Presented by

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Focal Point for SHM

Airbus
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Structural Health Monitoring (SHM)

AIRBUS

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2. Why SHM
3. SHM Technologies
4. Qualification of SHM technologies
5. Roadmap (Airbus)
6. AISC
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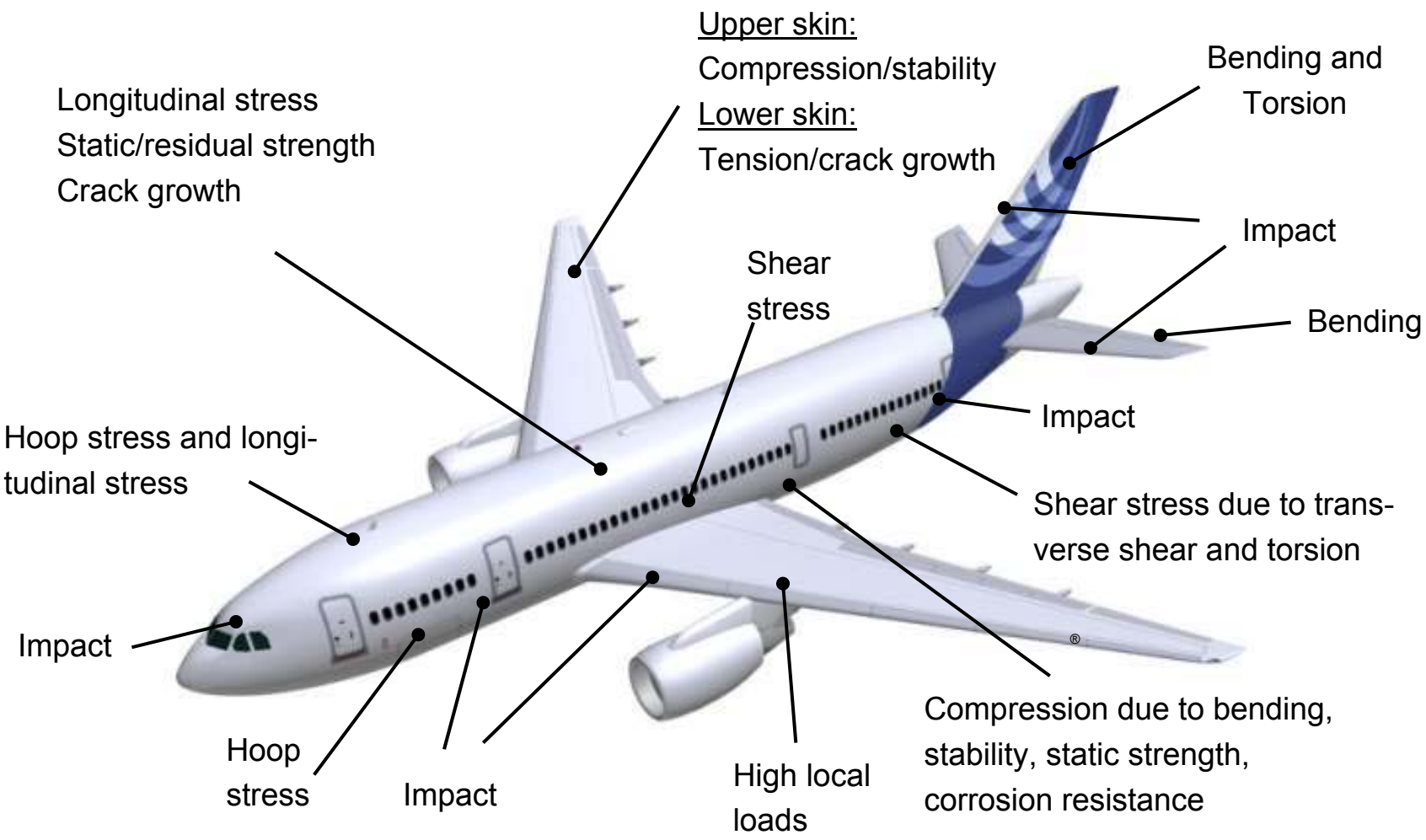
What is SHM?

Airframe Loading / Non-Destructive Testing



Non-destructive testing (NDT) is needed in order to ensure the integrity of the airframe.

