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An advanced fluid-structure interaction approach for wing-body configuration

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Summary

As analysis methods for the individual CFD (Computational Fluid Dynamics) and FEM (Finite Element Method) analyses are matured, many researches are going on recently and several commercial software are available and ready to use, but the application of the method is limited to the specific or relatively simple geometry. When the configuration geometry is complex or operating conditions are difficult to impose, the meshing and re-meshing process between aerodynamic analysis and FEM analysis is not an easy task and commercial software have limitations to be applied to the specific problems.

Therefore, in this study, the aerodynamics-structure coupled analysis for the conceptual baseline configuration of Very Light Jet aircraft will be investigated through the use of CFD-FEM interaction. A volume spline interpolation algorithm for data transfer between non-coincide fluid-structure meshes is developed and applied to in-house AADL-3D aerodynamic solver and NASTRAN structural solver. The algorithm is suitable for applications of fluid-structure interaction and other high-fidelity multidisciplinary analysis and optimization. The algorithm provides fast and accurate transfer of scalar or vector field data between non-coincide surface meshes. This paper contains a complete formulation of the algorithm with verification to the air-launched rocket FSI (Fluid-Structure Interaction) analysis. A comparison of the data transfer between coincide CFD, FEM mesh and non-coincide CFD; FEM meshes shows that the developed FSI process provides good accuracy. Hence, this is a potential approach for FSI analysis applications. Based on this approach with the help of the re-meshing procedure, a numerical investigation is performed for FSI analysis of Wing-Body configuration of Very Light Jet aircraft. The FSI convergent solution has been obtained and the maximum total displacement of the wing at equilibrium state is as 2.19 feet after seven FSI iterations.

The sequential FSI analysis is performed in this paper. AADL-3D solver is solved first, and then NASTRAN solver receives force distribution of interface between fluid and solid. Structure analysis is executed and transfers displacement to fluid domain. This process is repeated many iterations as Fig. 1 until getting the convergent solution at the interface.

The result of the integrated analysis will be compared with rigid geometry of the wing-body configuration and the effect of the deformation will be addressed as

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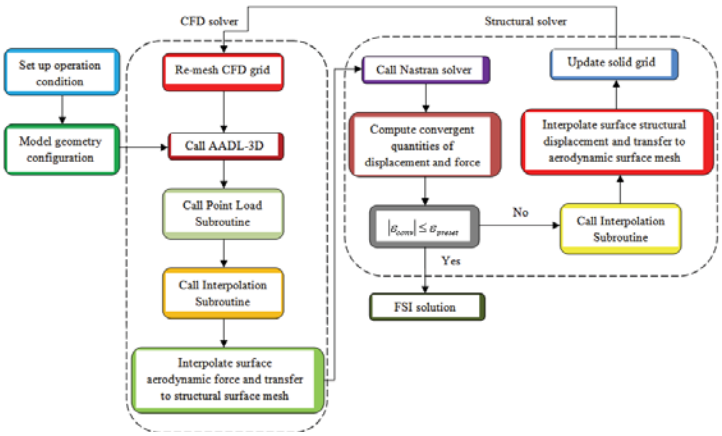

Figure 1: Coupled Analysis Process

shown in Fig.2.

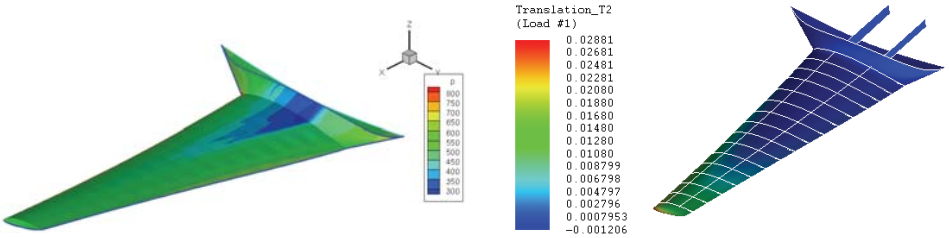

Figure 2: Pressure and Deformation distribution