Store Separation Analysis

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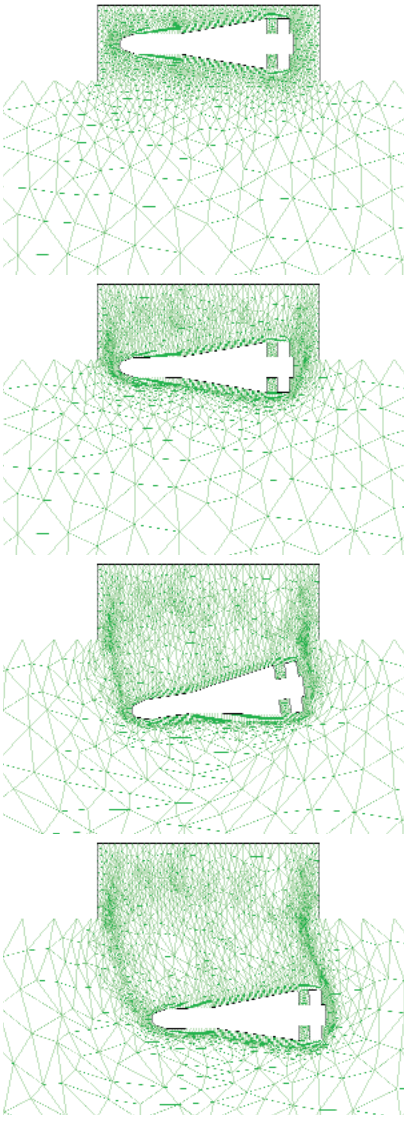


The evolution of the grid for a 2D store separation simulation

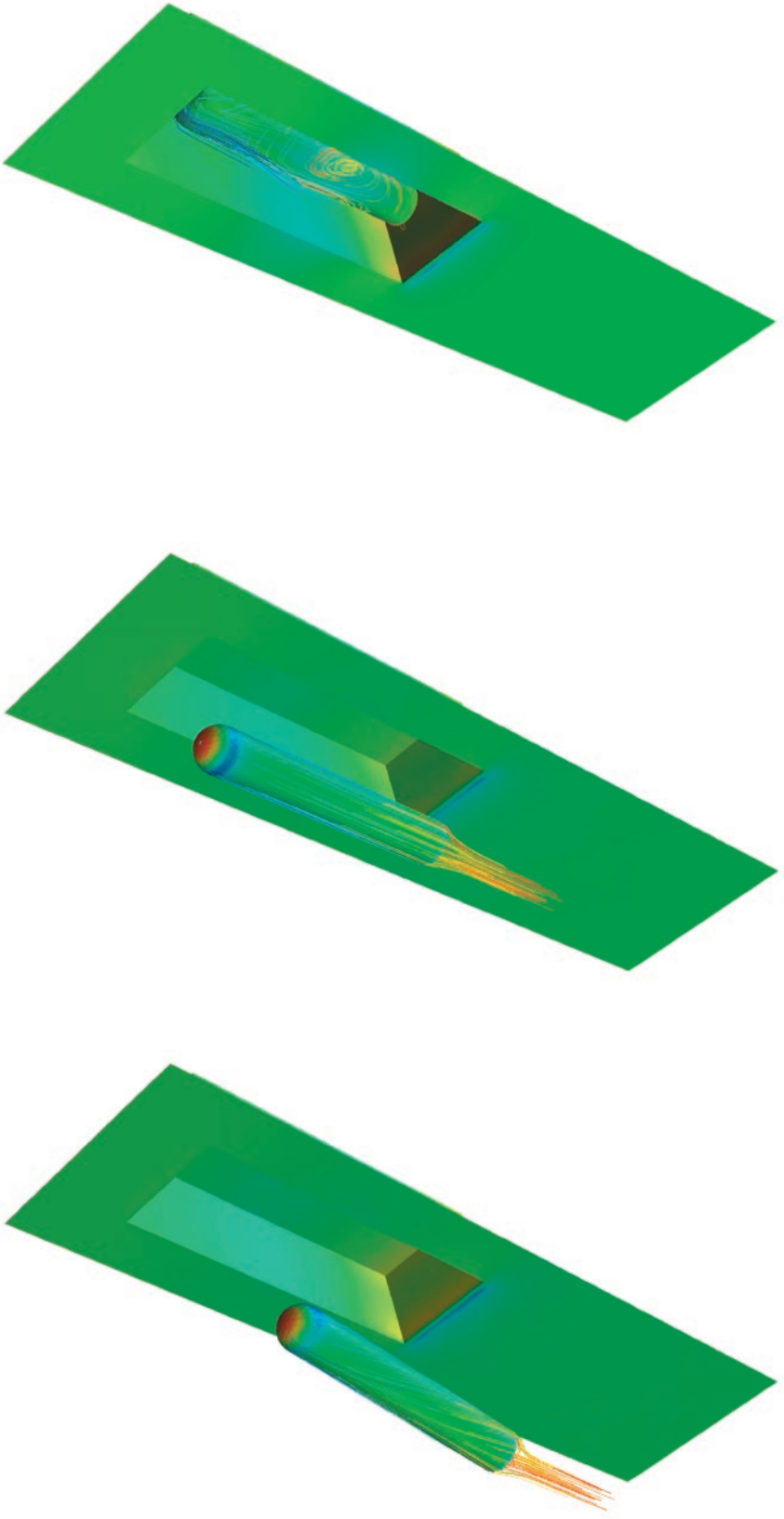
One of the most challenging problems in aerospace engineering, especially for military vehicles, is the analysis of a store (a weapon, fuel tank, or electronic countermeasures device, for example) that is released from a high-speed aircraft. Store separation analysis typically includes such things as a calculation of the trajectory, the identification of safe separation zones, an assessment of aerodynamic interference, and making sure that collisions are avoided. For multiple separations, typical of cluster bombs for example, the analysis could also include the dispersion characteristics of the weapon, so that the munitions cover the biggest possible area upon impact with the ground.