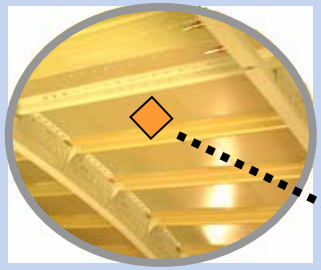
Possibilities for NDI inspection

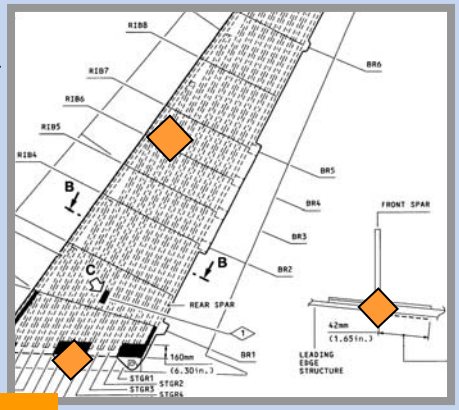
1. Visual Inspection (VI)
2. Non-Destructive Testing (NDT)
3. Structural Health Monitoring (SHM)

The optimum solution for structural inspections must be chosen out of these 3 options

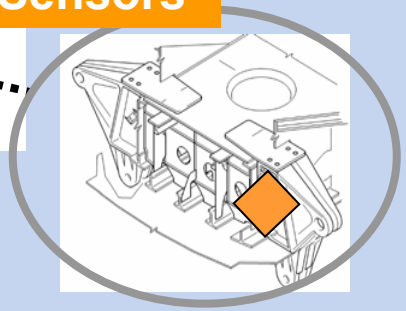
SHM (Structural Health Monitoring)

- SHM = innovative Non Destructive Testing (NDT) method
- Peculiarity: Sensor remains attached / embedded in the structure
- Advantage vs. NDT: Information on structural events or states to arbitrary times available





Sensors



Evaluation

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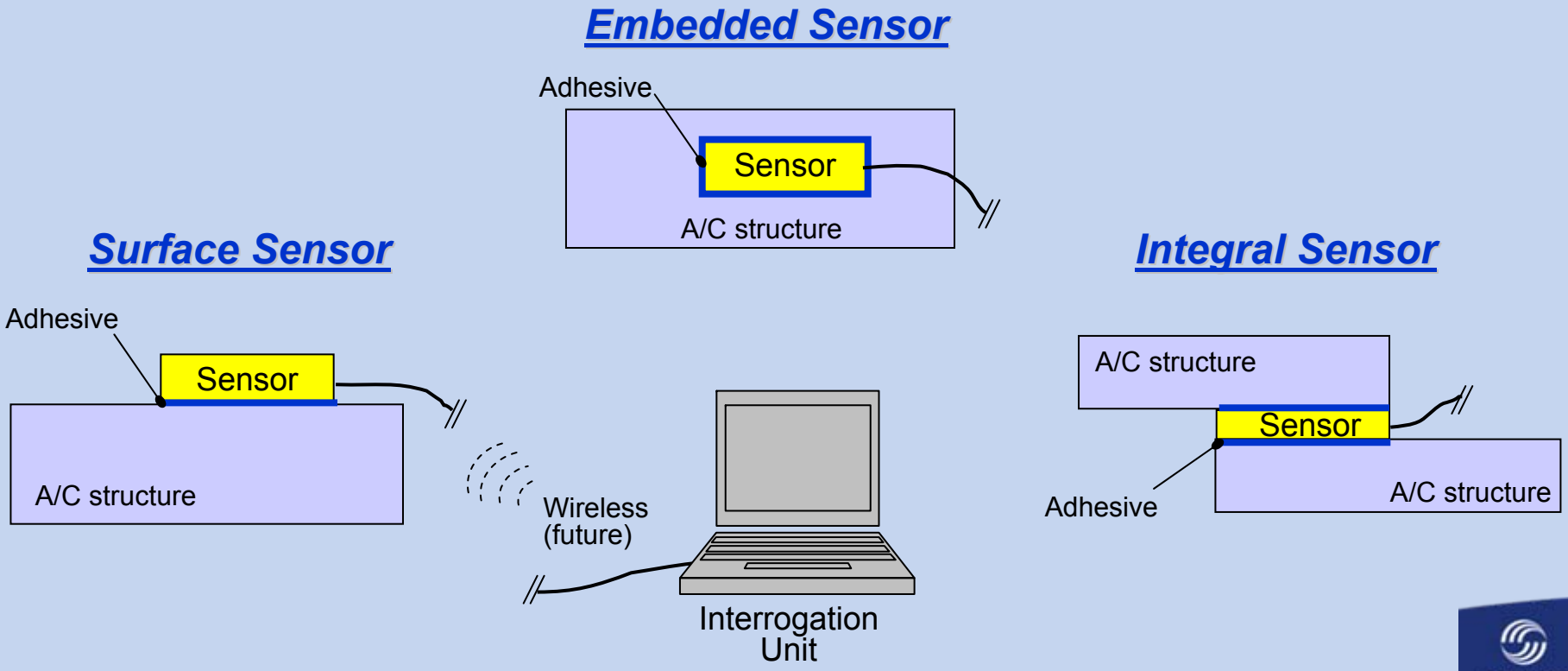
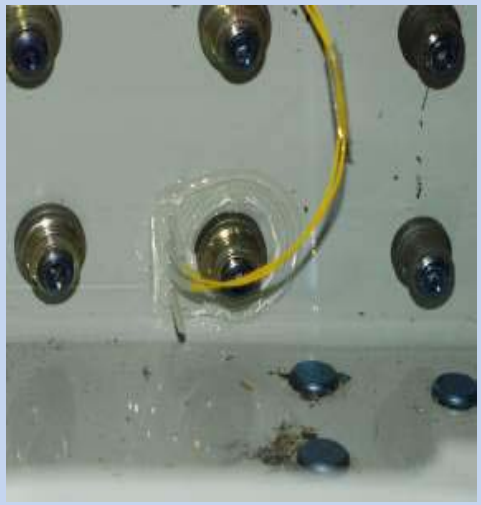
SHM System – Principle and Set-up

