Airbus Roadmap and Typical Solutions

MARIE-ANNE DE SMET

ABSTRACT

Structure Health (SH) sensing technologies selection is driven by stress requirements, what must be detected and allowable size of anomalies. This paper presents integrated Structure Health (SH) sensing technologies answering to several challenges. Top level challenges are considered such as: design optimization, integration into component during manufacturing or assemblies, and durability demonstration. All must sustain profitable and innovative maintenance operations.

Two technical solutions described in this publication cover damage detection, fatigue follow up, and corrosion detection. One system is made of an optical wave guide network including different optical fibre technologies already well known with added innovations. The second is based on electromagnetic technology known as Eddy Current, well known in the field of classical non-destructive testing addressing corrosion and deep crack detection.

AIRBUS DEVELOPMENT PLAN

Structural Health Management (SHM) applications are aligned with future aircraft developments and must be ready for first industrialization in 2020.

Projects have the ambitious to deliver technical solutions on specific aircraft structure configuration. First application case presented in this paper is about impact detection on large composite surfaces by low cost optical network. The second application is on metallic structure for corrosion and crack detections with no direct access in maintenance operation by electromagnetic sensor.

CHALLENGES

As for all technical solution implemented on aircraft, SH sensing must be qualified and offer innovation sustaining maintenance operation optimization.

Marie-Anne De Smet, AIRBUS OPERATIONS S.A.S., 316 route de Bayonne, Toulouse 31060, France

First sensing systems have to be designed and installed to withstand the conditions described in DO-160. Secondly development of innovative technologies must sustain design optimization, simple integration into component during manufacturing or assemblies, and durability demonstration defined by flight physics. All those aspect add specific requirements driving the technical solution development and qualification.

The qualification program will address different performances. First is to demonstrate detection or measurement capabilities aligned with expectation defined by the stress office and international standards such as: typical environmental conditions DO-160G (1), certification specifications EASA - CS 25 (2) and airworthiness standards FAA – FAR 25(3).

IMPACT DAMAGE DETECTION AND LOAD MONITORING ON COMPOSITES

The ambition of the development is to build a network made of optical wave guides that will detect and characterize damage surface plus loading measurement, see figure 1, with different functionalities, compatible with aircraft system standards. The entire optical network, including optical fiber and innovative optical wave guide, will be managed by one system integrating all the data.

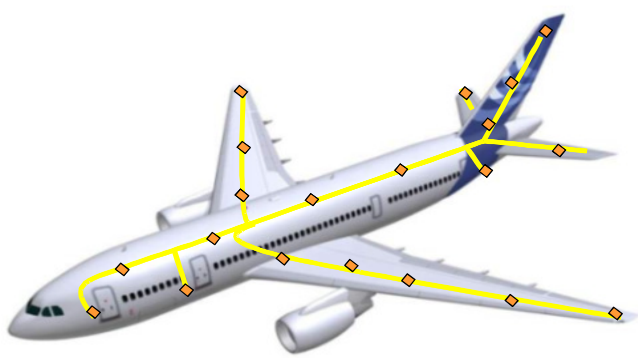

Figure 1. Illustration of typical Network distribution

The load measurements will be made by optical fiber sensing based on Fiber Bragg Grating (FBG) on specific area and Brillouin analysis where less sensitivity is required. Both sensing capabilities are already investigated and FBG implemented for testing, as described in references [4] [5] [6]. Their fields of applications are well identified in the aeronautical context, such as load monitoring, damage detection and de-bonding. They are not industrially optimized to detect and characterize delamination on large surfaces that could be exposed to impact during manufacturing, assemblies, flight and aircraft operations.

In comparison with classical load monitoring technologies, optical fiber sensing technologies have demonstrated an industrial interest and satisfying accuracy. It could be used on top for data transfer as on A380 and A350 aircrafts, not sensible to EMI, offering other functionalities such as temperature and pressure measurements. Anyway gaps must be solved to show industrial interest, such as: simplify bonding or integration into assemblies; optimize transceiver architecture and design to miniaturized system.

