

Non-intrusive implicit/implicit coupling & ABAQUS co-simulation

S. Guinard¹, O. Bettinotti², J.-C. Passieux³, and R. Bouclier⁴

¹*Airbus SAS*

²*Dassault Systèmes, SIMULIA*

³*Institut Clément Ader, Université de Toulouse, INSA-UPS-Mines d'Albi-ISAE-CNRS*

⁴*Institut de Mathématiques de Toulouse, Université de Toulouse, INSA-Toulouse*

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Abstract

Non-Intrusive Coupling Techniques (NICT) open the field to a variety of new analysis capabilities (non-intrusive domain decomposition [1], coupling of determinist to stochastic analysis [2], 2D-1D to 3D [3]). In particular, NICT may meet the challenges of industrial multi-scale analysis of large aero-structures: it allows investigating local structural non-linearities, while avoiding any human intervention on existing global models. This is a significant step beyond when compared to existing numerical technologies, which may already afford the coupling of different structural models (sub-modeling), but remain penalizing in terms of operability; or which are valid only within limited domains where local non-linearities do not affect the global behavior significantly.

Significant industrialization efforts and dissemination towards AIRBUS stress analysis community will be reported here: implementation of NICT as a global to local, implicit to implicit coupling engine into ABAQUS was managed, relying on co-simulation and adapted meshing strategy. Specific needs of civil aircraft structural engineering have been addressed: global shell to local solid modeling, linear orthotropic elasticity at global scale to damage and failure of composite materials at local scale. Attention was paid to consider models actually representative of day-to-day stress analysis exercises, which involve geometrical complexity, large number of dofs, mixture of element types (shell, connectors & solid), assembly of parts through imposed kinematical constraints. Critical sources of local non-linearity have been considered in local models: contact, damage and failure of composites, captured through adapted solid meshes (discretization at meso-constituents scale, plies & interfaces) and relevant constitutive models.

The advent of NICT capabilities into FEM industrial software lays the path to future evolution of industrial design & certification processes. State-of-the-art series of models, from global rough representations to local critical details, are usually processed through top-down analysis paths, with restrained capability of bottom-up updates: outcomes from detail simulations are not leveraged properly at global level. Both local and global models could now be processed jointly, bridging different levels of abstraction together, and enabling real-time forwards and backwards analysis. Such intended "*multi-level structural analysis process*" will be exemplified by re-exploring design & sizing exercises practiced on representative aero-structures.

References

- [1] M. Duval, J.-C. Passieux, M. Salaün, and S. Guinard. Non-intrusive coupling: Recent advances and scalable nonlinear domain decomposition. *Archives of Computational Methods in Engineering*, 23(1):17–38, 2016.
- [2] A. Nouy, F. Pled, and M. Chevreuril. A multiscale method for semi-linear elliptic equations with local uncertainties and non-linearities. *Submitted*, 2017.
- [3] G. Guguin, O. Allix, P. Gosselet, and S. Guinard. On the computation of plate assemblies using realistic 3D joint model: a non-intrusive approach. *Advanced Modeling and Simulation in Engineering Sciences*, 3(16), 2016.