- Physical Probe (acoustic, electro-magnetic, optic) + Material/Structure
  - ⇨ Interaction
    - ⇨ Analysis
      - ⇨ Diagnostic
        - ⇨ Detection and Monitoring of flaws, stress/strain, parameters
          - ⇨ Prognosis



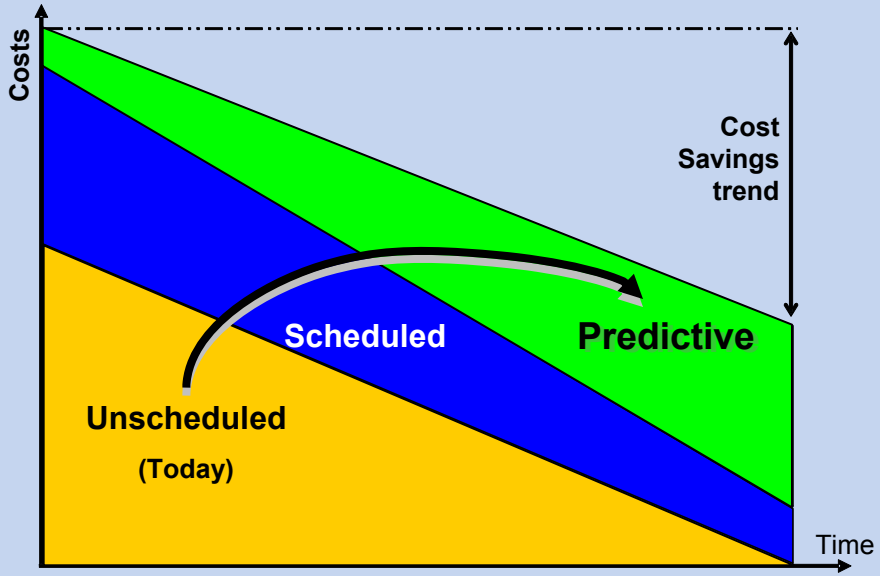
Parameters/Events to monitor

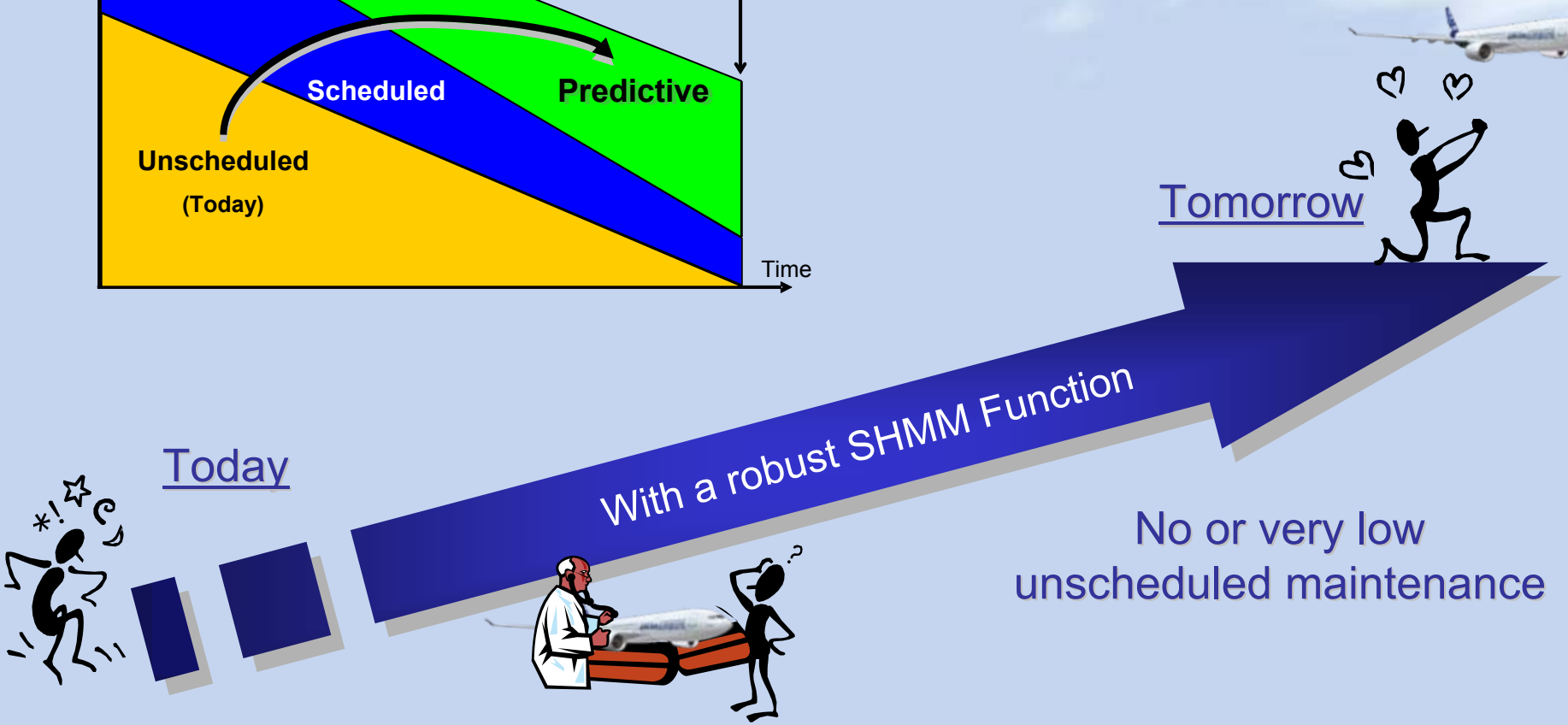
- ***Damages***
- ***Loads/Strains*** NEW
- ***Flight parameters and conditions*** NEW
- ***Environmental conditions*** NEW
- ***Production parameters*** NEW



Why SHM?

Structural Health Monitoring+Management





Benefits of SHM

SHM

Continuous and autonomous monitoring of defects, stress/strain, environmental and flight parameters by means of permanently attached or embedded sensor systems in order to ensure the structural integrity.

