Hypersonic Flow Modeling with Unstructured Grids

Rapid and accurate grid generation for re-entry vehicles

Priscilla Pak* & Geoffrey Andrews‡
*Senior, Boston University
‡Technical Staff, MIT Lincoln Laboratory

Problem

The high temperatures and pressures in hypersonic flow fields are difficult and expensive to measure during flight testing.

CFD models of hypersonic flows may produce a more detailed, less expensive picture of flight phenomena. However, accurate CFD models require careful setup, including satisfying stringent meshing requirements.

Unstructured meshes pose a viable alternative to structured meshes, which may take longer to adapt to a geometry.

Figure 1: Tetrahedral Cells Clustered at the Vehicle Nose Region

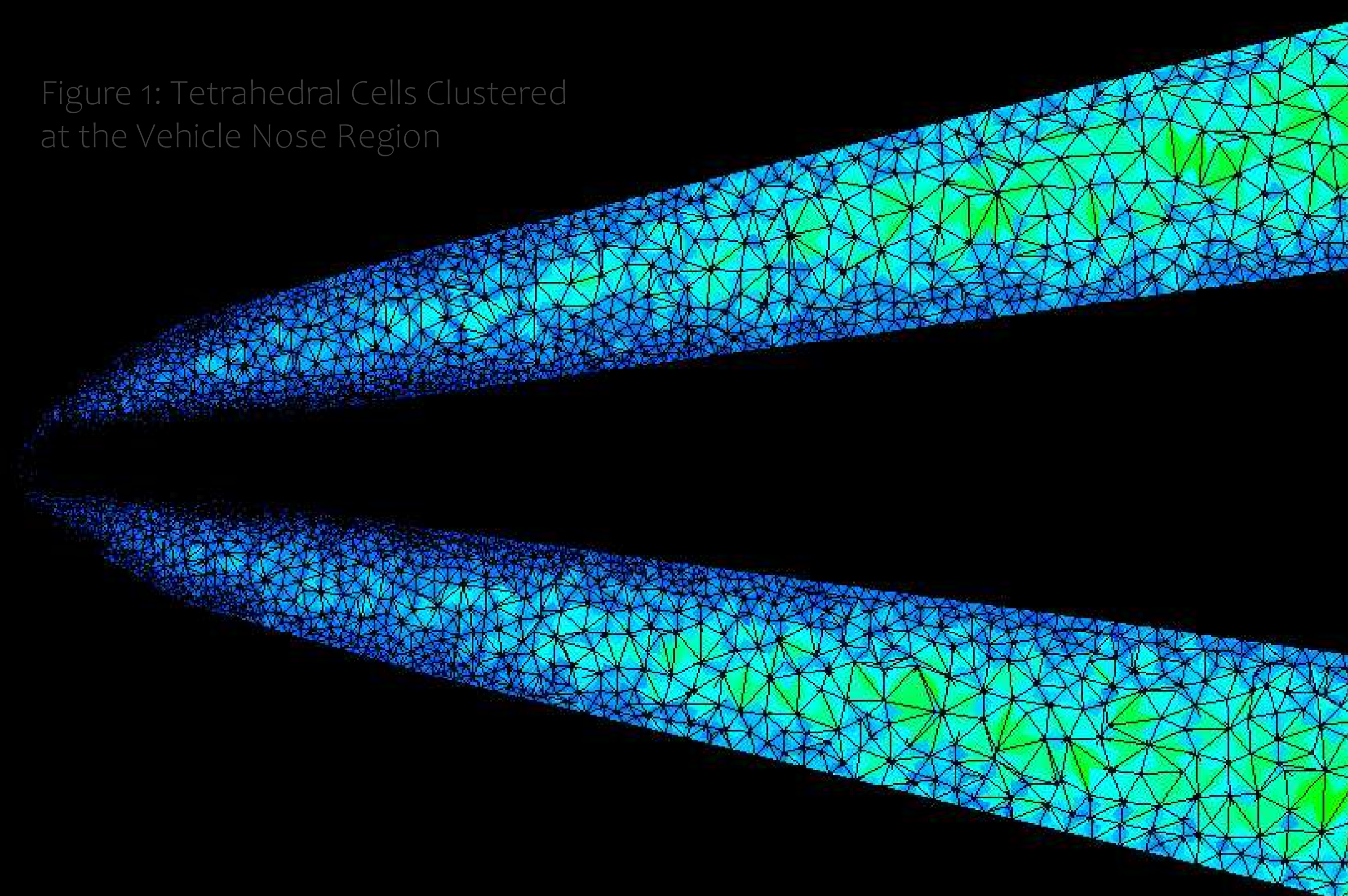
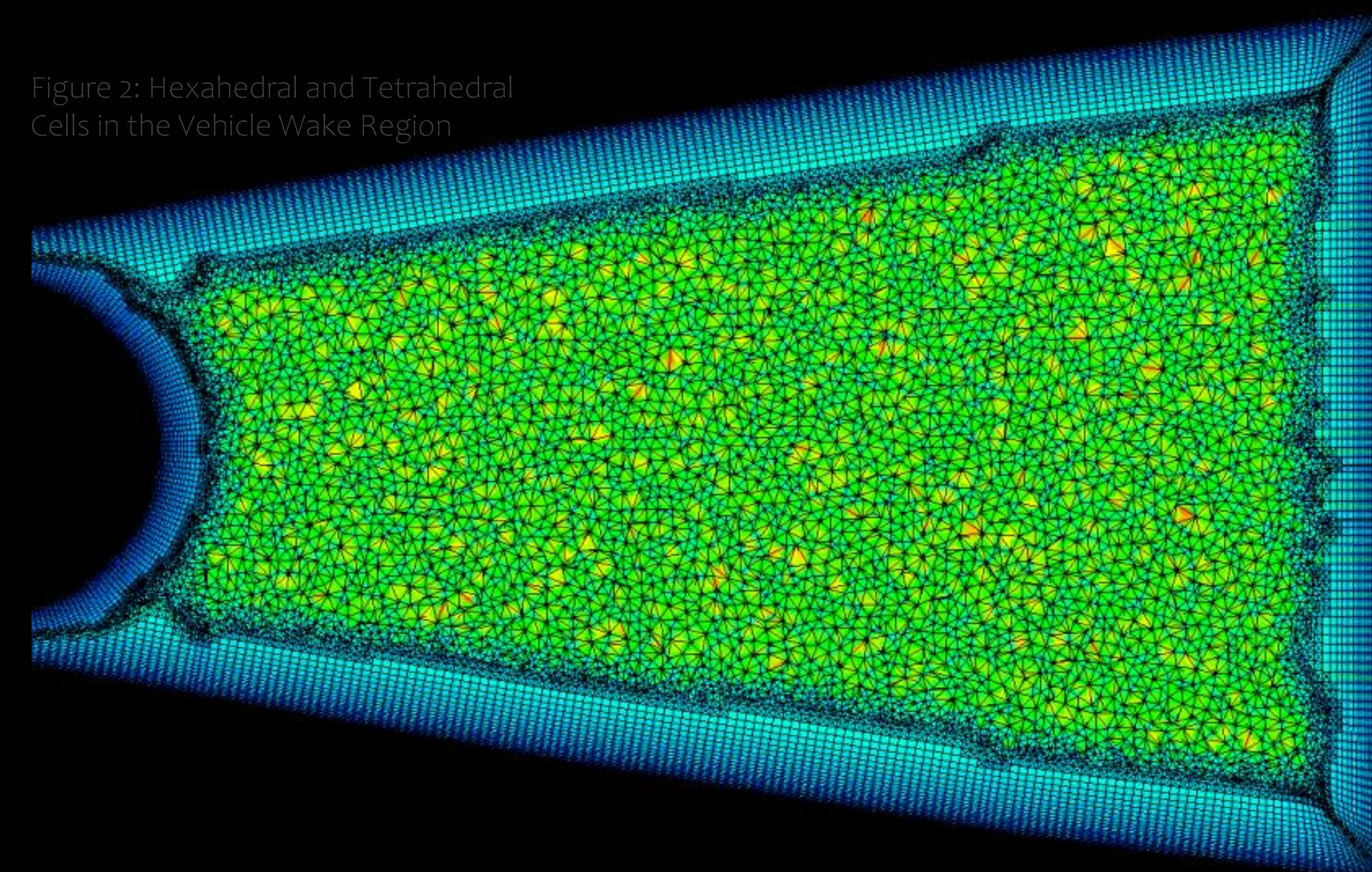


