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Use of Integral Boundary Layer Methods for Separated Flow and Thoughts on Fidelity in CFD

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Abstract: In the 1980's, a great deal of work focused on interactive boundary layer methods coupled with inviscid flow solvers. One of the best of these methods was developed by Prof. Mark Drela of MIT. At Boeing, we developed the TRANAIR code by coupling a solution adaptive full potential solver to Drela's strip integral boundary layer with various three dimensional corrections. However, research in the field of aerodynamic CFD has focused almost exclusively on Reynolds Averaged Navier Stokes (RANS) starting around 1992. The primary motivation seems to be the idea that current RANS turbulence models offer a predictive capability for general geometries not offered by older methods.

In this talk, we will discuss extension of TRANAIR to separated flows and show why these methods deserve a second look by comparing the results to RANS codes and to test data. Two dimensional results and some preliminary three dimensional results indicate that good results can be obtained even for large separation bubbles. In addition, computing times are orders of magnitude less than competing RANS methods, a key requirement for many multidisciplinary applications. We will also discuss some of the weaknesses of steady state RANS simulations, including the existence of multiple solutions, the role of time dependent flow phenomena such as vortex shedding, and the long continuing struggle to successfully implement solution adaptive grid refinement in these methods. We will also discuss the positive results bias that is being increasingly recognized in modern scientific research and its influence in CFD.

Finally, we will discuss some extensions of the integral boundary layer methodology that can perhaps address some of the weaknesses of TRANAIR.

Keywords: Integral boundary layer, computational fluid dynamics, separated flows, multiple solutions, nonlinear systems.

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