Maintenance / Operatability

- Reduction of inspection time
- Deferred maintenance / repair
- Maintenance on demand

➢ **Reduced DOC, DMC**

➢ **Increased Availability**

Design

- Optimised structural efficiency
- New design philosophies

➢ **Weight saving**

SHM Technologies

SHM Technologies for Metal Applications

Metal Structure Application Scenarios

Detection of…

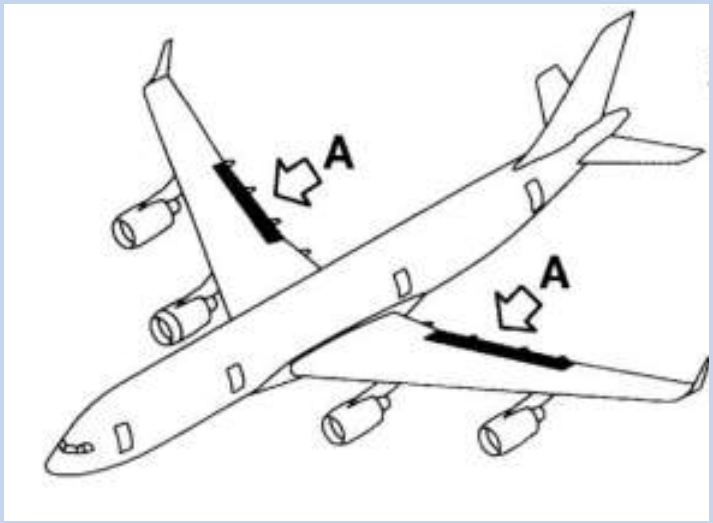
- Cracks (localisation, size)
- Crack growth (localisation, size)
- Accidental damage (localisation, intensity)
- Corrosion (localisation, severeness)
- Loads/Strain (localisation, intensity)

