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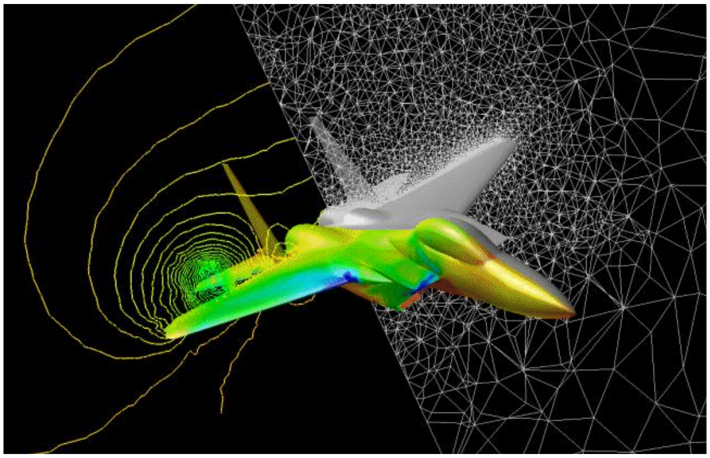
Hybrid Grids Save Time in F-15 Spin Analysis


Pressure contours and grid from Cobalt Analysis

Hybrid grids are a relatively new feature in Gridgen, but many customers are already seeing great benefits from them. Engineers at Cobalt Solutions, in conjunction with Arizona State University and the DoD High Performance Computing Modernization Office, are exploring techniques that can predict the spin behavior of F-15E fighter aircraft. They have found that using Gridgen's hybrid grids saves them weeks of analysis time compared to structured grids and other hybrid grid generators.

The F-15E is a two-seat version of the United States Air Force's frontline fighter aircraft. It is used primarily for all weather ground attack with the second pilot managing the complex sensors and weapon systems that differentiate the F-15E from the standard F-15. Adding the second seat changes stability and control slightly for most conditions, but can radically change flight characteristics in extreme maneuvers such as spins.

A spin is caused by asymmetric stall of an aircraft's wings and control surfaces. Stall occurs when the airplane reaches such a large angle of attack that the flow can no longer remain attached to the wings. This causes a sudden loss of lift and a rapid descent. If one of the wings stalls before the other it induces a violent rotation in addition to the rapid descent. This is a spin.

Spins can be difficult to recover from and in fact some airplanes are impossible to pull out of a spin once they start. Obviously, it is important to find out if your airplane is one of these before you take it for a spin. Traditionally, this is done through flight-testing. The aircraft is fitted with a small parachute in the tail that the pilot can deploy to hopefully break out of any unrecoverable spins. It is a risky business and does not always tell how to correct any problems that show up.

So spin analysis seems a natural place to apply computational fluid dynamics (CFD). An engineer sitting safely at her desk could model the flow around the spinning aircraft and thus gain insight into how it would behave. Unfortunately, the flow around a spinning fighter is separated and highly unsteady. Separated flow is difficult to model without properly applied turbulence models and an ample amount of grid points in the near-wake region. And the unsteadiness makes it expensive to analyze since many time steps have to be simulated.

At Cobalt Solutions, engineers have been working on this problem. They have developed Cobalt, an unstructured Navier-Stokes solver that works on hybrid grids. For analyzing separated flows they use an advanced turbulence modeling technique, Detached-Eddy Simulation, combined with hybrid grids, which provides a good balance between accuracy and computation time.

The engineers made an initial hybrid grid composed of approximately 6 million cells using Gridgen. This took about 3 days compared to the three to four weeks to make a structured grid. Near the surface of the airplane, where the boundary layer develops, they used prismatic, or wedge shaped, cells that align nicely with the boundaries to increase accuracy. Outside the boundary layer region, they clustered tetrahedral cells, which are easier and faster to build, in regions of highly unsteady flow. Thus they were able to make a grid that gave them the accuracy they needed in a relatively short time.

Ken Wurtzler from Cobalt Solutions said, "This research project will eventually require 15-20 million cells. With hybrid meshes, we can achieve an accurate boundary layer and a resolved field grid with a minimal amount of cells."

And using Gridgen, they can also do it quickly!

For more information, please contact Ken Wurtzler at (937) 902-6107 or wurtzler@cobaltcfd.com.

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App Sheet—F15 Spin
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