Damage Tolerance Testing and Analysis Protocols for Full-Scale Composite Airframe Structures under Repeated Loading

Waruna P. Seneviratne, *Ph.D.* - National Institute for Aviation Research, Wichita State University
John S. Tomblin, *Ph.D.* - National Institute for Aviation Research, Wichita State University

ABSTRACT

Fluid-ingression phenomenon in composite structures is a concern for sandwich structural details. Inadequate design details and/or poor material selections can result in microcracks during ground-air-ground (GAG) cycling that consequently coalesce to form transverse matrix cracks that lead to moisture ingression into the subsequent composite and adhesive layers and finally into the core. Impact damages on sandwich structures exacerbate the fluid-ingression phenomenon as a result of localized transverse cracks, delaminations, disbonds, and core damages. Thermo-mechanical loads during GAG cycling could cause the local buckling on compression side of a sandwich structure that result in localized mode I stresses that may result in further delamination/disbond growth creating more passageways for fluid migration. Additionally, the trapped water in sandwich cells translate into vapor during high temperatures and increase the internal pressure and cause core disbond and/or fracture. In some cases, the damage growth due to the above-mentioned two mechanisms is stable and occurs over a period of several flights, but may not be readily detected on the ground, when the thermo-mechanical and internal vapor pressure loads are released. Although the damage size continues to grow in such cases, the structure continues to carry loads until it reaches a critical damage threshold (CDT), where the unstable damage growth triggers the catastrophic failure. Unless such damage is detected and repaired prior to the reaching CDT, GAG effects will further the damage size and threaten the structural integrity and safety of the aircraft. The influence of sandwich parameters such as core size, density, and facesheet/core stiffness ratio on the onset and damage growth rate of sandwich composites will be investigated using double-cantilever beam static and fatigue testing for Mode I fracture toughness of core-facesheet disbond. In order to investigate the influence of fluid ingression and entrapped fluids in sandwich structures, test specimens will be conditioned in a hydraulic oil (Skydrol) and water mixture.