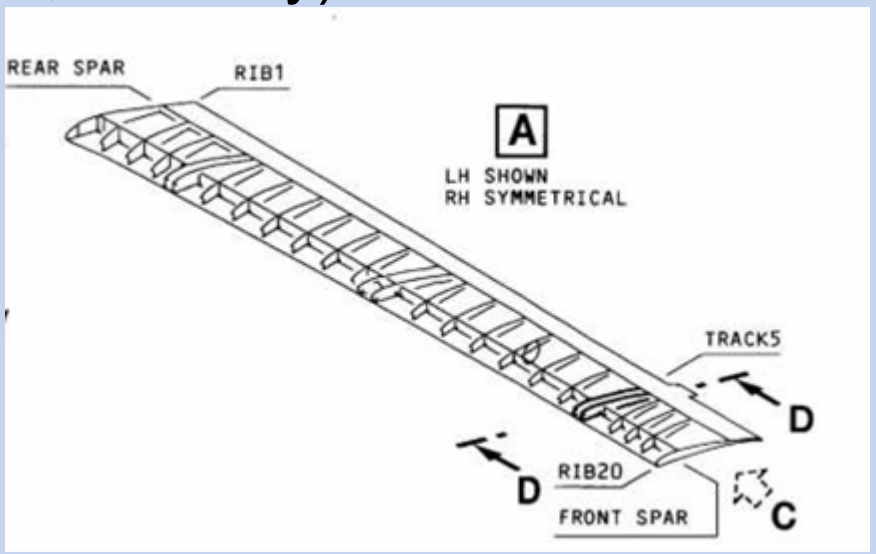
SHM Technologies for Composite Applications.

Composite Structure Application Scenarios

Detection of…

- Impact (localisation, intensity)
- Delaminations (localisation, size)
- Debondings (localisation, size)
- Water ingress (localisation, intensity)
- Loads/Strain (localisation, intensity)





Examples for SHM Technologies

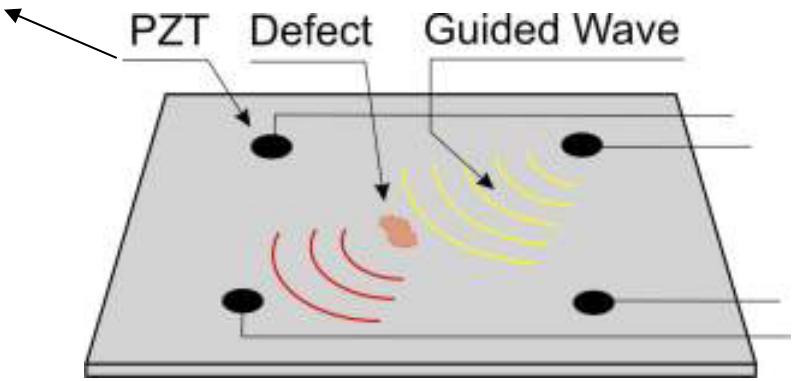
Acousto-Ultrasonics (AU) for Composite Structures

AU – Damage Detection System

- Network of PZT actuators / sensors
- Utilisation of guided elastic waves (lamb waves)
- Detection of debonding & delamination in composite structures

