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ADVANCES IN FENSAP-ICE FOR SIMULATION OF AIRCRAFT, ROTORCRAFT, UAVs AND JET ENGINES IN-FLIGHT ICING

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ABSTRACT

The paper highlights the recent advances in FENSAP-ICE, a complete 3-D standalone in-flight icing simulation system. These advances concern its extension to a full three-dimensional aircraft, helicopter, unmanned aerial vehicle and jet engine icing simulation system, in a steady, unsteady, or mixed (adjacent moving and stationary components)

Traditionally, very few rotorcraft have been equipped and certified for flight into known icing. Most helicopters have operational limitations, which allow flight into inadvertent icing only, with demonstrated safe flight capabilities to exit icing conditions or to safely land. However, the advent of tiltrotor technology and the requirement for more helicopters with full icing capabilities has created a need for affordable all-weather operations. One of the major contributing factor to bring development costs down is to develop new in-flight icing prediction methods applicable to helicopters and tiltrotors or improve on existing ones. Such second-generation icing simulation technology must be synchronous with general advances in CFD, accurate, upgradeable and capable of handling complex three-dimensional geometries. While undoubtedly aircraft and engine icing analysis can be complex, nothing approaches the complexities of helicopter icing in terms of geometries, attitudes, propeller/rotor interaction, engine intakes (side entrance, front entrance), etc.

In addition, a number of unmanned aerial vehicles are currently in development worldwide with wide-ranging size, payload, and mission profile as well as command and control capabilities. Due to their lower cruising altitudes and smaller excess power margins, propeller-driven unmanned aerial vehicles are particularly vulnerable to in-flight icing. Even high-altitude cruising turbine-powered UAVs can be exposed to icing conditions for long periods because their relatively low climb rates require longer times to cross critical icing altitudes. Lessons learned in operation include unforeseen mid-level icing encounters, which cause heated pitot tubes to freeze and therefore send the UAV computer erroneous flight information. This confirms the well-known fact that besides performance degradation due to loss of lift, drag and weight increase and change of handling qualities; in-flight icing can affect performance of an aerial system in a number of ways. To minimize probability of hull loss of UAVs due to icing, several recent designs have incorporated active ice protection such as freezing point depressants, electro-thermal or electro-expulsive systems.

Glaciated or mixed-phase environments, relating to the presence of ice particles at high altitudes have been identified as an adverse condition for turbofan engines on both commuter aircraft and, resulting in power loss and component damage due to the ingestion of these particles. Currently, powerplant numerical icing studies are mostly limited to static parts, as modeling rotating components adds another layer of complexity to an already very challenging process. It will be shown how FENSAP-ICE is able to solve ice accretion on rotating components, even as a complete rotor-stator stage.

Finally, recent accidents have clearly demonstrated the damaging impact of Supercooled Large Droplets and large efforts is expended on extending in-flight icing codes to model the splashing, breakup and formation of such large droplets when they hit the aircraft surfaces, resulting in very different ice depositions and requiring changes in the ice protection system design. Advances of FENSAP-ICE in that arena will be demonstrated.

The paper will also present results of flow, droplet impingement and ice accretion on a variety of geometries for aircraft, helicopters, UAVs and engines.