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ABSTRACT:

Multi-Winglets: Multiobjective Optimization of Aerodynamic Shapes

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Various configurations of aircraft wing tip devices have been investigated by performing 3D aerodynamics analysis. The wing tip device in this study was derived from the wing tips of a soaring bird, featuring three smoothely blended elements. Each winglet configuration was integrated into a complete wing-tail-body aircraft configuration. The entire winglet element was defined using 10 parameters, totaling to 30 parameters for the three elements used to define each complete winglet geometry. The current design methodology utilizes a second order, 3D geometry generation algorithm based on locally analytical surface patches. It works on the basis of piecewise composition of analytical functions, defined in 3D space, with the user having complete control over each section. This algorithm allows for creation of vastly diverse 3D geometries with minimal number of specified design parameters. A 3D, compressible, turbulent flow, steady state analysis was performed using a Navier-Stokes solver on each configuration to obtain the objective function values. Each configuration was analyzed at a free stream Mach number of 0.25 and at an angle of attack of 11 degrees to mimic the takeoff conditions of a passenger aircraft. Multi-objective optimization was carried out using modeFRONTIER utilizing a radial basis function based response surface approximation coupled with a genetic algorithm. Maximizing coefficients of lift and lift-to-drag ratio, while minimizing coefficients of drag and the magnitude of the coefficient of moment were the four simultaneous objectives.