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Overview and lessons from recent applications of rework shape optimisation for aircraft structural life extension: 2005 -2015

Manfred Heller[1], Xiaobo Yu[1], and Ron Wescott[1]

[1]Defence Science and Technology Organisation, Victoria, Australia

Abstract

DSTO has developed a fatigue life extension approach, where optimised rework shapes are designed and implemented at critical airframe features for aircraft in-service with the Royal Australian Air Force (RAAF). The shapes are used to remove local fatigue cracks, and at the same time minimise the subsequent stress peaks. These optimal shapes are free-form and are determined using a gradientless FEA method, based on a biological growth analogy. This work is fairly unique since it is a post build improvement and the modifications are generally done in situ with difficult access. The authors have applied this work previously to practical applications and completed and documented many successful benchmarks (WCSMO6 2005). Since 2005 the authors have continued improving the FEA design approaches and manufacturing capability and undertaken a number of further practical applications.

This paper covers aspects of the key challenges identified and resolved from a number of these applications. These include rework shape optimisation of: (i) F-111 upper wing skin access hole, (ii) F/A-18 store launcher housing flanges, (iii) F/A-18 outer wing spar web hole, (iv) F/A-18 inner wing shear attachment lug, and (v) F/A-18 wing centre pylon support assembly fillet. The key challenges addressed for shape design requirements and practical applications include:

(i) Fleet geometry variability and difference to blueprint design at local features
(ii) Uncertainty of local loading, inverse load determination, and robust design
(iii) Optimisation constrained to 2.5D method to match in-situ manufacturing capability
(iv) Mesh reposition quality for iterative 3D analysis cases and secondary stress peaks
(v) Typical manufacturing constraints; i.e. minimum radius of curvature, curvature ‘smoothness’, and access restrictions of machining tools
(vi) Fatigue life management philosophy and proposed NDI method used

Finally we discuss key remaining improvements needed to obtain full technology benefit.