# **Charmonic** Auvergne Reflectometry for the SHM of existing 2D and 3D structures Fatme MUSTAPHA<sup>1</sup>, Jaume BENOIT<sup>1</sup>, Pierre BONNET<sup>2</sup>

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# Introduction

**Structural health monitoring (SHM)** is the process of implementing a damage detection and characterization strategy for engineering structures<sup>[1]</sup>.



Structural Health Monitoring Dates Back Many Years

# Advantages of reflectometry

• Good performance : detection, localization and characterization

• Easy integration

#### **Disadvantages of reflectometry**

• In some methods an expensive directional coupler must be used to separate the incident and reflected signals

• The types of the faults cannot be exactly distinguished



#### **Problematic**

- Existing SHM approaches tend to be highly labor intensive and costly
- Efficient results were obtained by Appling the reflectometry to structures in 1D (complex wire networks)
- Reflectometry was recently limitedly applied to higher order structures (2D and 3D)
- In other methods we need access to the whole structure

The idea is to be able to diagnose a defect when it appears or, better still, predict the appearance of it at the first warning signs.



Damage caused by an airplane lightning strikes.



The development of new signal processing algorithms

The optimization of frequencies and/or waveforms

### **Stages of our work**

# Methods

# How to do SHM in practice ? <sup>[4]</sup>

### **Visual inspection**

• Base on human senses

Distributed Sensor

Networks for Structural

Health Monitoring

• Subjective/Non-quantitative



Thermal infrared test

Ultra-sonic test

# Vibration based SHM

• Based on the premise that damage will alter the dynamic properties of the structure, e.g. structural response, frequencies, mode shapes, damping or modal strain energy change

• By measuring the structural response by means of sensors strategically placed on the structure, and intelligently analyzing these measured responses, it is possible to identify damage occurrence (most of sensors can be wirelessly connected)

# **Static based SHM**

• Based on the premise that damage will alter the static properties of the structure e.g. displacements, rotations

### **Non-Destructive Evaluation(NDE)**

- Various technologies for different purposes
- The effectiveness of such inspections

# **State of the Art:** Bibliographic study

**Review and test reflectometry on 1D (wire network) structure** (\*)



**Modeling in search of a case that interests the industry :** Using CST, create and test 2D and 3D structures (airplanes, pipes..) using several methods

Adapt Reflectometry from 1D to 2D study and establish numerical module



Validate the research part and do the experimental part

# Results

(\*) Accepted International conference paper *M. KAFAL, F. MUSTAPHA, J. BENOIT, W. BEN HASSEN, «A Non Destructive Reflectometry Based Method for the Location and Characterization of Incipient Faults in Complex Unknown Wire Networks »,* 





depends upon the accessibility of the structural location to be examined



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Soft defect detection , location and characterization by solving the inverse problem of the measured reflectometry response by using optimization algorithms



[1] J. Ko and Y. Ni, "Technology developments in structural health monitoring of large-scale bridges, Engineering structures", vol. 27, pp. 1715- 1725, 2005.
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[4] K. Roy and S. Mukhopadhyay, "Workshop onStructural Health Monitoring". June, 2016.
[5] Mukhopadhyay, Subhas Chandra, ed. New developments in sensing technology for structural health monitoring. Vol. 96. Springer Science & Business Media, 2011.