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Case Study

AI-generated hypersonic vehicle rendering.

Hypersonic Modeling Development

OVERVIEW

Spirit AeroSystems, Inc., (Spirit) is a leading manufacturer of aerostructures for commercial aircraft and defense platforms. In response to national priorities, Spirit is applying their Design for Manufacturing expertise to exploring design methods to reduce cost and improve manufacturability of hypersonic air vehicles. To define a streamlined methodology for evaluating the thermostructural response and margins of safety of these advanced design concepts, Spirit partnered with ATA Engineering, Inc., (ATA) to create a workflow that automates the application of extreme aerothermodynamic flight loads onto detailed structural finite element models (FEMs) of conceptual vehicle designs.

ATA developed a modeling framework for assessing preliminary hypersonic vehicle structural layouts, joints, subassemblies, and components under defined aerothermal loads, including evaluating vehicle temperatures, load distributions, and structural stress. FEM development for two structural layout configurations focused on identifying a level of fidelity that adequately represented material architectures and failure modes of interest while minimizing computational costs to support conceptual design trade studies and rapid delivery of simulation insights. ATA developed guidelines for a suitable aerothermal analysis approach capable of identifying the thermal environments likely to drive structural designs without the computational cost associated with full-fidelity computational fluid dynamics (CFD) modeling. This approach was demonstrated with full-vehicle aerothermomechanical analyses of a notional hypersonic glide vehicle design, delivering insights into the performance and survivability of the vehicle and its subcomponents. At the conclusion of the effort, ATA transitioned all custom-developed modeling tools to Spirit and provided detailed technical reporting defining modeling procedures and best practices.

TASKS PERFORMED & KEY OUTCOMES

- Developed a hypersonic vehicle analysis framework using a combination of NASA CBAERO for aerothermodynamic environment generation and Abaqus for thermal heat transfer and thermostructural analyses.
- Provided a framework that minimizes computational costs when aerothermal, mechanical, and thermal fundamentals are applied to hypersonics.
- Delivered critical feedback to Spirit on two notional hypersonic vehicle designs.
- Transferred the modeling software framework to Spirit, along with recommendations for future improvements.