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Aerodynamic Optimization of Aircraft Configurations with Multidisciplinary Aspects

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ABSTRACT

Aircraft design is nowadays characterized by the demand of the collaboration of multiple disciplines considerations in order to provide products optimized in all their different aspects with multipoint requirements in performance and manoeuvrability. High-level methods allow the simulation of flight performance considering the essential aspects of aerodynamics, flight mechanics and structures. Modern process control helps to probe the disciplinary and multidisciplinary design sensitivities regarding mission and design constraints and provide guidance in shaping and sizing into a well optimized vehicle-system design.

Current work in the use of optimization techniques and the appropriate processes in 3-D aircraft designs will be presented. The use of an automatic optimization control environment (ModeFrontier) will be presented for different examples. This environment has been used to automatically obtain the parameterized CAD model (CATIA5), a robust automatic numerical mesh generation (Mesher), the automatic flow simulation control and monitoring (DLR-Tau, SimServer) as well as the treatment and combination of the results into the design objectives in order to find an optimized design (fig. 2).

Various optimization methods are applied. Evolutionary genetic algorithm and evolutionary strategies as well as the well known Simplex-procedure were utilized successfully for 3-D wing and aircraft configurations. For 3-D wing design an adjoint methodology was used to provide the sensitivities for a gradient method based on the SQP algorithm, thereby reducing the impact of many optimization parameters for the aerodynamic design optimization. Those parameters describe airfoil shape, camber, thickness, wing span and aspect ratio, twist, planform-shape, flight control shape and trimm-setting as well as flow condition effects (angle-of-attack) to be varied.

Aircraft optimizations also address the inclusion of other disciplinary considerations such as structures, weight and controls as well as the possible impact of design limitations. A process to automatically build a CAD wing structure, its provisions of a FEM-mesh for structural analysis including aerodynamic and inertia loads will be

described and discussed (fig. 3).

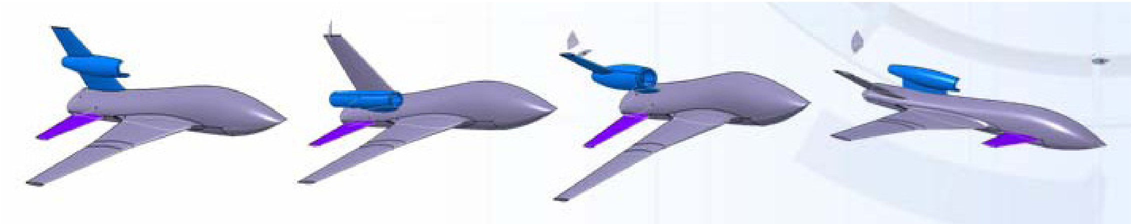

Fig. 1: Example of aircraft configurations out of a parameterized CATIA V5 model.

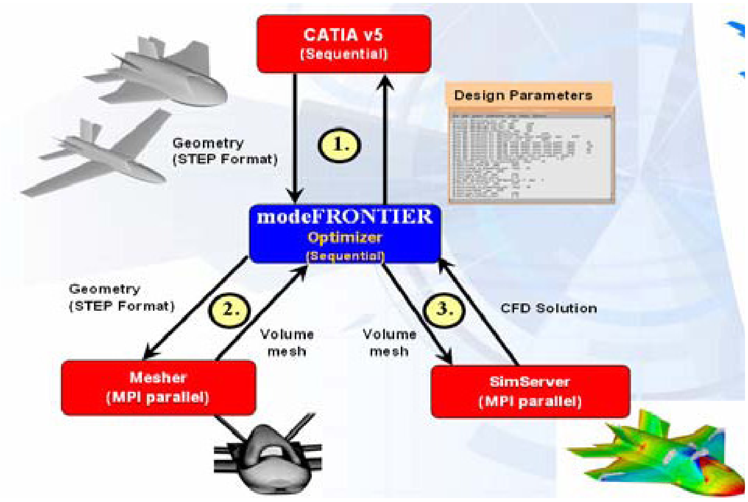

Fig. 2: Connections among the control process tool and the other software.

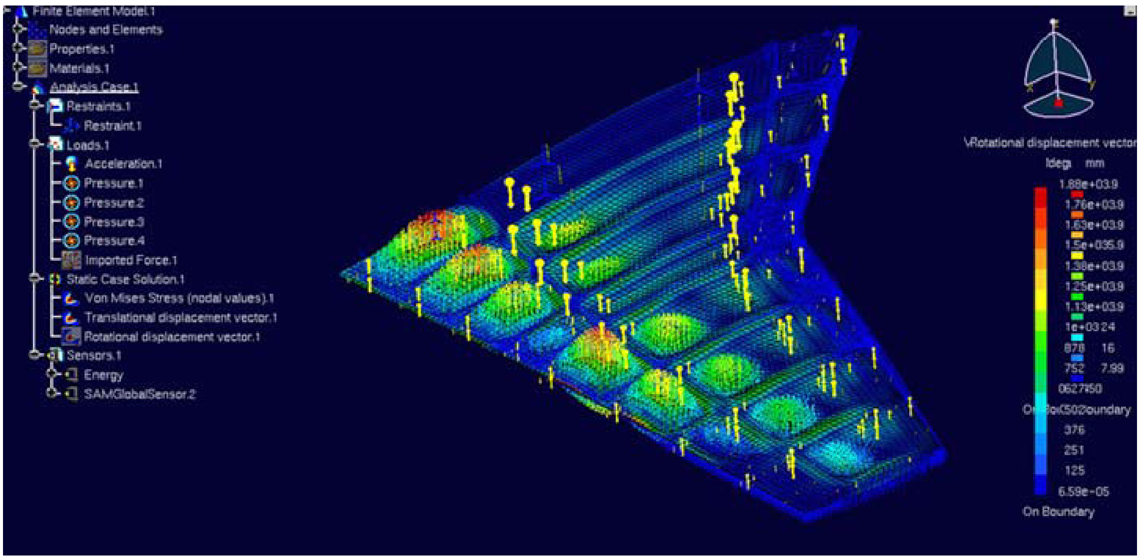

Fig 3: Visualization of aerodynamic and inertia loads on an aircraft wing during a multidisciplinary optimization and sizing process.