Certification of Composite-Metal Hybrid Structures

Waruna Seneviratne and John Tomblin
Wichita State University
Wichita, Kansas

ABSTRACT

The primary goal in a damage-tolerance certification program is to avoid catastrophic failure due to fatigue, corrosion, or accidental damage throughout the operational life of the aircraft. The damage-tolerance philosophy is well established for metallic airframes, where proven methods (structural analysis and inspection procedures) and supporting databases exist to detect damage and predict crack growth and residual strength. Damage growth mechanics and load spectra for composite and metal structures have significant differences that make the certification of composite-metal hybrid structures challenging, costly and time consuming. Several test substantiation approaches such as two separate full-scale test articles—one focusing metal certification and the other focusing composites certification, or address concerns related to composite components at lower level of building-blocks of testing (i.e., pre-production article) and focus the certification of metallic components in full-scale level can be used for certification of hybrid structures. Often composite structural certification uses load-enhancement factor(s) to reduce the test duration. In certain cases, this causes the enhanced load spectrum to have loads beyond the clipping level of metal structural details. A technique called a multi-LEF is introduced so that different combinations of life-load factors can be used for different parts of the spectrum so that the high loads (that potentially can go beyond clipping level after LEF application) can have a higher life factor and a lower or no LEF. Second concept called Load-Life Shift (LLS) is introduced so that a single test article can be used to substantiate both metal and composites as a two-phase certification methodology with different LEFs, i.e., first phase with LEF=1 for metal and second phase LEF>1 for composite to reduce the required test duration. The LLS approach provides a mechanism to obtain credit for the loads applied during first phase (focusing metal) so that the composite certification phase can be reduced. The application of LLS approach requires the use of differed spectrum in order to prevent metal crack growth retardation. A series of sequencing studies were employed to understand the implications of spectrum modifications to overall damage growth mechanism for both composite and metallic structure. The goal of the program is to provide an efficient certification approach that weighs both the economic aspects of certification and the time frame required for certification testing, while ensuring that safety is the key priority.