Computational Investigation of Hypersonic Aerodynamic Phenomena on Guided Flight Vehicles

About DEVCOM ARL:

The DEVCOM Army Research Laboratory (ARL) is the Army's sole foundational research laboratory strategically placed under the Army Futures Command. ARL focuses on cutting-edge scientific discovery, technological innovation, and transition of knowledge products that offer incredible potential to improve the Army's chances of surviving and winning any future conflicts. The ARL Flight Sciences Branch, located at Aberdeen Proving Ground (APG), MD, studies the flight of guided Army munitions. The branch accomplishes this through Computational Fluid Dynamics (CFD) using DoD HPCMP HPC resources, and through experimentation at the ARL Transonic Experimental Facility at APG, the world's largest free-flight spark shadowgraph range.

RESEARCH LOCATION: Aberdeen Proving Ground, MD

PROJECT DESCRIPTION:

The project will investigate complex high-speed flow phenomena and their impact on the aerothermodynamics of guided flight munitions. High-fidelity Navier-Stokes Computational Fluid Dynamics (CFD) simulations will be employed to study shock wave-boundary layer interactions, flow separation, heat transfer, thermal and chemical non-equilibrium, boundary layer instabilities and turbulence on the external components of high-speed configurations.

The objective of the project is to improve our understanding of the complex flow interactions on Army-relevant high-speed flight vehicles and canonical geometries. Computational modeling at multi-Mach and multi-Reynolds number flight conditions will be used to study the interaction of shock waves with high-speed boundary layers, flow separation, wall heat transfer, thermal and chemical non-equilibrium, boundary layer instabilities and turbulence modeling. Numerical approaches will include Reynolds-Averaged Navier-Stokes (RANS), Large Eddy Simulation (LES) and hybrid RANS-LES. The DoD HPCMP resources (e.g., DoD Supercomputing Resources Centers and Secure Remote Desktop) will be leveraged to generate computational meshes, perform CFD simulations and post-processing analyses.

High-fidelity CFD will be conducted to predict and analyze important flow phenomena in candidate high-speed weapon configurations at various Mach numbers, Reynold's numbers, and angles of attack. Configurations will include generic Army relevant tail-fin vehicles and canonical configurations with existing wind tunnel data for validation of accuracy.

The intern will generate computational meshes, perform CFD simulations and post-processing analyses using the DoD HPCMP resources which includes state-of-the-art commercial and academic numerical solvers and tools.

CFD simulations will include Reynolds Averaged Navier-Stokes (RANS), Wall-Modeled Large Eddy Simulations (WMLES), hybrid RAN-LES and multi-physics approaches. Analyses will include comparison with available experimental data, physical interpretation of results, validation and refinement of models and reduction techniques.

The intern will also actively participate in technical meetings and networking activities with internal and external collaborators and experts in hypersonic aerothermodynamics.

ANTICIPATED START DATE:

May 2025 – Exact start dates will be determined at the time of selection and in coordination with the selected candidate.

QUALIFICATIONS:

Prospective candidates should have a passion in fluid dynamics and have experience performing computational fluid dynamics. Candidates with a bachelor's or higher in aerospace engineering or mechanical engineering with a focus in fluid mechanics are preferred. Candidates should have a fundamental skill in Unix and programming. Proficiency in analyzing and interpreting data, applying theoretical knowledge to solve practical problems, attention to detail and the ability to research effectively in a collaborative environment are essential. Experience in hypersonic research will be considered favorable.

ACADEMIC LEVEL:

Degree received within the last 60 months or currently pursuing:

- Bachelor's
- Master's
- Doctoral

DISCIPLINE NEEDED:

- Computer, Information, and Data Science
- Engineering
- Science & Engineering-related