For delamination detection on large surfaces, the optical network will be completed by new low cost optical wave guide type made of Solid material mixt with Gel technology (SolGel) material, see figure 2. A development is ongoing with a SolGel material giving the possibility to have a 2D dimensions localization. On top that technology could cover large surface of the aircraft up to 10 meter square. The detecting sensor will be not inserted into the composite layup, but on top and will be covered by final paints customized to airlines specifications. It must be easily replaced in maintenance by adapted automatic devices.

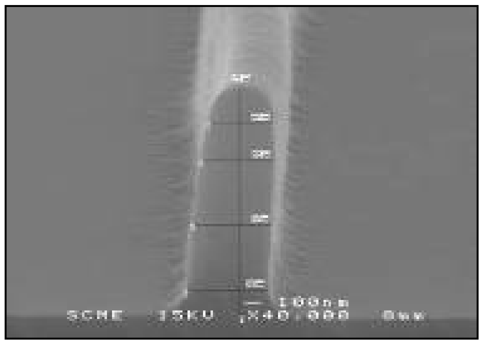

Figure 2. Typical SolGel optical wave guide - produced by Kloe company

This project it at the launching stage into Clean Sky 2 European project. In order to validate working conditions and demonstrate compliance with aircraft design requirements, a prototype will be implemented on a curved stiffened panel of 2m by 2m with demonstration of delamination detectability and localyzation. The target is to have feasabillity demonstration with the whole optical network, including FBG and Brillouin capabilities end of 2020.

CORROSION DETECTION AND DAMAGE CHARACTERIZATION IN METALLICS

In the context of detection and characterization of crack and corrosion in metallic structure, the selected sensing technology is based on Eddy Current physics. It has already demonstrated its capability in the field of aircraft maintenance. Made of a set of coils, it will be embedded into assembly with difficult access for classical maintenance operations.

Eddy currents physics offer the possibility to detect and characterize in depth cracks and corrosion. Their behaviour are well known, analysis of amplitude and phase behaviour in front of crack or corrosion are similar to what is visible in figure 3.

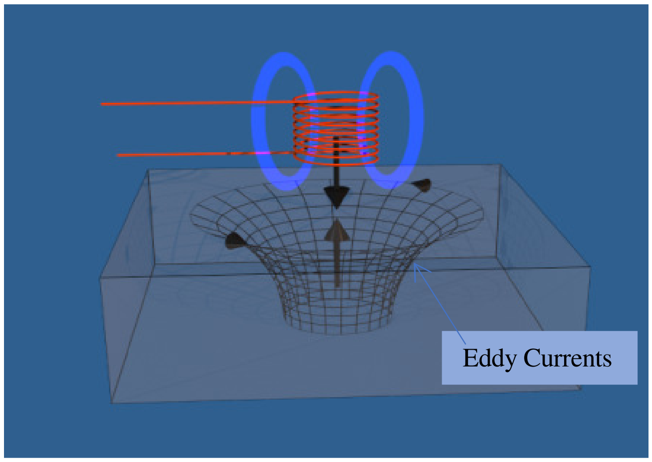

Figure 3. Typical geometry of induced Eddy Current in the tested component

When Eddy Currents are in front of damage, crack or corrosion, the electromagnetic balance is different and induces modification of the signal measured by the system. In order to identify depth, here we list the function representing Eddy Current (1). The depth of the damage is identified thanks to the phase shift of the signal calculated thanks to (2), and standard depth of penetration (3) giving the reference.

$$A=Ao.\exp(-d/\delta) \quad (1)$$

$$\varphi(deg) = -57{,}3.d / \delta \quad (2)$$

$$\delta = \frac{1}{\sqrt{\pi\sigma\mu f}} \quad (3)$$

Legend: σ : electrical conductivity
μ : magnetic permeability
f : electrical current frequency
d : depth
φ: phase angle

In order to illustrate capability of Eddy Current in corrosion detection, hereunder results obtained on a reference block used for corrosion detection procedure, see figure 4, and results shown on figure 5 on a corroded plate at the interface with another component.