Standard AU-Configuration

SMART Layer™ Sensors

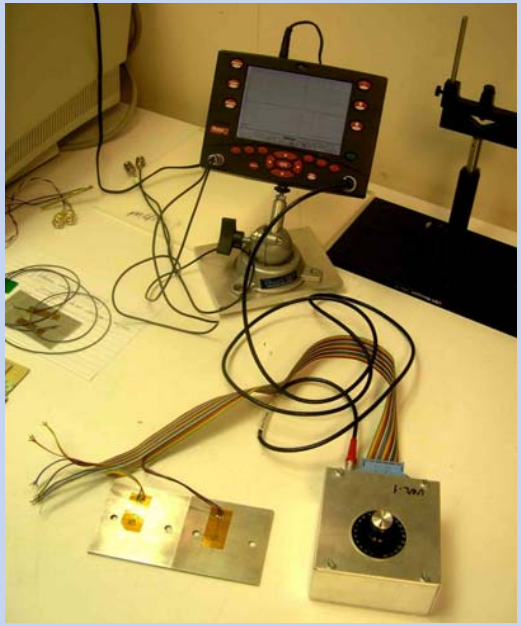


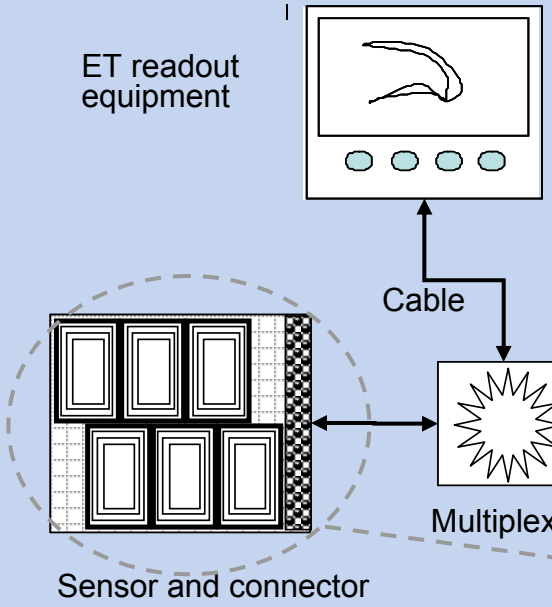
SMART Suitcase (data acquisition unit)

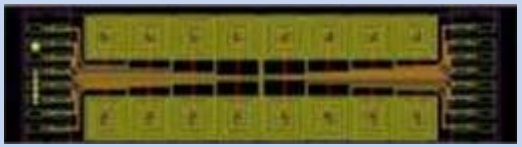
Eddy Current Testing Foil Sensors (ETFS)

- ETFS: Polyimide substrate with conductive printed coil
- ETFS coil generates eddy current field in metallic structures
- Monitoring of crack growth and corrosion by interaction of the defects with eddy current field

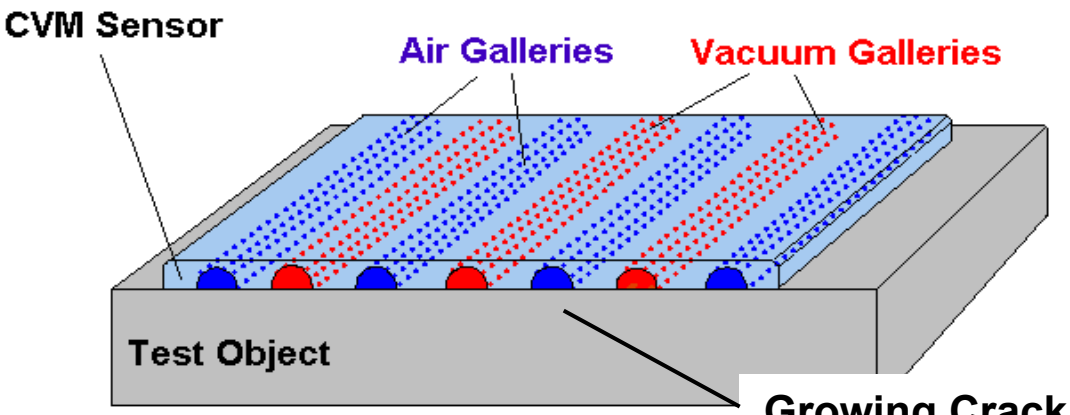
ETFS - Data readout equipment

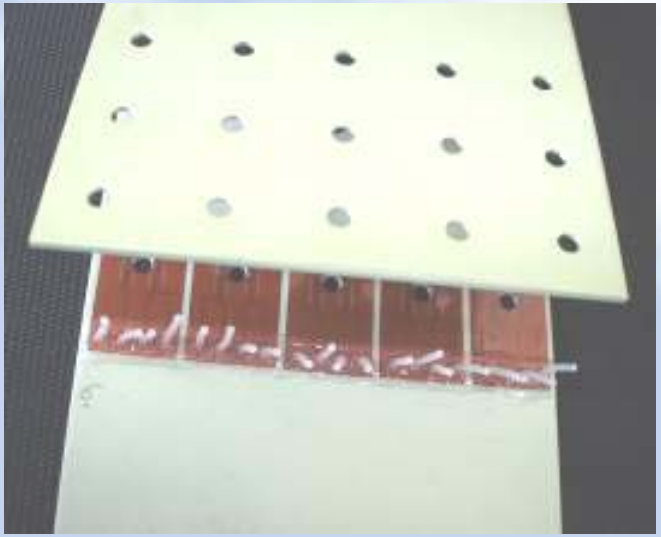






CVM-Technology





Integral sensor to detect crack initiation

- Connection of an air gallery with a vacuum gallery
- Increasing pressure in the vacuum gallery
- Crack detection by equipment

