P-3C Aircraft Provides Surveillance of the Battlespace to Protect Land and Sea

The P-3C Orion, the U.S. Navy's maritime and anti-submarine warfare aircraft on patrol

This HPCMP High Priority Project, "P-3 CFD Flight Clearance," was run at the AFRL MSRC by Mr. Joseph Laiosa, Principal Investigator (PI), Naval Air Systems Command (Navair) Warfare Center, Patuxent River, Maryland. AFRL MSRC HPC System Utilization: SGI Altix 3700 (EAGLE) and HP XC Cluster (FALCON) with 111,309 total hours

By Gary Sivak and Dinah Luneke

P-3C Aircraft Provides Mission Support

Flying at a low observable altitude, the P-3C aircraft views the battlespace below and instantly transmits that information to U.S. Naval forces. The P-3C Orion is a low wing aircraft in the 135,000-pound gross weight class designed for patrol, anti-surface warfare, and anti-submarine warfare. It is powered by four T56-A-14 turbo-prop engines, each providing 4,600 shaft horsepower for takeoff. The aircraft features integration of advanced submarine detection, ordnance, and armament systems. The armament/ordnance system is comprised of two subsystems: the armament (kill stores) and ordnance (search stores). The armament subsystem refers to equipment used for the carriage and delivery of weapons, and the ordnance subsystem refers to equipment from the wing pylon stations and bomb bay stations. Thanks to the invaluable research of Mr. Joseph Laiosa and his colleagues, the P-3C will continue being updated with new weapon systems and mission support. All this ensures it will survive to fly another day.

Understanding the Project

The P-3C carries bombs, mines, torpedoes, missiles, rockets, and practice bombs. The goal of this research was to provide a safe separation flight clearance for the High Altitude Anti-submarine Warfare Weapons Concept (HAAWC) weapon system demonstration. The selected HAAWC prototype design concept, which was developed by Lockheed Martin, combines an existing MK-54 torpedo with a wing/tail kit to provide longitudinal and directional flight stability. This study resulted in clearing the weapon release of the HAAWC for a proof of concept flight demonstration from the P-3C naval aircraft.

The main issue was how to safely release this new weapon from the bay. An aerodynamic database was developed for the weapon in proximity of the airplane using the Cobalt flow solver. This data was then used with a six degree-of-freedom (6DOF) code to predict trajectories. During this time, the Cobalt developers were also working on a new version, which utilized an unstructured overset moving grid capability.This version was time accurate, provided a more realistic solution, and served as a final check on the project.

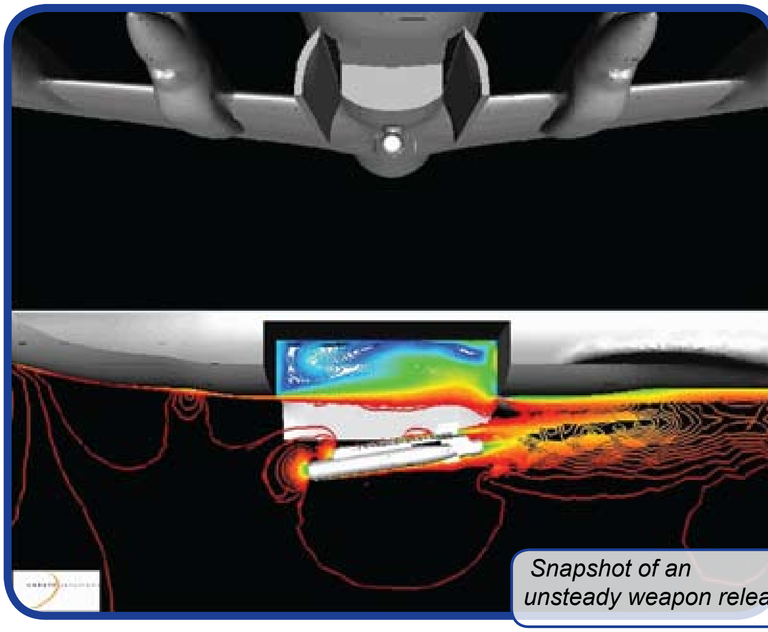
Why HPC?

Normally, the wind tunnel is used to develop the aerodynamic database, which is then used with a 6DOF code to predict the trajectories and provide a safe separation flight clearance. However, the P-3C is an older aircraft, with no readily available wind tunnel model equipped to test bay release weapons. The cost to build such a model would be exorbitant, with a projected cost totaling $1 to 3 million and an additional $3 million more to fund a wind tunnel test program.

"Time and cost constraints of building models for the wind tunnel and getting the solutions out were just too far downstream," Mr. Laiosa said. "They wanted this done quickly, at low cost, and the only way to get it done was with CFD using high performance computing."

