and block faces, no degenerate edges or faces, and minimal cell skew near block boundaries for accurate solutions using the mapped multiblock algorithm.