National Aeronautics and Space Administration

NASA ADVANCED SUPERCOMPUTING (NAS) DIVISION

APPLIED MODELING AND SIMULATION

The NASA Advanced Supercomputing (NAS) Division's applied modeling and simulation capabilities, coupled with its high-end computing resources, provide high-fidelity analyses for critical NASA engineering and design decisions.

Benefit

NAS high-fidelity modeling and simulation (M&S) capabilities are playing a key role in solving NASA's most challenging science and engineering problems. Our computational fluid dynamics (CFD) experts develop and conduct advanced simulations that provide key insights and performance data for a wide range of NASA's critical engineering, design, and safety efforts.

Coupling state-of-the-art codes with their unique expertise in numerical analysis, computational grid generation, and aerodynamics, NAS CFD experts are able to both rapidly vet basic performance factors for new design concepts, and perform the intensive, high-fidelity simulations needed to refine detailed design features later in development.

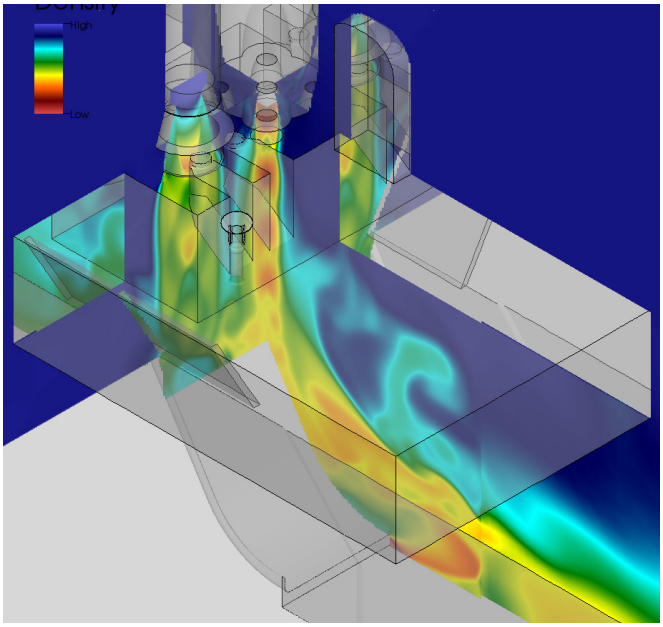
One key benefit of computational modeling is that it can reduce the amount of costly, time-consuming experimental testing required to validate a design or fine-tune its performance. CFD analyses efficiently supplement limited or unavailable wind tunnel data, and are used to extend wind tunnel-scale test results to full-scale flight conditions.

High-fidelity simulations are also able to provide unique insights into complex interactions and phenomena that are difficult or impossible to test experimentally, such as jet plume interactions or rocket stage separation dynamics. In these ways, NAS applied modeling and simulation efforts enable improved designs, significant cost savings, and faster turnaround times for the Agency.

Overview

The NAS Applied Modeling and Simulation team specializes in designing and conducting advanced simulations to optimize system design and safety objectives for NASA missions. Using NAS's high-end computers and specialized codes such as OVERFLOW, Cart3D, and INS3D, this team of experts provides a wide spectrum of intensive computational analyses to quantify and understand the complex physical processes and phenomena that affect the performance of NASA systems and technologies. The team also develops and refines analysis tools and techniques to achieve an optimal balance of fidelity and efficiency for NASA's diverse design and analysis needs.

One of the Applied M&S team's core contributions is providing extensive aerodynamic analyses of NASA's aerospace vehicles, including the recently retired Space Shuttle and the next generation of space launch and exploration vehicles. The team also conducts simulations of environmental flows for weather



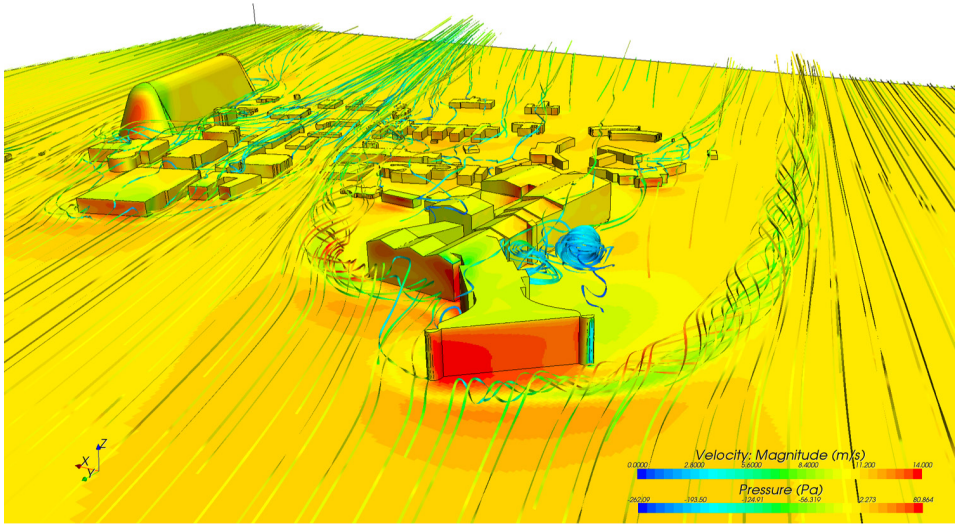
High-fidelity CFD simulation of launch environment conditions for an early candidate heavy-lift launch vehicle design. (Cetin Kiris, Jeffrey Housman, Michael Barad, NASA/Ames)

