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Store Separations for F-35s Analyzed Using Grids Made With Gridgen

By Jae M. Lee and Alfred Piranian, Naval Air Systems Command, and John Martel, Capt. Darrell Crowe, and Magdi Rizk, Air Force SEEK EAGLE Office

F-35 pilots need the ability to jettison stores in the event of emergencies during takeoff (such as a cold catapult stroke or power plant problems), and emergencies in landing configuration (such as during Short Take-Off and Vertical Landing - STOVL mode approach). No wind tunnel data have been obtained for store separation in the STOVL mode, with landing gear extended and vectored thrust from the lift fan propulsion system, as shown in Figure 1. A collaborative team consisting of Naval Air Systems Command (NAVAIR), Air Force Seek Eagle Office (AFSEO), and Lockheed Martin store separation engineers was formed to conduct computational fluid dynamics (CFD)-based trajectory analyses to support issuance of flight clearance limits related to F-35 emergency jettison in those flight conditions. This article, taken from AIAA paper 2010-510 "Store Separations in Jet Flow Environments," describes challenging aspects and results of CFD-based trajectory analyses for stores separating in jet flow environments.

The Beggar CFD code was selected for this task because the code has been tailored exclusively for store separation applications and validated against flight test data for more than 20 years. The philosophy behind Beggar is to use a Chimera, or overlapped, grid system so that the components of a problem may be gridded independently of each other and then assembled to form the complete system of computational grids. By automating the Chimera assembly process and incorporating an algorithm to solve the rigid-body equations of motion, the code has become a user-friendly platform ideal for store separation calculations.

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http://www.pointwise.com/focalpt/Focal-Point-Spring-2011.pdf

Figure 1: F-35B in STOVL Mode

Store Separations for F-35s Analyzed Using Grids Made With Gridgen

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Gridgen was used to generate CFD grids for configurations of interest. The NAVAIR, AFSEO, and Lockheed Martin engineers were well aware of the challenging complexities associated with STOVL aircraft configuration/control.

When this project was started a year ago, a Lockheed Martin CFD engineer already had worked on CFD validation of the F-35B propulsion system (main nozzle, roll nozzle, and lift fan). High resolution grids for the propulsion system had been built to capture jet flow characteristics better and Lockheed Martin had already validated their solutions against a thrust-based criterion. The computed thrust had 99 percent accuracy against measured wind tunnel test data. The CFD grids for the propulsion system were transferred to NAVAIR and converted to a Beggar format.

The CFD grids for geometrically complex nose and main landing gear were built by AFSEO CFD engineers using Gridgen and had 30 million grid points, the weapon bay itself had 30 million grid points to have a direct eddy simulation (DES) quality grid. NAVAIR engineers integrated the CFD grids from different sources to attain the desired configurations, set up input files for Beggar runs, and transferred both integrated CFD grids and Beggar input files to the AFSEO CFD team to use their computing resources.

All of these grids, plus grids for any stores to be carried are assembled in a build-up procedure highlighted in Figure 2. Grid quality for the individual components was validated through comparisons with data to provide confidence in the results from the integrated system grids. Results from CFD computations on the complete configuration compare favorably to wind tunnel tests of store trajectories.

The joint team consisting of NAVAIR, AFSEO, and Lockheed Martin engineers has worked together successfully to take a CFD approach to support issuance of flight clearances that provides for STOVL emergency jettison of stores. The CFD models were validated and applied to a couple of STOVL conditions. The CFD analyses showed that STOVL emergency store ejection looks safe and benign for configurations and conditions investigated. ■

Figure 2: Build-up and validation processes