High Fidelity Aerodynamic Modeling of Coupled Ship/Rotor Wakes during Shipboard Operations

About NAWCAD:

The Applied Aerodynamics Branch at the Naval Air Warfare Center Aircraft Division supports development of new and improved aerodynamic technologies to fixed wing and rotary wing aircraft. Provides aerodynamic research required by the Navy; develops and validates methods for aerodynamic and performance analysis; derives, maintains, and improves engineering criteria, techniques, and methodologies for predicting the aerodynamic characteristics for which other aeromechanics competencies are responsible; and aerodynamic analysis as required by outside competencies dealing with external aerodynamic interaction effects. Defines and conducts aerodynamic Science and Technology research programs. Provides advanced modeling of aircraft/ship air-wake interaction. Provides the development and application of computational fluid dynamics while conducting research into fundamental aerodynamic principles and advanced aerodynamic concepts. Conducts analytic investigations to derive, maintain, and improve engineering criteria, techniques, and methodologies for predicting aerodynamic characteristics; reducing the technical risk associated with the design and development of aircraft. Develops and validates concepts and methods for reducing aerodynamic drag or increasing usable aerodynamic lift in flight vehicle configurations. Provides computational fluid dynamics analysis, lower level theoretical and empirical analysis, and experimental test support to characterize the aerodynamics of air vehicles.

RESEARCH LOCATION: Patuxent River, MD

PROJECT DESCRIPTION:

The Navy's long-term vision is to develop a virtual simulation environment which provides realistic aircraft response sufficient to develop a launch and recovery envelope in place of, or in addition to, full-scale at-sea flight testing. A key component to this effort is the incorporation of a real-time coupled aerodynamic / flight dynamics capability. Recent advancements in the CREATE-AV Helios CFD code have enabled coupling with the Navy's flight dynamics modeling environment known as CASTLE. The goal of this internship will be to assess the sensitivity of computational model fidelity on the coupled aeromechanic phenomena driving shipboard operations. The results of the high-fidelity analyses will help guide the development of future real-time models.

The primary goal of this project is to execute a demonstration and model fidelity study focusing on the coupling of the CREATE-AV Helios CFD solver with the NAWCAD CASTLE flight dynamics model (aka CASTLE/Helios). The notional use case will be a small UAS vehicle recovering to a representative Navy ship. Where applicable, recent flight testing conducted by the Navy will be utilized. The project will examine the impact of CFD modeling parameters such as near-body/off-body solver (e.g. KCFD vs. Lattice Boltzmann, SAMCart vs. Orchard), grid density, turbulence modeling, rotor model, etc. The project will also investigate effect of vehicle size on the aerodynamic coupling effects.

Best practices established during this study will be transitioned to multiple Naval S&T programs as well as the many aircraft and ship programs that seek CFD modeling of shipboard operations.

Intern Activities:

- Familiarization
- Literature survey / review of current state-of-the-art
- Helios, CASTLE, & CASTLE/Helios Tutorials
- Grid Generation / Model Development
- Navy ship unstructured and/or LBM grid
- Navy helicopter airframe unstructured and/or LBM grid
- CASTLE/Helios Execution & Model Fidelity Sensitivity
- Airframe grid refinement study
- Airframe model sensitivity (e.g. unstructured solver, IBM, LBM, etc.)
- Blade element rotor model refinement study
- Data Analysis
- Develop post-processing and visualization scripts to analyze data and determine impact of modeling parameters
- Documentation and Presentation

The intern will have access to tour and training opportunities available to all NAWCAD, Patuxent River interns.

ANTICIPATED START DATE:

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

QUALIFICATIONS:

Bachelor's degree or higher in Aerospace or Mechanical Engineering. Candidates must be familiar with aerodynamics and numerical methods, preferably with a knowledge of computational fluid dynamics. Rotary wing experience is desired, though not required.

Skills:

- Familiar with at least 1 CFD code (e.g. Kestrel, Helios, Overflow, OpenFOAM, STAR-CCM+)
- Familiar with post-processing software (e.g. Ensight, Tecplot, Paraview, Matlab)
- Proficient in at least 1 programming language (e.g. Python, C/C++, Fortran, Matlab)

ACADEMIC LEVEL:

Degree received within the last 60 months or currently pursuing:

- Bachelor’s
- Master’s
- Doctoral

DISCIPLINE NEEDED:

- Engineering
- Science & Engineering-related