Ship Airwake Flow Study Enhances Pilot Training and Mission Safety

By Gary Sivak and Dinah Luneke

This high priority project, "Integrated Ship/Rotorcraft Airwake Simulation" was run at ASC MSRC in FY04 by Principal Investigator Ms. Susan Polsky of the Naval Air Weapons Center, in Patuxent River, Maryland.

Perhaps the most demanding of all aviation environments, the operation of aircraft from ship platforms involves turbulent airwake produced by a ship's superstructure. This phenomenon is a major contribution to the workload required for such operations. Past airwake modeling efforts were, at best rudimentary, offering only representative levels of turbulence for a particular ship class. The current study involves the prediction of time variance for ship dynamics variables.

Ship Airwake and Flight Simulations

"The emphasis of our work at the ASC MSRC is to understand the physics of ship airwake flows and to predict those flows with sufficient accuracy to aid in ship design, aircraft control system development, and pilot training," Ms. Polsky stated. "Airwake data produced by Computational Fluid Dynamics (CFD) computations has been integrated with real-time, pilot-in-the-loop flight simulations and autopiloted simulations." (Figure 1)

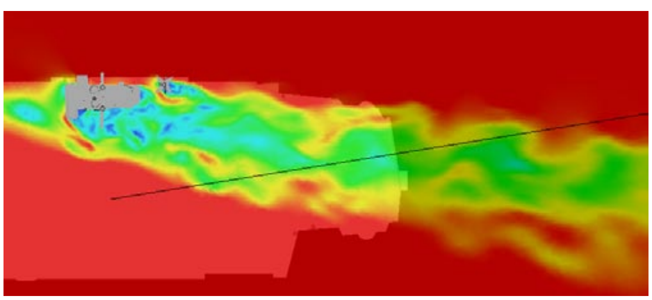

Figure 1. CFD solution overhead view, color-coded to show areas of high airwake produced by the island structure and a typical fixed wing flight path.

This research project seeks to understand the physics behind the complex, and difficult to model, interactions (hydrodynamics coupled with aerodynamics) between naval ships, the ocean, the air above and behind, and Naval aircraft flying through airwakes. Turbulent airwakes created behind a ship, such as when a large aircraft carrier plows through the water, are especially evident within the vicinity of an island. An airplane flying behind a ship can experience a sudden and unexpected drop in indicated airspeed, similar to what a moving car experiences while "drafting" behind a tractor trailer. Produced mainly by the ship's superstructure, the airwake starts out on the scale the same size of the ship, from a length of a few thousand feet, and may extend up to approximately a mile in length.

CFD Modeling

By applying CFD to understand the underlying physics, Ms. Polsky describes the impediments to modeling as "turbulent, unsteady, chaotic, and difficult to model." The researchers have tried to manage the scope of the effort, by only modeling the laminar (boundary layer near surface) flow, and not the turbulent (distant free wake) flow. The researchers have a high confidence level that the Cobalt application running on the ASC MSRC SGI O3900 "gets them close to reality." (Figure 2)

Research Applications

Through this invaluable research, Ms. Polsky seeks to use the output of this analysis to improve ship design, aircraft control system development, and by entering the data as inputs for flight simulators, to improve pilot training. In the past, the flight simulators would shake the pilots with a certain frequency profile, i.e., they would experience the same identical "random" turbulence pattern over and over again. With the inputs of this new research, Ms. Polsky is endeavoring to incorporate the cyclically, varying turbulence patterns into flight simulator training sessions to impart a more realistic flight experience for the

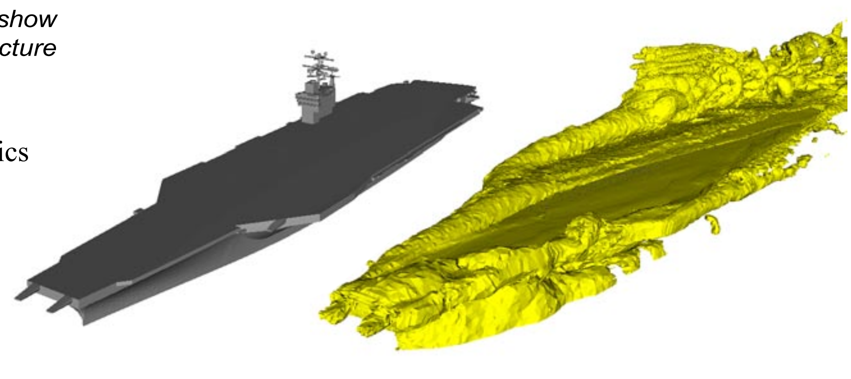

Figure 2. The CFD model of the CVN 73 aircraft carrier (left); the same carrier rendered in yellow (right) represents the airwake prediction using iso-surfaces of vorticity.

pilots, better educating them to handle these chaotic, and potentially life threatening aerodynamic conditions. (Figure 3)

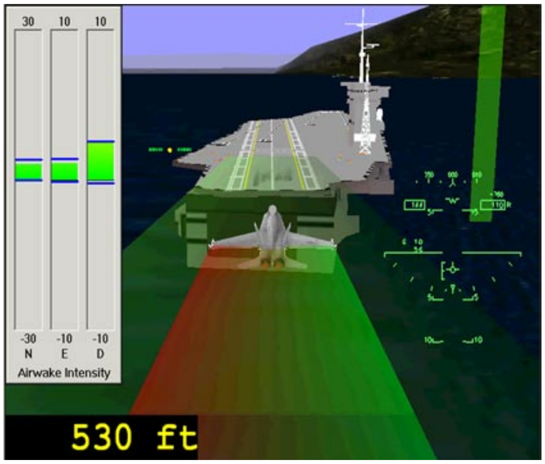

Figure 3. Display produced by off-line flight simulation tool developed to evaluate impact of ship airwake on aircraft operations.

Improving mission readiness and saving lives while protecting valuable resources continues to inspire Ms. Polsky in the development of “better ships, better aircraft, better control, and an increase in operational capability.”

For information regarding this research please contact Ms. Polsky at susan.polsky@navy.mil or contact the ASC MSRC Service Center at msrchelp@asc.hpc.mil, or (888) 677-2272 or (937) 255-1094.