Improvement of fatigue-crack resolution and prediction via DFEM for metallic helicopter airframes

David DAYAN [1], Teddy SEBAG [2], Nicolas GENELOT [3], Sandrine COSTE-ROUTHIAU [4], Laurent GIRARD [5],

[1,2,3]*Airframe Stress Engineer AIRBUS HELICOPTERS Marignane, France*
[4]*Loads compliance verification engineer AIRBUS HELICOPTERS Marignane, France*
[5]*Flight test analysis Engineer AIRBUS HELICOPTERS Marignane, France*

Helicopters structures loadings are various and complex. While sustaining aerodynamic loads, structural parts have to both maintain the aircraft in a stable position and support anti-torque loads from rotating parts.
For example, the upper deck area load path is composed of anti-torque suspension loads, struts loads and airframe modes reactions.
Unfortunately it happens that cracks occur in service-life of metallic helicopter airframes especially due to fatigue loading.
In order to avoid occurrence or re-occurrence of cracks observed in service, the origin of damages must be investigated and deeply understood, in order to define corrective solutions.
Origin of in service fatigue damages are multiple, among the investigated causes the presented analysis will focus on root causes linked to complex load paths, local static and dynamic stress level on critical hot spot and customer's usage spectrum.
A stepwise approach is applied to achieve an accurate prediction of local phenomenon, as described below:

1. Determination of the exact local load path: Identification of the area of interest to be modelled in a Detailed Finite Element Model (DFEM) based on potential crack locations and global load paths.
2. Creation of detailed model: Accurately determine hotspots in complex loaded area.
3. Ground and flight test: Determine test spectrum and instrumentation type and location.
4. DFEM simulation using measured loads from tests: Using main rotor head (MRH) loading, aircraft attitude, and inertial loads on airframe part to apply realistic load on DFEM.
5. Correlation of DFEM: using laboratory and flight test, build confidence in DFEM predictive capabilities.
6. Scenario confirmation: Compare crack initiation time calculation to real cases with accurate analysis of customer's Health and Usage Monitoring Systems (HUMS).

This methodology will be presented in the publication applied on the example of an H225 upper deck area.
Outcomes of this stepwise approach allow definition of an optimised corrective solution or limitations to meet design goals. Some key learnings will be summarized.