HORIZON 2020

European industrial doctorate for damage modelling and online detection in aerospace composite structures

Rendicontazione

Informazioni relative al progetto

SAFE-FLY

ID dell'accordo di sovvenzione: 721455

Sito web del progetto

DOI
10.3030/721455

Progetto chiuso

Data della firma CE
22 Luglio 2016

Data di avvio
1 Gennaio 2017

Data di completamento
31 Dicembre 2020

Finanziato da
EXCELLENT SCIENCE - Marie Skłodowska-Curie Actions

Costo totale
€ 789 498,32

Contributo UE
€ 789 498,32

Coordinato da
THE UNIVERSITY OF NOTTINGHAM
United Kingdom

Periodic Reporting for period 2 - SAFE-FLY (European industrial doctorate for damage modelling and online detection in aerospace composite structures)

Periodo di rendicontazione: 2019-01-01 al 2020-12-31

Sintesi del contesto e degli obiettivi generali del progetto

Modern aeronautical structures are increasingly made of composite layered materials due to their well-known benefits. Composite structures however may exhibit a great variety of structural failure scenarios. Delamination, Fibre Breakage, Matrix Cracking and Debonding are the most commonly occurring failure modes. Certain aircraft parts are more susceptible to specific damage types (e.g. the lower part of the fuselage is more vulnerable to buckling induced deformations, while the upper is more susceptible to cracks) and have to be regularly inspected.

There is an urgent and genuine need for development of reliable, accurate and lightweight systems for online structural integrity inspection in modern aeronautical structures. SAFE-FLY aimed to deliver valuable, original technological tools for satisfying the industrial needs by focusing on:
• The development of novel, accurate mathematical descriptions for modelling the failure modes that can occur within composite structural segments.
• Development of novel methodological approaches for identifying damage in composite layered segments by means of ultrasonic guided waves (GWs).

The aim was to achieve faster and more accurate identification of structural failure enabling:
• Increase of the awareness on structural integrity for the pilot and the engineers.
• Increase of the availability of the aircraft.
• Decrease of the inspection related aircraft's cost with simultaneous financial benefits for the operator and/or the passengers.

Lavoro eseguito dall'inizio del progetto fino alla fine del periodo coperto dalla relazione e principali risultati finora ottenuti

The following scientific and technological breakthroughs were achieved that open new directions for the next generation of onboard aerospace health monitoring technologies. Specifically:

ESR1 achieved the following:
1.Development of a novel damage modelling approach to simulate brittle fractures in thin composite plies.
2.Development of an anisotropic 3-parameter cohesive phase-field model for modelling diverse intra-laminar failure modes in composites involving fiber fracture, fiber pullouts, fiber bridging, plastic shear deformation and subsequent cracking of matrix.
3.Development of a fast and efficient surrogate model based on Artificial Neural Network (ANN) to exploit the capability of Artificial Intelligence based approaches in minimizing the computational costs incurred during damage modelling.

ESR2 achieved the following:
1.A novel state of the numerical model was developed to simulate transient wave propagation and damage interaction in one-dimensional composite structures.
2.A state of the art 2D wave propagation model was developed and programmed for wave-damage interaction in flat plate structures.

3.A major upgrade of Aernnova's SHM device, PAMELA, was undertaken where hardware and software modifications were done to enhance its capabilities.

ESR3 achieved the following:
1. Development of a general framework for optimal sensor configuration based on value of information by trading-off information and cost.
2. Development of a methodology for simultaneous optimal actuator and sensor configuration based on (1) a rigorous quantification of modelling uncertainties and (2) a description of the cost of the system using convexification strategies to address the objective function in a highly efficient manner.
3. Development of a multi-level Bayesian inverse problem for (1) time-frequency (TF) model class selection and (2) damage localization along with an efficient algorithm that facilitates the identification of multiple locations of damage within a structure.

It was envisaged that the SAFE-FLY project would have a significant impact in increasing social awareness on modern aircraft safety as well as inspire the new generation of aerospace engineers. To facilitate this, the project had a communication and public engagement strategy to focus on communicating to the public. The following activities were performed:

• The Early Stage Researchers (ESRs) exhibited their work at the Farnborough International Airshow having a stand dedicated to illustrating the SAFE-FLY technologies
• Ten high quality green Open Access publications containing the essential scientific developments of SAFE-FLY were published in peer-reviewed journals for effectively disseminating the research results.
• The ESRs prepared a SAFE-FLY video illustrating the challenge of inspecting damage in a modern aircraft. https://youtu.be/IDwpOSYoqcY
• The work produced by ESRs was presented to high-calibre international conferences also attracting industrial audience interested in Structural Health Monitoring (SHM) as well as in 'numerical modelling of composite structures'
• The scientific and technological developments were communicated to targeted industrial and academic researchers through the SAFE-FLY dedicated Network Short Courses (NSC) organised by UNOTT and AERNNOVA.
• A public-facing SAFE-FLY website has been set up at https://safe-fly.eu/ and a file depository at https://nottingham-repository.worktribe.com/ and http://eprints.nottingham.ac.uk/.
• An open source Matlab code related to optimising the sensing configuration on a structural panel was published in the SoftwareX international journal under the GNU General Public License.
• Presentations were given at UNOTT's Institute for Aerospace Technologies Workshops
• The technological demonstrator (PAMELA), property of Aernnova, was not demonstrated to the public as a physical prototype. This was due to COVID restrictions and the cancellation of the TRA2020 event. There were however multiple demonstrations of the system within reports that the Consortium generated.

All deliverables have been submitted.

All milestones have been achieved.

All recruitment actions have been completed.

Progressi oltre lo stato dell’arte e potenziale impatto previsto (incluso l’impatto socioeconomico e le implicazioni sociali più ampie del progetto fino ad ora)

The future challenges remain and globally are related to:

i) Developing sensing technologies able to detect small amounts of damage. The sensed information should be cheap to acquire (in terms of cost and added weight and complexity) and should also be sensitive to damage location, size and type.
ii) Accurate damage modelling at minimum computational cost. Capturing families of damage scenarios with only a few models that are inexpensive to run is a major challenge. This normally requires the development of effective metamodeling techniques.
iii) Extend the simulability of the sensing techniques employed. This process should include damage modelling in order to ensure that signatures of damage are visible. The same simulations can be employed for optimizing the sensing configuration.
iv) Develop dedicated techniques for identifying damage. Machine learning or purely statistical techniques need to be developed for quantifying the probability of existence of a certain damage scenario in a robust manner.
v) Couple damage propagation to damage identification models in order to predict the remaining useful life for a certain component and identify the optimal maintenance strategy for a structural component.
vi) Promote the new technology to the industrial aerospace sector so as to develop willingness in the industry to adopt these technologies.

The beneficiaries and partners very much look forward to joining forces in the near future in order to tackle the above challenges and provide further developments towards shaping the SHM systems of the 22nd century.

One of SAFE-FLY Network Training Courses, bringing together academic and industrial researchers.

Ultimo aggiornamento: 1 Giugno 2021

Permalink: https://cordis.europa.eu/project/id/721455/reporting/it