Figure 2: Hexahedral and Tetrahedral Cells in the Vehicle Wake Region



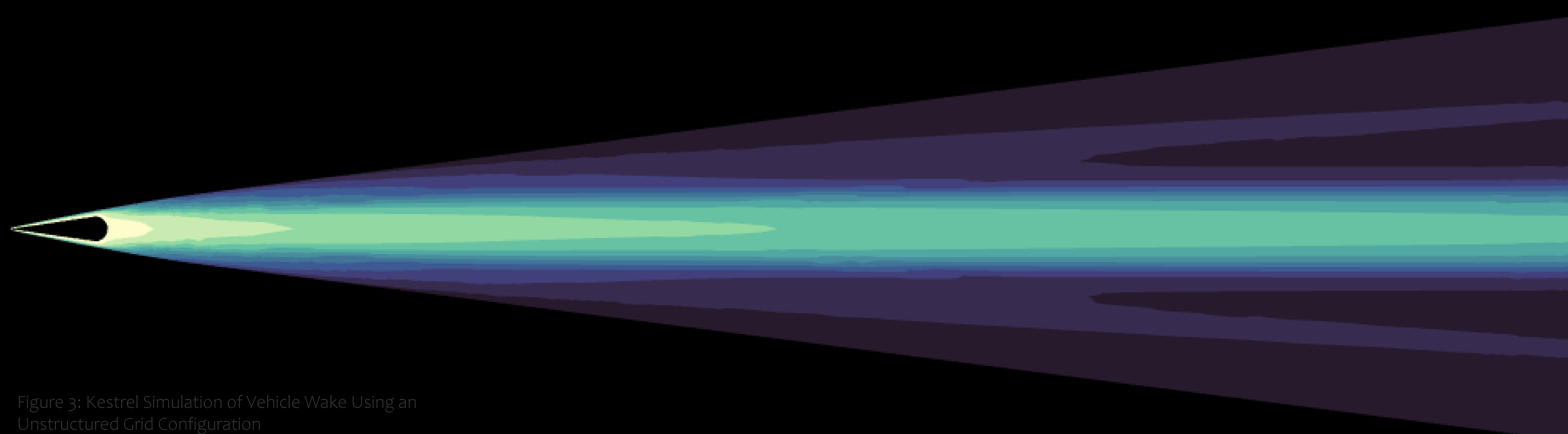
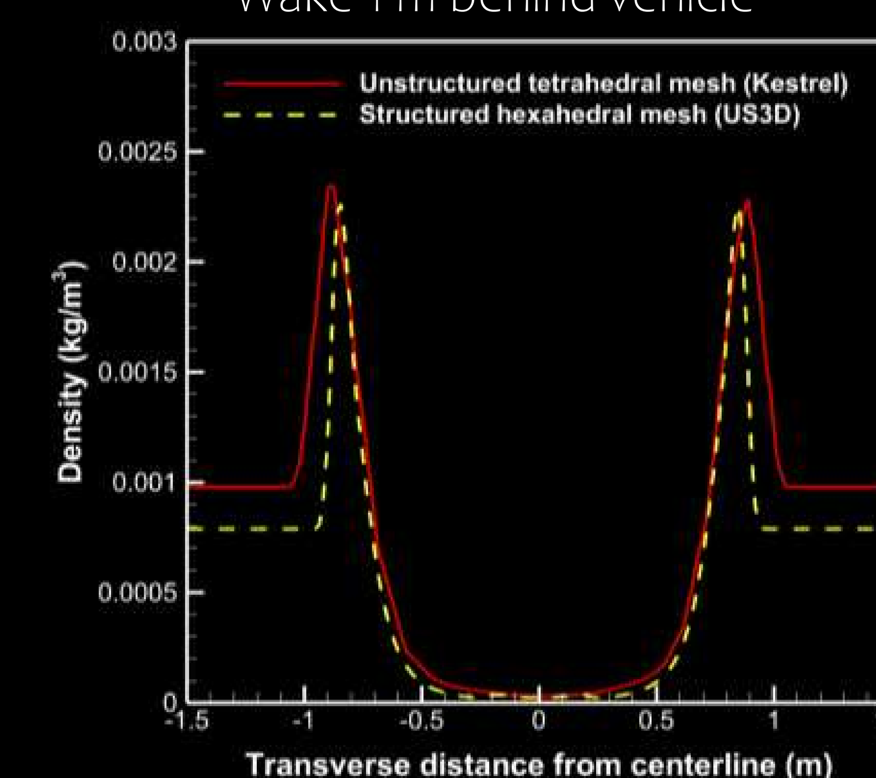


Figure 3: Kestrel Simulation of Vehicle Wake Using an Unstructured Grid Configuration

Method

Hexahedral and prismatic cells are extruded from a vehicle body to resolve the boundary layer, while the bow shock and wake are resolved in the farfield using both tetrahedral and hexahedral cells.

Results



Tetrahedral cells proved to have acceptable accuracy with appropriate clustering but prismatic and hexahedral cells demonstrated superior resolution of the boundary layer with less mesh generation time and storage.

This approach is demonstrated for a sharp cone-sphere at Mach 21.

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.
This material is based upon work supported by the Department of the Air Force under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of the Air Force.
© 2023 Massachusetts Institute of Technology.
Delivered to the U.S. Government with Unlimited Rights, as defined in DFARS Part 252.227-7013 or 7014 (Feb 2014). Notwithstanding any copyright notice, U.S. Government rights in this work are defined by DFARS 252.227-7013 or DFARS 252.227-7014 as detailed above.
Use of this work other than as specifically authorized by the U.S. Government may violate any copyrights that exist in this work.