FP7- Activity 7 - Transport

Call title: FP7- AERONAUTICS and AIR TRANSPORT (AAT) - 2008- RTD-1
Call identifier: FP7- AAT- 2008- RTD-1

ACTIVITY: 7.1.3 ENSURING CUSTOMER SATISFACTION AND SAFETY
AREA: 7.1.3.4 Operational Safety
Topic: AAT.2008.3.4.2. Maintenance

ACTIVITY: 7.1.4 IMPROVING COST EFFICIENCY
AREA: 7.1.4.2 Aircraft Operational Cost
Topic: AAT.2008.4.2.6. Maintenance

ACTIVITY: 7.1.6 PIONEERING THE AIR TRANSPORT OF THE FUTURE
AREA: 7.1.6.1 Breakthrough and Emerging Technologies
Topic: AAT.2008.6.1.4. Life-cycle

ACTIVITY: 7.1.2 INCREASING TIME EFFICIENCY
AREA: 7.1.2.1 Aircraft Systems and Equipment for Improved Aircraft Throughput
Topic: AAT.2008.2.1.3. Maintenance and Repair

Deadline: 7 May 2008

Proposal title:
Embedded Electrical-Grid Based Monitoring System for Damage Detection in Composite Structures (ELGRID)

Abstract:
The usage of composite materials and sandwich profiles in aeronautical structures is constantly increasing. The combination of high strength, light-weight and decreasing cost of fabrication makes composites an attractive alternative for traditional structural materials (steel, aluminum). However, anisotropy of mechanical properties resulting from non-homogeneous structure (resin matrices reinforced with fibers, laminates, honeycomb structures) causes difficulties with modeling, analysis and design of composite elements and structures. The same issues concern mechanisms of damages and methods of their detection and identification.

Cracks and delamination are the two most common damages occurring in composite materials. Particularly, the intrinsic nature of delaminations and inter laminar cracks makes them a crucial issue in the safety and a challenge for a proper maintenance of aircrafts. Currently, main methods of damage detection are based on ultrasound and wave propagation, optical fibers and acoustic emission. There is a shortage of reliable on-line monitoring methods and systems.

This proposal presents the concept of embedded electrical sensor system, which will enable continuous monitoring of the state of crucial composite elements during the normal operation of the aircraft and set an alert if some defect is detected. The general idea of the system is that crack or delamination would simultaneously induce some modification (local degradation) in the embedded electrical circuit. Conductive elements arranged in the network of skeletal topology serve as a sensor part of the system. External circuitry and electronics provide power supply, signal generation and data collection. Signal processing and analysis is conducted in the specialized controller. Detection of electrical faults in the embedded electrical network will be done using an original, recently developed software package EG-VDM. Method of fault detection included in the EG-VDM package is based on the concept of signal propagation, using the adapted algorithms of the Virtual Distortion Method (cf. Ref.1). Inverse problem of fault identification is solved through gradient optimization, based on difference between reference response obtained for healthy state

and response measured during operation of the system. Successful results of defect identification strongly depend on topology of the embedded network, selection of terminals for signal generation and response measurement and shape of the signal. The concept of the system and solutions ensuring its proper operation have been included in patent application.

High interdisciplinary nature of the proposal requires knowledge base and experience from different fields of science (mechanics, electronics, material sciences, software). Various conductive materials and technologies are going to be investigated during the project and obtained results are expected to find potential applications in different (beside aeronautics) areas. The ELGRID concept offers new technology of damage detection and identification in composite materials, competitive to other available SHM methods.

References:

1. M.Kokot, J.Holnicki-Szulc, “Defect identification in electrical circuit via Virtual Distortion Method. Part 1 & 2”, submitted to *Journal of Intelligent Material Systems and Structures*

Keywords: embedded system, SHM, damage detection, damage identification, composite materials, sandwich profiles, electrical circuits

Tentative consortium:

▪ IPPT	PL (R&D)	signal processing and damage identification
▪ TUDelft ?	NL (Univ)	composite materials and lab-scale testing
▪ PZL Swidnik	PL (Ind)	rotorcraft producer, end-user, full-scale testing
▪ Fraunhoffer Inst.?	D (R&D)	embedded systems, electronics development
▪ CONTEC	PL (SME)	SHM systems, hardware development
▪ ???	?? (??)	composite material producer, full-scale model production
▪ ???	?? (Ind)	aircraft producer, end-user, exploitation plan
▪ VPI ?	US (Univ)	large deformation smart sensors

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