Proceedings of the 7th International Conference of Fluid Flow, Heat and Mass Transfer (FFHMT'20)
Niagara Falls, Canada – June, 2020
DOI: TBA

Reduced Order Modeling: the Road to Parametric Explorations and Optimization in CFD and CHT

Dr. Wagdi G. Habashi
Professor, Department of Mechanical Engineering, and
Director, Computational Fluid Dynamics Laboratory
McGill University
Montreal, Quebec, Canada
wagdi.habashi@mcgill.ca

Many areas of computational fluid dynamics (CFD) and computational heat transfer (CHT) require large samplings in order to perform parametric explorations or for optimization. This is very demanding to do in 3D and even more so for multidisciplinary problems involving both CFD and CHT.

Nowhere is this problematic more apparent as in the in-flight icing problem, involving studies of external aerodynamics, internal aerodynamics, conjugate heat transfer, phase change, coupled problems, and finally component optimization.

While keeping the approach general and applicable to a wide variety of problems, the Keynote Lecture will use in-flight icing as an application example.

The Keynote Lecture will review aspects of modern CFD-Aero and CFD-Icing that enable straddling the analysis, design, testing and certification processes, via a Reduced Order Modeling (ROM) framework capable of calculating 3D viscous turbulent aerodynamics + water impingement + ice accretion (heat transfer with phase change) + performance degradation, in real-time: in 1/100th of a second!

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 will be demonstrated on "full aircraft" through the "entire" icing certification envelope, providing invaluable additional data to the limited ones from icing tunnels or natural flight-testing. Examples of optimization of hot air (most commercial aircraft flying today) and electrical (Boeing 787) ice protection systems will be given.

"Gappy-ROM" will be demonstrated for using ROM in enriching fluid and heat transfer experimental data and reducing test models' complexity.

ROM paves the way for small organizations with no in-house CFD or CHT specialists, and no supercomputers, to analyze and optimize components with data as rich as any major OEM.