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An Innovative High-Fidelity Approach to Structural Health Monitoring

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ABSTRACT

Structural health management for Defence air platforms is traditionally driven by scheduled inspection intervals and pre-emptive maintenance based on interpretation of structural certification test results or reactive based on unique or unexpected fleet in-service incidents. However, in the current environment of budget constraints and shrinking resources, a major shift towards actionable and proactive condition-based maintenance is required to improve aircraft availability and reduce fleet management and sustainment costs.

Significant improvements in structural life prediction and management can be achieved by implementing an integrated approach to aircraft operation and sustainment. Numerous uncertainty factors and safety margins used in the fatigue life calculation can be minimised or even eliminated by integrating a high-fidelity numerical model of the aircraft with a 'smart' health monitoring system and a comprehensive historical database for each individual aircraft covering its operation, maintenance, upgrades and repairs. Detecting and tracking the global airframe health as well as local structural anomalies caused by fatigue and wear is a crucial component towards the development of a smart structural diagnostics capability to support the sustainment of the current and future aerospace platforms.

This paper describes the progress of a collaborative effort between DSTG and RMIT University in developing a high-fidelity approach to structural health monitoring and individual aircraft tracking inspired by the Aircraft Digital Twin concept. Operational Load Analysis and Asset Diagnostics (aka OPERAND) is a multi-physics analysis suite for structural health monitoring based on integrating current state-of-the-art software techniques, data-driven methods, and model-based approaches. This innovative structural diagnostics and prognostics framework has the potential to considerably improve aircraft fleet airworthiness management, provide substantial savings to aircraft operators and optimise aircraft availability for enhanced operational effectiveness. It aims to enable proactive condition-based aircraft maintenance through high-fidelity airframe fatigue tracking by significantly improving airframe load and stress predictions.

Keywords: data analytics, digital twin, individual aircraft tracking, OPERAND, structural dynamics.