Research Reduces Airplane Tests with Increased Resolution of Simulations

By Gary Sivak and Dinah Luneke

Project Identification

Two HPCMP Challenge projects were run at the ASC MSRC by Dr. Scott Morton, Technical Manager of the Institute for HPC Applications in support of the Air Armament, AF Seek Eagle Office at Eglin Air Force Base. The first project, "Multidisciplinary Applications of Detached-Eddy Simulation to Separated Flows," began in FY05, and the subsequent project, "High Resolution Simulation of Full Aircraft Control at Flight Reynolds Numbers," started in FY06.

Spinning out of Control

You are the Program Manager for the F-89 Fighter Attack Group, a high visibility program, which is developing the F-89, a state-of-the-art super-stealthy attack fighter for the Air Force. Your Contracting and Finance Program Office informs you that the Air Force has just slashed your flight test budget by 70 percent. Next, you receive a call from flight test personnel at Edwards Air Force Base, informing you that, due to busy flight range schedules and over-bookings, the number and time of your scheduled flight tests have been cutback by 80 percent! Will your F-89 program crash and burn? This article outlines how Dr. Scott Morton of the Seek Eagle office and the high performance computers at the ASC MSRC came to the rescue.

A Seeker of Excellence

Dr. Morton envisions his work as virtual flight testing, which can make more effective use of or even reduce actual flight tests. His team's simulations augment actual flight testing for stability and control to make sure the aircraft flies the way it is designed to fly. "You run through different maneuvers and develop a composite aircraft model by combining CFD with 6-degrees of freedom motion, i.e., translation and rotation of the vehicle," Dr. Morton said. "Current flight test capability is not sufficient for our future programs, and therefore a new simulation capability is essential."

Research Approach

The work involves aspects of both application and theory and includes these important flight testing steps:

1. Simulation Model Integrity. This is an attempt to repeat the same maneuver as performed in flight tests during aircraft certification for flight worthiness. "We are trying to develop new treatments of turbulence to improve simulation of aircraft with massively separated flows," said Dr. Morton. "You can incorporate other disciplines, such as maneuverability or aeroelasticity to improve the fundamental physics models. Through these simulations, we want to understand specific characteristics of control for air vehicles doing complex maneuvers."
2. Minute Maneuvers. For simulations within the

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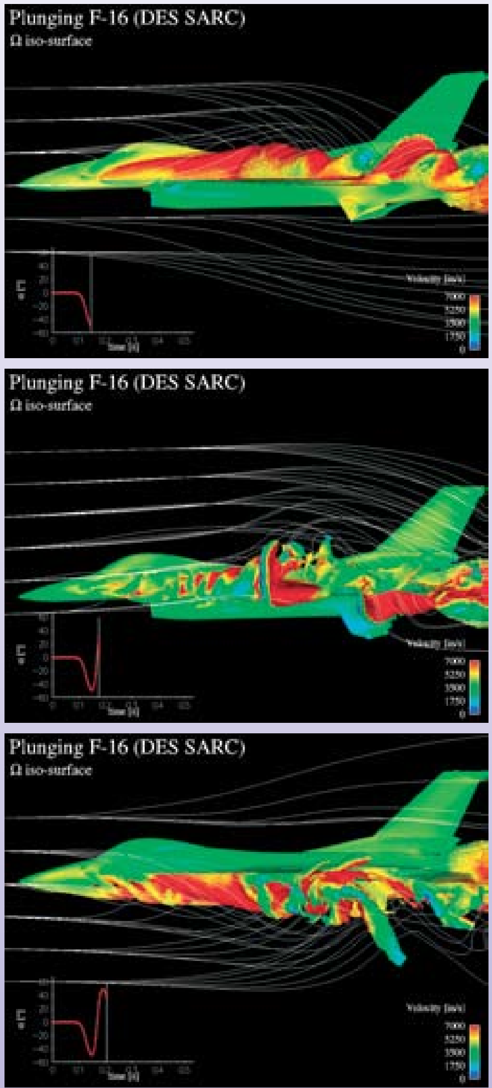
operational envelope (or range of possibilities) of an aircraft, maneuvers are dissected into their various components to gauge the aircraft's sensitivity or response to each individual component. This type of test is impossible to perform with an actual aircraft. For example, turning an aircraft away from its present course involves both rolling the aircraft into the turn with the stick and making the actual turn with the rudder controls. Individual maneuver components, such as these, are impossible to perform in the air, and therefore can only be tested through simulation.

3. Out of Bounds. Simulations can go outside the flight envelope or expected flight scenarios into risky territory so that the pilot doesn't have to go there. It is then known in advance that some maneuvers are not necessarily safe, before pilots would ever experience them and thus risk their lives. A good example of this would be an out-of-control spin.



Aircraft CFD flow field representation

Project Strategy

"We are applying proven CFD techniques to what we're calling 'virtual flight test,' but we're also developing new maneuvers to improve the efficiency of flight - the theoretical side," said Dr. Morton.

The work does not eliminate but rather augments flight tests to reduce the number of tests needed and increases their payoff. For example, to certify a particular test point in the sky (safe operation at 400 knots), traditionally operations at 350, 375, 400, 425 and 450 knots would need to be verified. With a CFD simulation, it is only necessary to verify that 400 knots is safe and conduct one flight test instead of five. These HPC studies protect both the integrity of the aircraft and pilots' lives, while giving the exact information needed by the test team.

The Power of ASC

Dr. Morton likes running at the ASC MSRC. "I have a good working relationship with the great support staff at the ASC MSRC," Dr. Morton said. "I've been running Challenge projects at the ASC MSRC for more than six years and want to continue in that relationship."

Morton's application of choice is the Computational Fluids Dynamics (CFD) program, Cobalt, which he runs on the FALCON Linux cluster. FALCON is well-suited to Cobalt since the application scales well. Cobalt has a super-linear scaling curve up to 4,000 processors, and he has been able to achieve that level of super-linearity. Cobalt can efficiently run the large, geometric grids representing large, complex, aircraft vehicles with stores (i.e., weapons, bombs, fuel tanks, and sensors).

Value to the DoD

Dr. Morton's Challenge projects benefit the warfighter by reducing the time and money spent on flight tests. For example, the F-22 and F-35 programs have less money to spend on flight tests, so the difference is made up in high fidelity simulations which augment expensive testing.

For more information, contact the ASC MSRC at asc.hp.outreach@wpafb.af.mil.