Sensor for surface crack detection

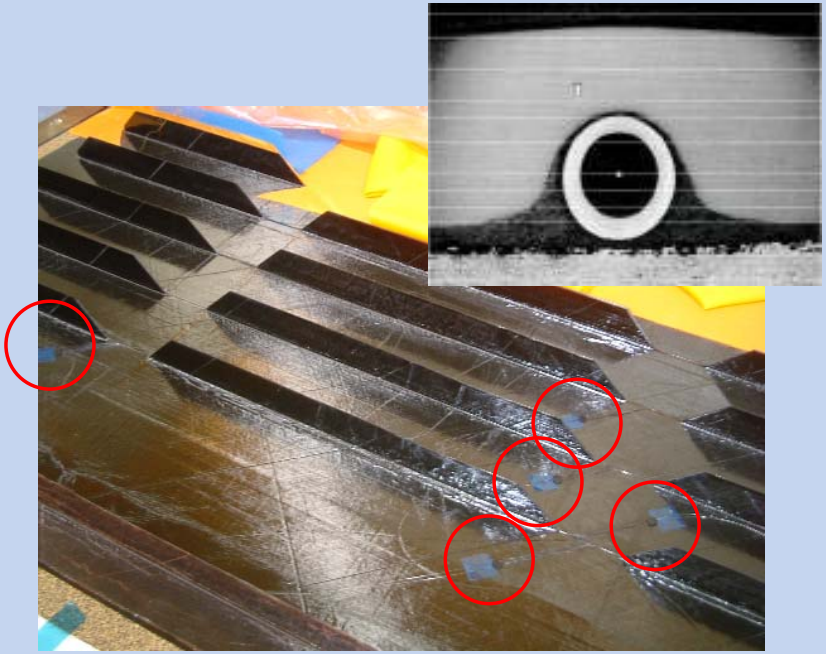
Optical fiber sensors – potential applications

Vision on future airframe technology

Optical fiber sensors

- Structural Health Monitoring
- In-service condition monitoring
- Composite manufacturing process monitoring

Embedded Fiber Bragg Grating sensors



Advantages

- Robust in terms of electromagnetic interference and corrosion
- Handling in terms of geometry, size
- Lightweight, low costs, sensing & data transmission, networking

Maturation and Qualification of SHM Technologies

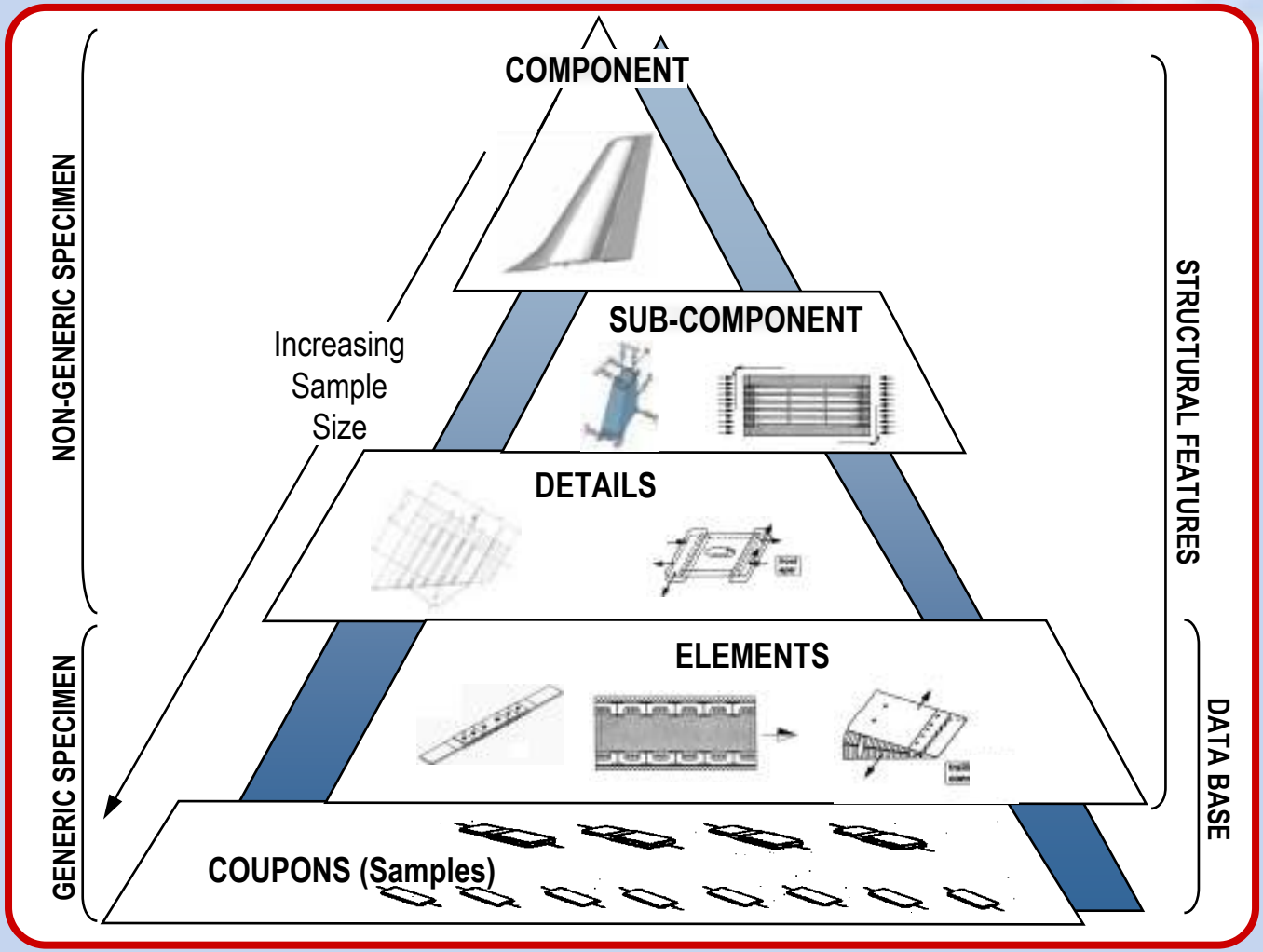
Qualification of Technology: Requirements

