MODEL BASED CORRELATION METHODS FOR FAULTS DETECTION AND IDENTIFICATION ALGORITHMS ON ELECTROMECHANICAL ACTUATORS USED IN PRIMARY FLIGHT CONTROL

Summary

This research examines innovative prognostic "model-based" algorithms able to identify the precursors of aerospace subsystems incipient failures, developed for primary and secondary aircraft flight control systems driven by electromechanical actuators. The proposed simulation model represents a virtual experimental bench on which innovative prognostic techniques are designed, as result of multi-disciplinary engineering analysis based on spectral signal processing. Electromechanical actuators represent the main test article simulated by a high-fidelity dynamical model to approximate primary flight control system behaviour in different operating conditions during multi-failures mode. A detailed simulation framework is developed to compensate, for designing an efficient Prognostics and Health Management study, a poor available experimental data since the electromechanical actuator is limited in onboard aircraft applications to non-safe critical secondary systems. Since the electromechanical actuator and the entire physical behaviour of the transmission a numerical model, to improve accuracy it considers also several non-linear behaviours both mechanical (end runs, back lashes, friction phenomena) and electrical (electrical hysteresis on controller commutation logic and electrical white noise).

During simulated operating conditions, four failure types are integrated in the same time with different degradation paths acting in concurrent mode on the same prognostic precursors. Proposed harmonic analysis approach can produce a big amount of simulation data organized in several "failure maps" database, able to highlight how each degradation path influences the dynamic responses in integration to the others. The main target is developing methodologies, that could be easily integrated on board, able to give a system health state report by comparison with the real-time acquisition system on aircraft during the ground pre-flight test by automatic avionics' system check process, which can be periodically performed.

The comparison between real-time operative experimental data with the off-line simulated failures maps, coming from virtual test bench, ensures with accuracy to establish the health state for electromechanical actuation system driving aerodynamic surfaces of the primary control system.

The outcome benefits to early identify symptoms of progressive degradations before the actual exhibition of anomalous behaviours by defining FDI (fault detection and Identification) numerical model, improve flight safety reducing maintenance costs for this innovative actuator type in future all electric avionics' aircraft philosophy. The conducted study supports the relevance of harmonic analysis performed on prognostic precursors as mean approach to detect, and diagnose sudden unpredictable fault occurrences, before arising anomalous behaviour as clearly supported by the current findings.