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CECAM featured project

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

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Overview:

Advanced composites have emerged as the structural materials of choice for many aerospace applications because of their superior specific strength and specific stiffness properties. First developed for military applications, composites now play a significant role in a wide range of current generation aviation structures. The large commercial transport aviation industry has seen a significant increase in use of composite materials during the past 25 years, and many advances have been made in general aviation and rotorcraft vehicles where composites are used for primary-structure applications.

Over the past ten years, general aviation and the small aircraft industry have steadily increased the number of applications of advanced composite materials in primary and secondary airframe structures. Today's certified aircraft utilize composite materials as the primary structural material in both the wing and fuselage (pressurized and nonpressurized). These activities have produced many FAA policies that advanced certification and guidance documentation substantially.

As these composite aircraft applications increase, more efficient methodologies are needed to certify these composite airframe structures. The main objective of certification is to test the performance of the aircraft over its intended life and to demonstrate airworthiness and safety of the design. This program assesses current structural testing protocols involved in the certification of composite airframe structures. This project is intended to provide guidance including a "best practice" approach to these tests along with a series of verification on full-scale composite airframe structures.

Objective:

The primary objective is to investigate acceptable means of compliance for fatigue, damage tolerance and static substantiation of composite airframes structures. Secondary objectives are:

(a) to evaluate existing analysis methods and building block approach needs for composite airframe structural substantiation.

(b) to investigate realistic service damage scenarios, inspection procedures, and repair procedures suitable for field practice.

In general, composite materials exhibit superior fatigue performance and excellent corrosion resistance relative to metals. However, special considerations must be applied in the fatigue/damage tolerance design due to the increased scatter in both strength and fatigue life. This program will evaluate various approaches for the certification of the structures and investigate methodologies for newer material forms. The program is supported by a number of aircraft companies, which have certified composite aircraft or currently are in the certification process.

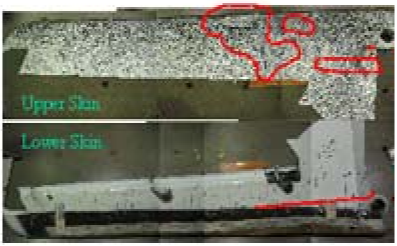
The research methodology used in this program will consist of combining existing certification approaches utilized by various aircraft manufacturers with protocol for applying these methodologies. This will allow extension of the methodologies to new material systems and construction techniques. Because these tests are usually the most expensive performed during the certification process, 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.

The program will involve a number of full-scale demonstration test articles to provide background and examples for the resulting guidance. Because the program is to supply the industry with as much information as possible, partnerships were developed in support of this program. Two aircraft models will be used as typical composite airframe structure: the Beechcraft Starship and Liberty Aerospace XL2 aircraft.

The Beechcraft Starship (left) and the Liberty XL2.

Expected Outcomes:

1. Guidelines defining various approaches for the certification of composite airframe structures. This document will include full-scale test results and analysis guidance.
2. Test results for several full-scale tests, with supporting coupon and element testing will support the approaches outlined. These will provide details of the generation of Weibull shape parameters for obtaining load enhancement factors through various fitting models for composite material fatigue data.
3. Identification of acceptable means of compliance and associated technical issues for demonstration of fatigue, damage tolerance and static strength substantiation of composite airframe structures
4. Identify procedures to use analysis in support of certification and demonstrate how it can be used with the building block process.



A composite wing installed in a text fixture at NIAR's Full-Scale Structural Testing Lab (left) and highlighted damage to the structure after testing.

For more information about the Center for Advanced Materials Performance at Wichita State University's National Institute for Aviation Research visit the website.