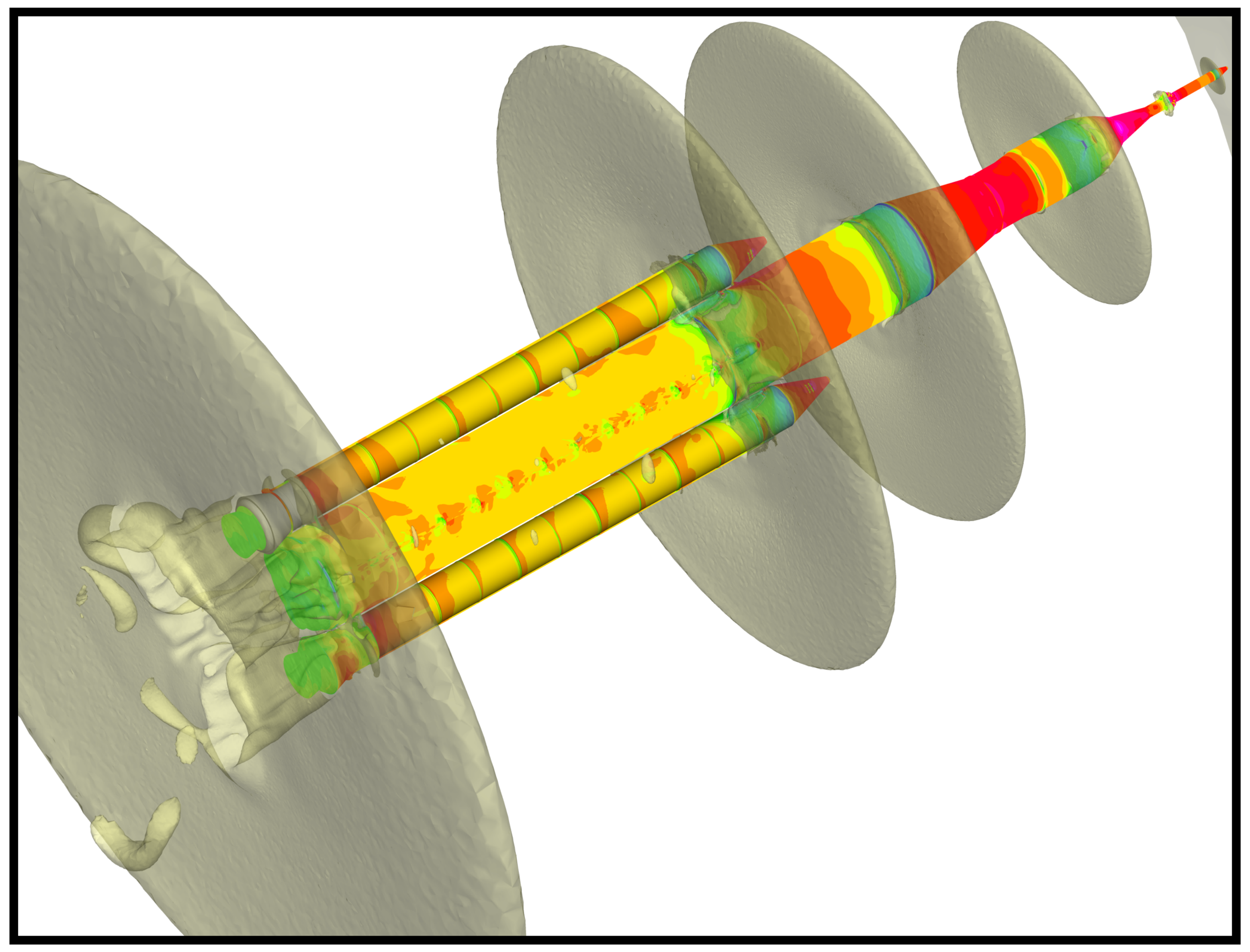
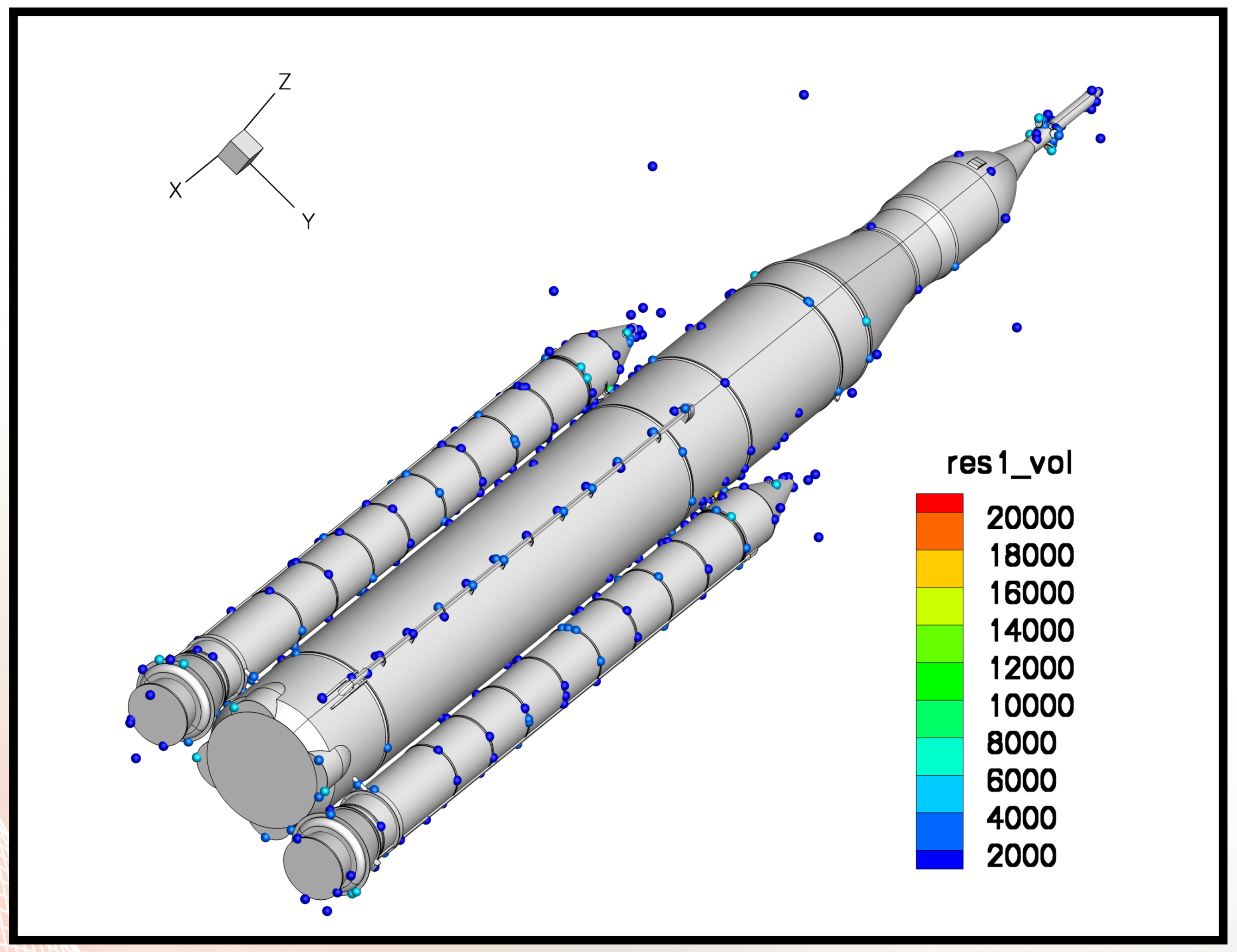
Ensuring Safe Passage of the Space Launch System Through the Speed of Sound



