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Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project:
A probabilistic approach to estimate the remaining useful life of composite structures under fatigue loading utilizing real-time health monitoring data

Principal Investigator:
Dr Theodoros Loutas

Reader-friendly title: Remaining useful life structural prognostics

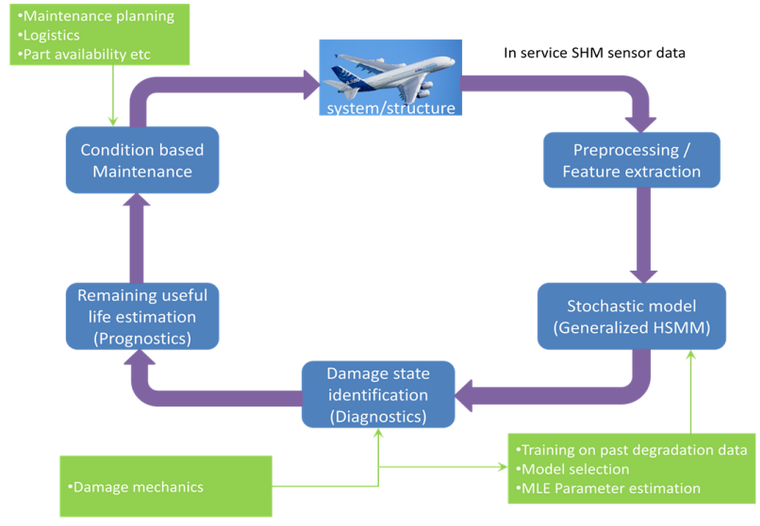
Scientific Area: Mechanical & Aeronautical Engineering

Institution and Country: University, Greece

Host Institution: University of Patras

Collaborating Institution(s): TU Delft, NL

Project webpage (if applicable): http://accelerationproject.upatras.gr/



Budget: 162,706.50 €

Duration: 36 months

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Research Project Synopsis

The objective of ACCELERATION project is to extend the work pioneered recently by the PI and members of the research team in the field of fatigue damage mechanics and structural prognostics of composite materials under fatigue combining probabilistic mathematical models and structural health monitoring (SHM) data. This early work has shown certain potentiality to deal with the problem of remaining useful life estimation in composite structures and through ACCELERATION project the PI with the research team wish to build on this legacy and extend to more complex (than coupons) sub-structures as well propose new more advanced versions of the original mathematical models. Three major objectives of the proposed work are summarized below:

I. Investigate with analytical and numerical models the mechanics of the delamination/disbonding fatigue of composite materials and adhesively bonded elements (especially with stiffness mismatch) towards an adequate explanation of the physical mechanisms that drive delamination/disbonding damage in composites

II. Develop novel prognostic methodologies for the probabilistic estimation of Remaining Useful Life (RUL) utilizing Structural Health Monitoring (SHM) data as well as knowledge gained from the physical models investigated in the previous objective I

III. Validation of the developed prognostic methodologies in representative environment (i.e. stochastic loading) through lab testing on test articles of increasing complexity (two-level building block approach)

Project originality

ACCELERATION project will attempt to pave the roadmap to an ambitious paradigm shift by addressing the challenging problem of condition-based maintenance not from a design point of view but from an in-service operation and a health management one. We propose a novel approach which in its foundation utilizes operational health monitoring data and we shall attempt to hybridize this with knowledge of the physical mechanisms from either analytical or numerical models. We aim to demonstrate the potentiality of Structural Health Monitoring (SHM) coupled with high fidelity numerical models and probabilistic mathematical models to diagnose damage and even beyond to prognose the Remaining Useful Life (RUL) of complex structures with an emphasis on state-of-the-art composite aeronautical structures. Several original elements exist in the research activities taking place in ACCELERATION project. The most representative ones are summarized below:

- Fatigue tests beyond the small test level through a hierarchical building unit approach - Upgrading to representative structures (level-1) and (level-2)
- Combination of Acoustic Emission as well as strain measurements for the proposal of innovative fault indicators
- Extension of the existing probabilistic Hidden Semi Markov prognostic model in two directions to improve its forecasting performance
- Evaluation of the feasibility of SHM data in combination with numerical and probabilistic mathematical models in the direction of fault diagnosis and prognosis

Expected results & Research Project Impact

The major socio-economic impact of the *ACCELERATION* project will be the reinforcement of the competitiveness of Greece's and in a broader sense Europe's industrial sectors requiring new opportunities in the way they maintain infrastructure, machinery or other engineering assets. *ACCELERATION* focuses on aeronautical industry, but the methodologies are applicable in other technological sectors as well. Structural prognostics in wind energy or civil infrastructure are still at its infancy but condition-based maintenance is clearly the future. Machinery prognostics is an essential item of the factory of the future vision where reliable data-driven methodologies such as those developed in *ACCELERATION* project will be indispensable. This is in full alignment with Greece's and European Union's strong focus on innovation as a basis for societal growth and prosperity, as well as the emphasis placed on the R&D impact on job creation, societal growth and investment associated with the creation of a strong industrial base. Medical prognostics is another application where these methodologies may be applied. Greece, despite its size and its relatively small industrial activity, may stay at the forefront of these technologies and continue pioneering this field with the achievements of Greek influential researchers in the country or abroad.

The importance of this funding

The funding from ELIDEK is extremely important for my scientific work and my academic development. It will ensure the continuation of my past research in this field by allowing accurate and unique experiments to be conducted. It will fund promising young engineers on their way to obtaining a doctorate by allowing them to stay in the country. In addition, it will allow me to invite at least 1 postdoctoral researcher from a University abroad to continue his research in Greece. The publications from this project will promote the research I am conducting on the subject of the prediction of the failure of composite materials and the collaboration with TU Delft is expected to reinforce substantially my academic profile as well as the profile of the Department of Mechanical & Aeronautical Engineering of the University of Patras.

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