For many years, physical testing using the actual aircraft and device has been the only method for performing store separation analysis. The cost and risks associated with such tests can be high, however, especially during parametric studies. The dynamic mesh model in FLUENT now provides a safer, more cost-effective solution to the analysis needs of aerospace companies involved in this kind of application.

The basic characteristic of store separation analysis is the presence of a body that moves in the computational domain as a result of its interaction with the computed flow field. This means that in addition to the need for a dynamic mesh, tools are also required that determine the body movement based on the local flow conditions. These tools need to accurately compute the aerodynamic forces on the body, and determine the dynamic response of the body to these forces. A trajectory calculation is performed to integrate the forces and moments on the body, and provide an accurate position of the body as a function of time.

The most challenging of these tasks, by far, is the mesh handling. The geometric complexity of modern aircraft and the stores, which may be outfitted with fins, guidance devices or release mechanisms, necessitates the use of complex meshes, comprised mostly of tetrahedral elements. The remeshing schemes need to be robust and deliver high quality meshes that can be relied upon for accurate aerodynamic load predictions at each time step. Since thousands of time steps may be needed for an accurate analysis, depending on such factors as the release speed or aircraft speed, the mesh handling also needs to be done in a time-efficient manner.

For the store separation simulation shown at left, a user-defined function (UDF) is used to compute the



aerodynamic load and trajectory of the store at each time step, based on the local flow conditions. The UDF is a full force and moment calculation that allows for six degrees of freedom. User inputs include the basic characteristics of the store, such as the location of the center of gravity, the store mass, and components of the moment of inertia tensor. Once the new location and orientation of the store is computed, a new mesh is constructed using a combination of the spring smoothing and local remeshing algorithms.

Sizing functions, introduced in the latest version of GAMBIT, are used in these algorithms to produce an optimum mesh distribution. Other quality controls include user-specified limits on the mesh skewness and cell volume. When complemented with the full suite of postprocessing tools in FLUENT, including animations, the dynamic mesh model can offer a clear picture of the store trajectory and identify potential problems before or even without an actual flight test. ■

Pressure contours and pathlines on a generic store being released from an aircraft bay at a Mach number of 0.7 at three times