Surface pressure coefficient (colored magenta to blue) with sonic isosurfaces (represented by the grey disks), from an 11,640-processor computation of the transonic flow around the Space Launch System (SLS) configuration. Variations in pressure along the body of the SLS can be seen, particularly around the protuberances off the smoother surface of the vehicle. The shock structures show regions along the SLS where buffet loads are stronger. *Stephen Alter, NASA/Langley*



Simulation of the SLS with color contoured locations of highest residual, per-unit volume, for each mesh block. Visualization of the residuals were used extensively to determine where mesh resolution was needed, in order to improve the model accuracy when compared to wind tunnel data. *Stephen Alter, NASA/Langley*

Detailed flow field analyses were performed on the Space Launch System (SLS) to model flow induced vibratory-loads (buffet) on the vehicle during ascent flight near the speed of sound (transonic conditions). If not properly predicted, buffet loads can excite structural harmonic frequencies that can lead to catastrophic loss of the vehicle. Due to advances in algorithms and high-end computing, computational fluid dynamics (CFD) simulations can now provide data that was previously obtained through physical experiments.

Computational data can be obtained earlier in the design cycle than experimental results from wind tunnel tests, but the accuracy of such data needs to be verified. In this study, we used a variety of analyses to evaluate the computational data accuracy and help develop new tools to aid in the successful and safe operation of NASA's next-generation space flight vehicle. We found that:

- Location of the peak oscillatory force was the same for CFD and wind tunnel tests, and magnitude was within 15%.
- Data analyses with histograms indicate the simulations are capturing the physical phenomenon in the flow field.
- Large-scale simulations of 0.5 to 1 second of duration are needed to acquire sufficient data to converge frequency content.
- Computational analyses proved valuable as a screening tool for SLS vehicle designs to mitigate adverse loads expected during near-transonic flight conditions.

The Pleiades supercomputer at the NASA Advanced Supercomputing (NAS) facility made it possible to obtain computational data an order of magnitude faster than using mid-range computing, due to the thousands of cores used per computation.

CFD simulations have advanced to a point where the accuracy of these detailed models make good tools for validating complex vehicle design for NASA missions. The high-performance computing resources at NAS allow for a timely turnaround of data, which increases the viability of CFD simulations as part of the design process of existing and future vehicles.

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