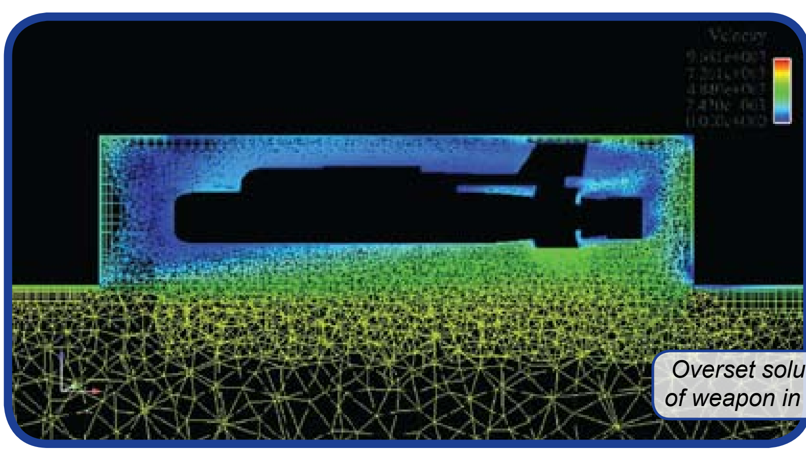
Understanding the Science

This work is applied research, and it is performed in direct support of the naval fleet. Flow simulations initially employed a quasi-steady approach similar to that in the wind tunnel. Aerodynamic coefficients of the weapon are obtained at discrete locations in proximity of the aircraft using the Cobalt flow solver. This data is then used in conjunction with an isolated weapon database (obtained either from CFD or the wind tunnel) and a 6DOF code to predict weapon trajectories. As a check of this procedure, Mr. Laiosa used a newer version of Cobalt. This version employed an unstructured overset capability to track the weapon's movement as a function of time. The unsteady time accurate approach eliminates the need of developing databases for both the isolated weapon and the weapon in the proximity of the aircraft. This code figures all the forces in moments and then calculates the trajectory based on those forces at each time step.



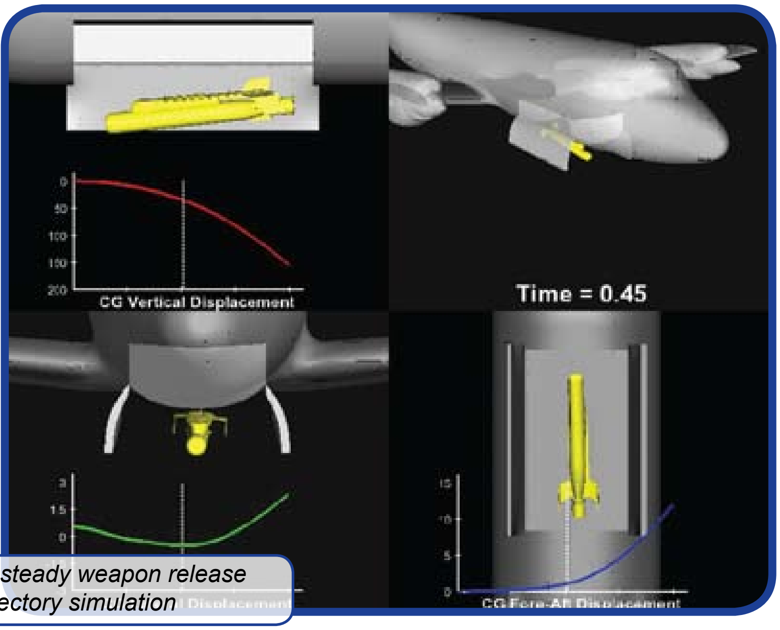
Snapshot of an unsteady weapon release

The wind tunnel uses two similar methods to develop weapon release trajectories. The grid, or flowfield, method is where the weapon is placed at discrete points away from the airplane, and the forces are measured to develop the database. This database is then used off-line with a 6DOF code. The Captive Trajectory Systems (CTS) method is used where the weapon is actually moved based on its forces. The problem with using the wind tunnel is usually time and cost. Wind tunnel test time needs to be scheduled months in advance, and the model cost is usually in the millions of dollars range.



Overset solution of weapon in bay

"There are more unknowns with this new weapon system and aircraft than typical weapon systems," Mr. Laiosa remarked. "For example, the MK-54 torpedo is usually released at lower altitudes and speeds. Also, the combination of the MK-54 torpedo and the long shot wing kit has just been developed, and there is very little experience with this system. The importance of this program is that torpedoes are released at 500-feet or less. The higher altitudes are safer for the airplane and more forgiving on the structure."



Unsteady weapon release trajectory simulation

Mission Accomplished at the AFRL MSRC

"I have always used the AFRL, as it had been the location that held all the licenses for the grid generation tool, Gridgen, developed by Pointwise, Inc. and the flow solver, Cobalt, developed by Cobalt, LLC. The volume grids were generated by AFLR3, which was developed by Mr. David Marcum from Mississippi State. The combination of these tools and the HPC system results in a quick and responsive approach," Mr. Laiosa reported.

Benefits that Will Fly Into the Future

This research has given the U.S. "the potential of developing another weapon in its tool box with a safer release from its aircraft, with more of a strategic weapon available," Mr. Laiosa reported. "Savings are estimated between $5 and 7 million, as a minimum, with the elimination of the wind tunnel test costs and the reduction of the flight test program, as only one drop was needed. Without this work, flight testing would have resulted in multiple drops. With this research, only one drop was required."

Other benefits include a decreased time-to-solution and the completion of this work within required deadlines. This research resulted in clearing this weapon for the entire flight envelope, which has become part of the Navy arsenal. The wind tunnel tests various versions of the wing kit, and it was what the Navy deemed as the most stable to include in the HAAWC: MK-54 System and Bay Release, which is the center line station of the aircraft.

"Productivity at the AFRL MSRC has been superb and, with receiving High Priority status for this project on a dedicated HPC system, this meant simply everything. Without this, I would not have been able to obtain the solutions in time to provide the P-3C HAAWC flight clearance," Mr. Laiosa said. "Technical issues with my script were also resolved quickly. Running at the AFRL really helped me to get my work done. Some solutions for my code had to be developed 'on the fly' for me by AFRL staff. Their entire system is simply state of the art." ■

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