An Analysis Approach Toward FAA Certification For Damage Tolerance Of Aircraft Components

Challenge

FAA airworthiness certification and supplemental type certification ensure the safety of aircraft and aircraft components, while controlling the modification and upgrade of those products from their original design. Durability and Damage Tolerance (D&DT) evaluation of an aircraft component requires assessment of damage initiation and fatigue crack propagation under service loading, which may be achieved by experimental examination or a combination of reduced testing and numerical simulation. In this study, a general aviation pressurized fuselage skin with an exterior functional antenna supported by an interior backing plate (doubler) experienced multiple cracks that formed on the fuselage exterior surface under the antenna mounting base after a standard period of operation. In order for the aircraft to retain certification without the need for repair, the antenna mount assembly must demonstrate damage tolerance for its designed service life; such as, one crack dominating the fracturing process thereby providing a mechanism for scheduled inspections and potential confirmation that fatigue damage, at design operational life would not exceed static safety requirements.

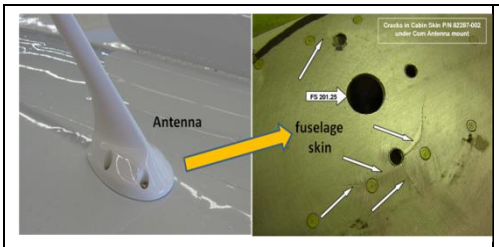

Figure 1. Fuselage skin and antenna with cracks

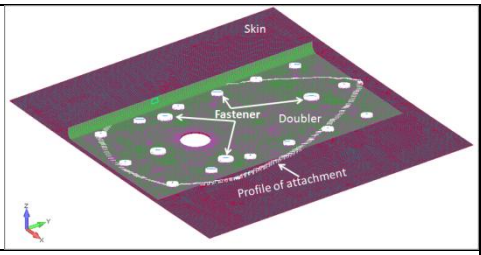

Figure 2. Assembly: Fuselage skin and doubler

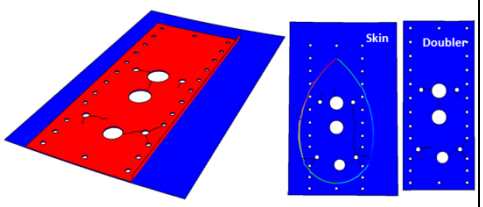

Figure 3. Fatigue cracks formed during operation

Solution

Durability and damage tolerance was performed using VCCT in GENOA with ABAQUS and fracture properties from MCQ Metals. The procedure involved FEA model development with loading and boundary conditions, material modeling, and simulation analysis. Material test data was extended to threshold and accelerated crack growth regimes using MCQ Metals. Loading was due to three sources (i) loads at cut-boundaries of fuselage skin, (ii) loads from attached antenna, and (iii) uniform pressure on skin and doubler due to fuselage pressure. Loads varied from node to node and different operation conditions, i.e., maneuver, gust and

ground-air-ground. Loads were scaled from 1 to 19 in accordance with FAA AC 23-13A/ACE 100-01 and paired with a specific number of loading cycles.

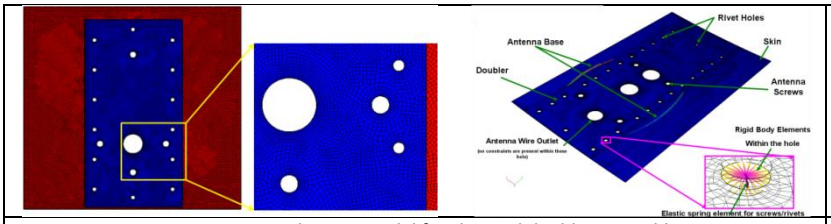

Figure 4. Finite element model for skin and doubler assembly

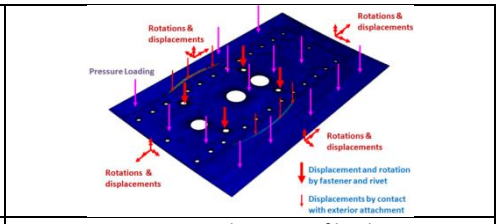

Figure 5. Schematics of load

GENOA MS-PFA with ABAQUS showed qualitatively how cracks would initiate and propagate in the skin and doubler. Overall, damage predicted by analysis showed good agreement in size, direction and location with practice. Concerning durability and damage tolerance, crack paths were embedded in the finite element model as a seam-line of duplicated nodes. Each visible crack had an initial length of one element that was approximately 0.02 inches. Under defined loading, most cracks did not propagate significantly but grew steadily with respect to increase in loading cycles. At 10,000 hours, the maximum crack length was about 0.35 inch. The aircraft component sustained limit load with developed cracks during 10,145 service hours. Accordingly, FAA certificate was retained for damage tolerance under 14CFR 23.571(c) and 23.573(b) per amendments 23-1 through 23-48.

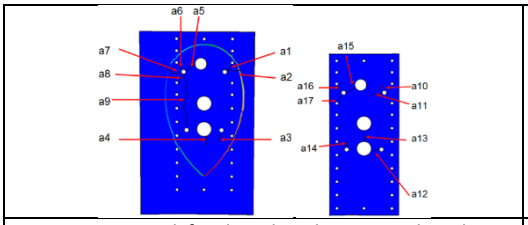

Figure 6. Predefined crack paths in revised mesh

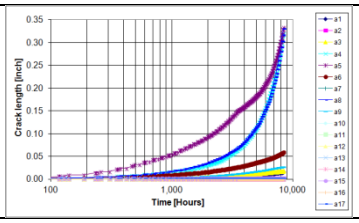

Figure 7. Crack extension versus flight time

Figure 8. FAA Certification

Results/Conclusions/Benefits

- Novel analysis was used to achieve FAA DADT certification for aircraft component.
- New approach reduced conservatism and was validated against tests.
- Methodology has potential in scheduling condition-based inspections.

Key Highlights
Product: MCQ-Metal, GENOA with ABAQUS Solver
Industry: Aerospace
Application: Durability & Damage Tolerance, Cert.
Performance: Crack Propagation Residual Life

Reference

Nikbin, K.; et al; "An Analysis Approach Toward FAA Certification for Damage Tolerance of Aircraft Components", Aeronautical Journal, February 2014, Volume 118; p. 181.