MECHANICAL ENGINEERING

MUR DM 117/Leonardo - Development of a prognostics and health management system for aviation industry

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Context of the research activity	The activity of the research program "Development of a prognosis and health management system for the aeronautical industry" deal with the development of an effective and reliable PHM (Prognostics and Health Management) system that allows the introduction of new maintenance approaches in the aeronautical sector. Progetto finanziato nell'ambito del PNRR - DM 117/2023 - CUP E14D23002030004
	PHM is a relatively recent discipline that aims at defining routines capable of predicting the residual useful life (RUL - Remaining Useful Life) of systems and components, allowing to increase flight safety, reduce maintenance costs and optimize operations logistics. The technological trend that we are witnessing in recent years is leading to a greater electrification of aircraft, affecting both propulsion and on-board systems. In particular, the use of electromechanical actuators (EMA - Electromechanical Actuator) for the movement of the primary flight surfaces, replacing the traditional hydraulic or mechanical systems, leads to advantages such as the reduction of the overall weight of the actuation system, the absence of leakage, ease of feeding and control, etc. On the other hand, the introduction of EMAs in the aeronautical field is hampered by the sensitivity to some failure modes that can lead to system jamming, affecting the movement of the flight surface. By monitoring the state of health of the actuator in real time, it is possible to recognize the incipient failure and act accordingly, avoiding the failure. Furthermore, a prediction of when the failure will occur, i.e. of the RUL, obtained with sufficient margin in advance allows to optimize the logistics linked to maintenance activities and, therefore, to reduce costs and AoG (Aircraft on Ground) situations.

Objectives	The purpose of the research activity is to define and develop a PHM system that can be implemented on board an aircraft taking into consideration the characteristic constraints of the aeronautical sector related to the ability to manage and process signals. In particular, high fidelity modeling of electromechanical flight actuators and their main failure modes is required in order to develop ad hoc diagnostic and prognostic routines. It is also required the implementation and comparison of different types of predictive algorithms, such as Particle Filter (PF), Convolutional Neural Networks (CNN), Physics-Informed Neural Networks (PINNs), Long Short-Term Memory (LSTM), Support Vector Regression (SVR), etc. In order to bridge the gap between the preliminary numerical analyzes and the full-scale implementation, the use of a demonstrator (hereinafter iron bird) is required for ground validation of the developed solutions. The iron bird consists of a "real" wing of an aircraft and a "simulated" one. In the real part the electromechanical actuators are installed, controlled by force, which allow the movement of the flight surface, while the virtual half-wing is created through simulations carried out in real time. In order to integrate the operation of the two wings with the rest of the aircraft, these interact with the Flight Control Computer (FCC) which receives inputs from the cockpit and from the Flight Mechanics Simulation Module (FMSM), which has the task of simulating in real time the dynamics of the aircraft, also taking into account the atmospheric conditions. The research activities will be carried out at: the Department of Mechanical and Aerospace Engineering (DIMEAS) of the Politecnico di Torino, in the Leonardo office(s) of the Aircraft Division, mainly at the OGR located in Turin in corso Castelfidardo 22, and abroad in a university or research facility to be defined, for a period of six months. The international experience represents an opportunity for the student to acquire a broader perspective on the subject, to deal with different approaches and to develop new skills. The study and subsequent creation of an effective and reliable PHM system will allow the Company to optimize maintenance and logistic processes, promptly managing any anomalies or breakdowns on board the aircraft and planning maintenance activities with greater precision. This will result in an improvement in aircraft efficiency, in a reduction of operating times/costs and in an overall increase in system reliability, confirming the importance of technological innovation as a ke

Skills and competencies for the development of the activity	simulation, modeling, dynamic analysis of servos, servo systems, PHM algorithms, , mechatronic systems