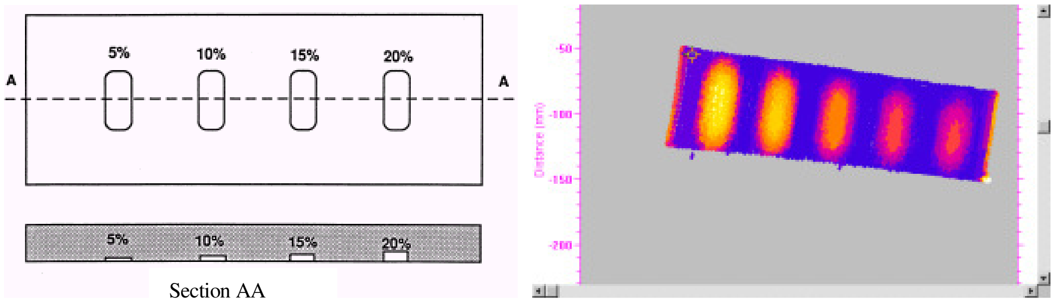

Figure 4. Typical geometry of induced Eddy Current on a calibration block

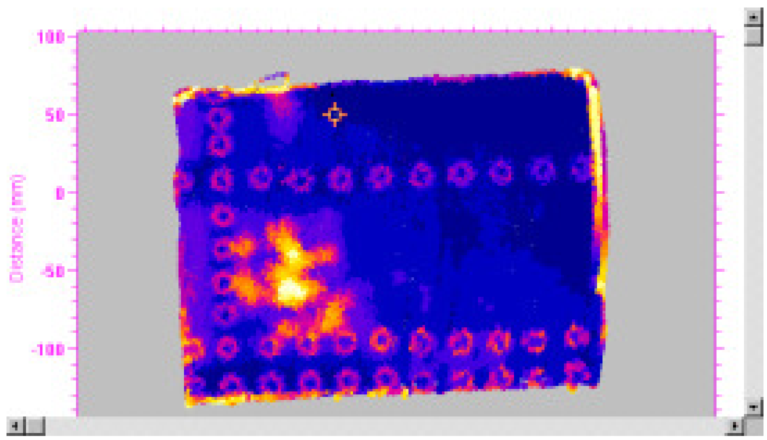

Figure 5. Typical geometry of induced Eddy Current in the tested component, corrosion visible in yellow

Today the inspection is done by sliding the probe onto the surface to be inspected. In the frame of SH measurement the difference is that we do not scan the area. An array of coils will be positioned on the surface to be inspected. The reference called “zero” in Eddy Current field, is replaced by the edge effect and measurement will be done during on ground checks. , the data analysis is done from an exported connecting device, and could be in the future done by wireless through a smart interrogating system integrated into the assembly.

SH SENSIBILITY SETTING

Generally speaking SH measurements are considered as too sensitive inducing earlier repair in the life of the aircraft. In fact is important to clarify that the detection sensitivity will be adjusted to the required level as for classical inspection for maintenance operation.

The acceptance level is adjusted on the amplitude, phase or frequency shift, based of signal changes obtained on a calibration block with representative damages. The difference with classical NDT is that the block will be used only during SH solution development.

Of course SH minimum detectable could be very small and will sustain design optimization where needed for more profitable maintenance operations.

REFERENCES

1. RTCA, “Environmental conditions and test procedures for airborne equipment”, *RTCA report DO-160G, DO160*, 2010
2. EASA, “Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes”, *EASA - CS 25 - Amendment 12*, 2012.
3. FAA, “Part 25 — Airworthiness standards: transport category airplanes”, *FAA – FAR 25*, 2008.
4. N Sabri, SA Aljunid, MS Salim, S Fouad, “Fiber Optic Sensors: Short Review and Applications”, *Springer*, 2015.
5. R. Di Sante, “Fibre Optic Sensors for Structural Health Monitoring of Aircraft Composite Structures: Recent Advances and Applications”, *Sensors*, vol. 15, pp. 18666-18713, 2015
6. A. Minardo, A. Coscetta, S. Pirozzi, R. Bernini and L. Zeni, “Modal analysis of a cantilever beam by use of Brillouin based distributed dynamic strain measurements