March 16th LECTURE

Towards Real-Time CFD Simulation of In-Flight Icing

Professor Wagdi G. Habashi
Director CFD Laboratory, McGill University, Montreal, Canada and President CERTIF-ICE Inc.

Abstract

Despite the concerted efforts of manufacturers and certification agencies, incidents and accidents continue to happen to aircraft certificated to "Fly Into Known Icing", falsely thought of as being "immune to in-flight icing". The current successive process of CFD for ice shape prediction, then icing tunnel testing (experimental fluid dynamics- EFD), and finally flying in natural ice conditions (flight fluid dynamics-EFD), has many gaps that can only be filled by modern CFD.

By developing compatible CFD tools able to simulate both the aerodynamics and icing in a concurrent engineering way, and by viewing the aircraft as a system and not as disjoint components, it will be shown how CFD, EFD and can be combined in a rigorous mathematical way to carry out a much faster, more complete and more thorough evaluation of the aircraft's FIKI and result in a much safer aircraft.

The Seminar will cover aspects of physical and mathematical modeling (impingement, accretion, de-icing, anti-icing, conjugate heat transfer, turbulence modeling), CFD (FEM, FVM, automatic mesh optimization) and the

actual certification campaign of China's first regional Jet, the ARJ21.

The seminar will particularly focus on a reduced-order modeling (ROM) framework inching toward the calculation, via RANS, of the aerodynamics + water impingement + ice accretion + performance degradation, in real-time. The ROM methodology is based on Proper Orthogonal Decomposition, multi-dimensional interpolation and machine learning algorithms, along with an error driven iterative sampling method, to adaptively select an optimal set of snapshots. The methodology is applied for the first time to a "full aircraft" and to the "entire" icing certification envelope, providing invaluable additional data to the limited ones from icing tunnels or natural flight-testing. The level of accuracy achieved strongly supports the drive to incorporate more CFD information into in-flight icing certification and pilot training programs, leading to increased aviation safety.

Short Bio

Wagdi (Fred) Habashi is a Professor of Mechanical Engineering at McGill University in Montreal. He holds Bachelor and Masters degrees in Mechanical Engineering from McGill and a Ph.D. in Aerospace Engineering from Cornell.

He has taught for 2 years at the Stevens Institute of Technology in New Jersey and for 25 years at Concordia University in Montreal, before coming to McGill, where he holds the NSERC-Bombardier-Bell Helicopter-CAE Industrial Research Chair for Multi-disciplinary CFD.

Dr. Habashi is the founder of two successful spin-off companies. He is President and Chief Scientific Officer of Newmerical Technologies International developing software and providing services for multi-disciplinary applications of Computational Fluid Dynamics www.newmerical.com, TVE: CFD. He is co- founder with Captain Gary Wagner, and Chairman, of Scientific Aircraft Accident Analysis (SA3)

www.sacubed.com, using science as a forensic tool in aircraft accident investigation such for the Embraer crash over Monroe, MI and the Concorde in Paris.