modeling and optimization of green building architectures, and models circulatory system flows for human safety factors and the development of biomedical devices such as the NASA/DeBakey Ventricular Assist Device.

Next-Generation Space Launch & Exploration Vehicles

NAS M&S experts provide a range of simulations to support the design and analysis of NASA's next-generation space launch and exploration vehicles, including the new heavy-lift Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV). High-fidelity CFD simulations of the SLS provide detailed databases of aerodynamic flows, forces, and interactions that could affect flight performance and safety during launch. This data is used to compare alternate candidate designs, perform structural analyses, and optimize the vehicle's shape and trajectory.

Crew vehicle simulations analyze stability and control during launch aborts, abort motor plume effects and interactions, and



Large-scale CFD simulation of wind flows around the Sustainability Base green building at NASA Ames Research Center. (Michael Barad, NASA/Ames)

other critical aerodynamic and aerothermal performance factors during atmospheric entry, descent, and landing. These simulations provide key performance data for conditions that are difficult or impossible to obtain using ground-based or flight testing.

NAS experts are also developing new CFD tools and techniques to simulate launch environments for the heavy-lift SLS, which will be even more intense than those generated by the Space Shuttle's 7 million pounds of thrust. These analyses predict critical pressure loads and acoustic noise levels during ignition and liftoff to assess the suitability of existing launch facilities for larger vehicles, and to ensure that excessive vibrations won't damage their valuable payloads.

Green Building Architectures

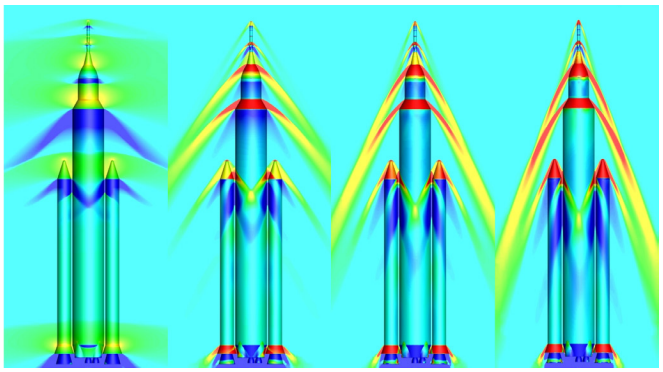
NAS modeling and simulation experts have performed CFD simulations of environmental flows and how they interact with architectural designs to aid in the development of energy-efficient green buildings, such as the new Sustainability Base at NASA Ames Research Center. The team modeled the sustainability base within the surrounding structures at NASA Ames, and performed simulations of exterior airflows for typical summer and winter wind conditions. The team also provided preliminary simulations of interior temperatures and airflows, using a model conference room to investigate the effects of windows, vent locations, and other design factors on building temperatures and circulation systems.

Space Shuttle Safety

NAS modeling and simulation efforts played a crucial role in the safe return of the Space Shuttle and crew over the last seven years, including its final mission in July 2011. For every Space Shuttle mission since 2005, NAS researchers used their advanced M&S tools to run extensive debris transport analyses and CFD simulations of the shuttle during launch, ascent, and orbit. These analyses were crucial to evaluating the threat of debris damage from ice and foam shedding from the bi-pod ramps and external tank.

Background

The NAS Division's preeminent applied modeling and simulation capabilities are built upon longstanding expertise in aeronautical engineering and aerodynamics. Throughout its history, NAS has been a leader in applying cutting-edge modeling and simulation technologies to solve engineering challenges, optimize designs, and facilitate efficient development cycles for NASA missions.



CFD simulations of ascent aerodynamics for an early candidate crew launch vehicle design. (Michael Barad, NASA Ames)

Point of Contact:
Cetin Kiris
NASA Advanced Supercomputing Division
Computational Aerosciences Branch
cetin.c.kiris@nasa.gov

For more information on NAS Division activities, please scan the QR code to visit: www.nas.nasa.gov

FS-2015-11-02-ARC