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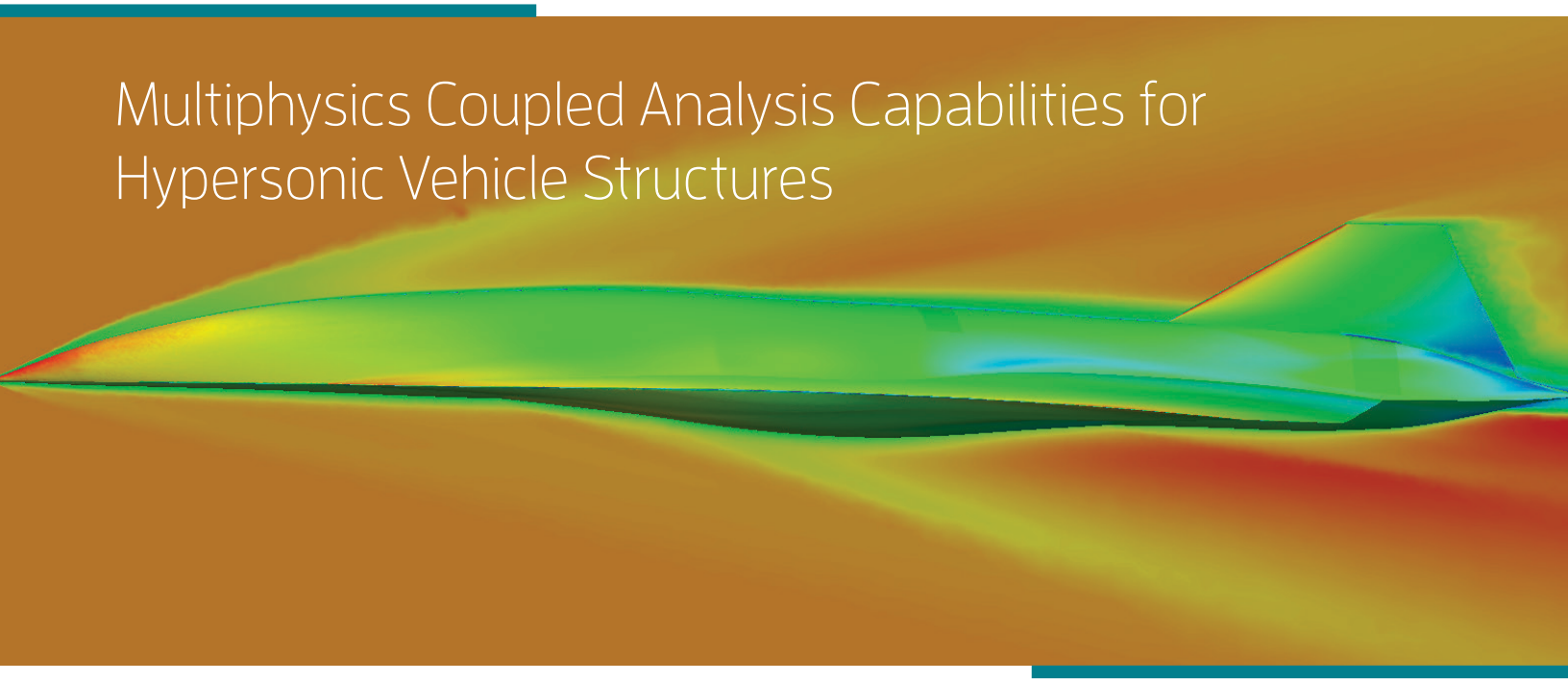
Multiphysics Coupled Analysis Capabilities for Hypersonic Vehicle Structures



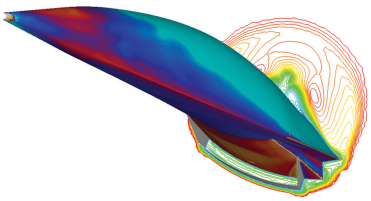
Case Study

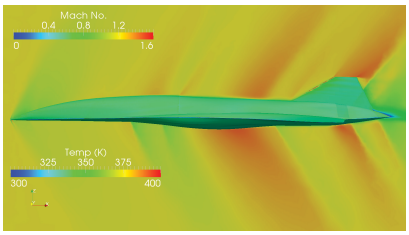
OVERVIEW

ATA has developed a high-fidelity, tightly integrated multiphysics analysis capability for performing coupled aerothermal-structural simulation of hypersonic vehicle structures. ATA's methods leverage a set of coupled software tools created to model the response of these structures in extreme flight environments at both the global level of the full flight vehicle and the local level of critically loaded vehicle skin panels. The approach improves upon traditional uncoupled methods by integrating a hypersonic-capable computational fluid dynamics (CFD) code with a nonlinear computational structural dynamics (NLCSD) code in a fully coupled fluid-structure interaction form.

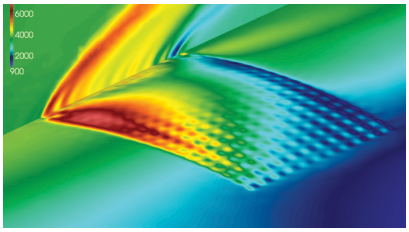
TASKS PERFORMED & KEY INNOVATIONS

- Coupling of a hypersonics finite rate reacting chemistry CFD solver, Loci/CHEM, to a state-of-the-art commercial NLCSD solver, Abaqus.
- Development of a novel mesh-morphing algorithm to preserve mesh quality in the near-wall region, enabling more accurate aerothermoelastic co-simulations.
- Demonstration of quasi-static and dynamic aerothermoelastic solver capabilities on notional geometries of a hypersonic vehicle forebody and local panels in the Mach 15 flight regime.
- Development of methodologies to extract a local CFD subdomain, including boundary conditions, from a global vehicle-level CFD solution to facilitate local static and dynamic multiphysics simulations in the region surrounding a vehicle panel.





Whole-vehicle CFD simulation



Static pressure on surface and vehicle symmetry plane showing shock formation due to localized deformation