A FRONTIER OF PARALLEL CFD: REAL-TIME IN-FLIGHT ICING SIMULATION OVER COMPLETE AIRCRAFT

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With the power of supercomputers increasing exponentially, there is an insatiable need for more advanced multi-disciplinary aerospace CFD simulations. A particular current interest is the 3D viscous turbulent simulation of the highly nonlinear aspects of aero-icing. The applications of CFD in that field are literally light-years behind aerodynamics, with a significant number of users still mired in correlations, or 2D, inviscid, incompressible, and, yes, Panel Methods simulations! Thus, the disparity of tools between aerodynamics and icing departments within an organization leads to a disconnect that makes ice protection a downstream isolated process that is not an integral part of the aerodynamic behavior of an aerospace system (aircraft, rotorcraft, jet engine, UAV, etc.). While 3D RANS has been recently introduced, it is still considered computationally too demanding for industry when wide parametric studies for certification are required. In addition, not unlike the situation in aerodynamics say 20 years ago, naysayers are at every corner claiming that CFD is not reliable and is of limited use.

In order to make such compute-intensive simulations more affordable, credible and eventually carried out in real-time, 3 important steps will be presented:

1. The formulation of the icing problem as a truly unsteady phenomenon, and the derivation of new Navier-Stokes-like equations for each of its 5 successive facets: CFD of clean aircraft, droplet impingement, ice accretion, anti- and de-icing, and CFD of iced aircraft,

2. The elimination of many long time empiricisms, via CFD,

3. The formulation of Reduced Order Models to extract information from a limited number of high fidelity runs, in order to form a more complete database for certification verification and for flight simulation.