Basic Technology Requirements Range

- Detection capability (POD)
- Durability
  - Temperature loading
  - Chemical loading
  - Mechanical loading

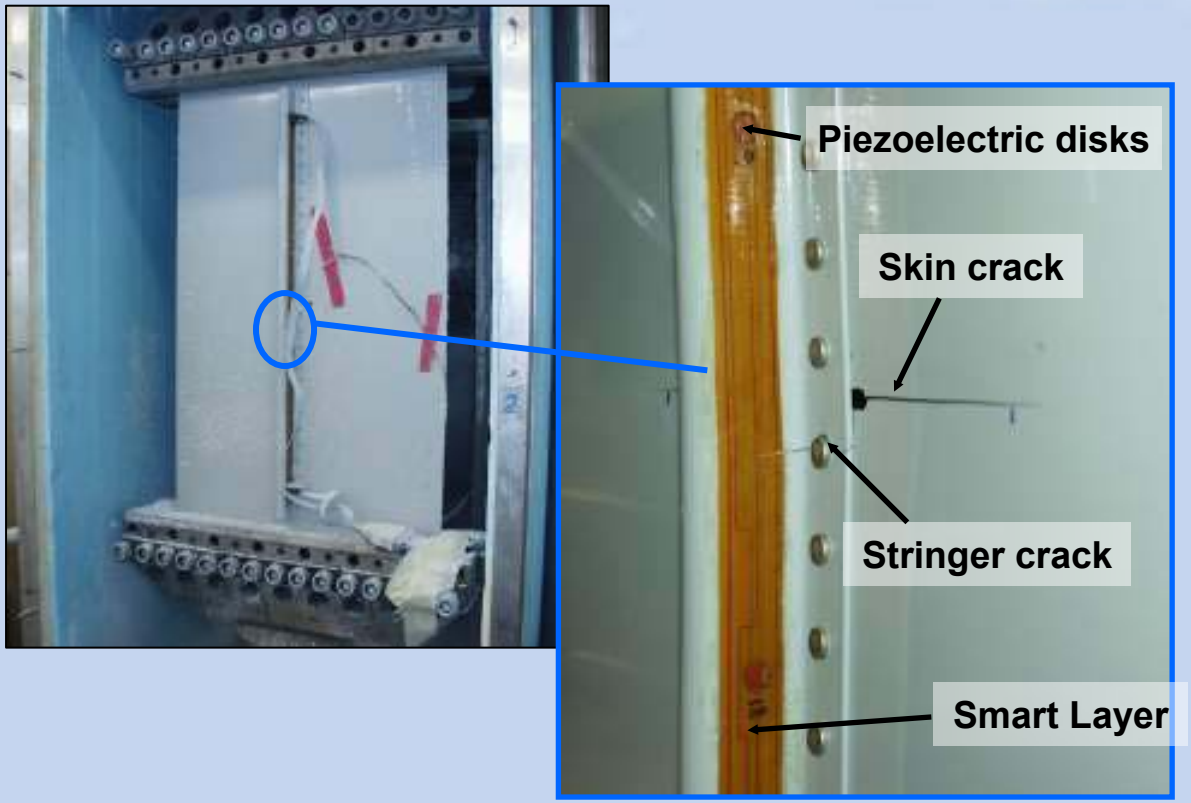
  } ***Reliability > 30 years***
- Manufacturing aspect
- System integration aspect
- Maintainability
- Reparability
- Self-diagnostic capability

Technology Development Plan

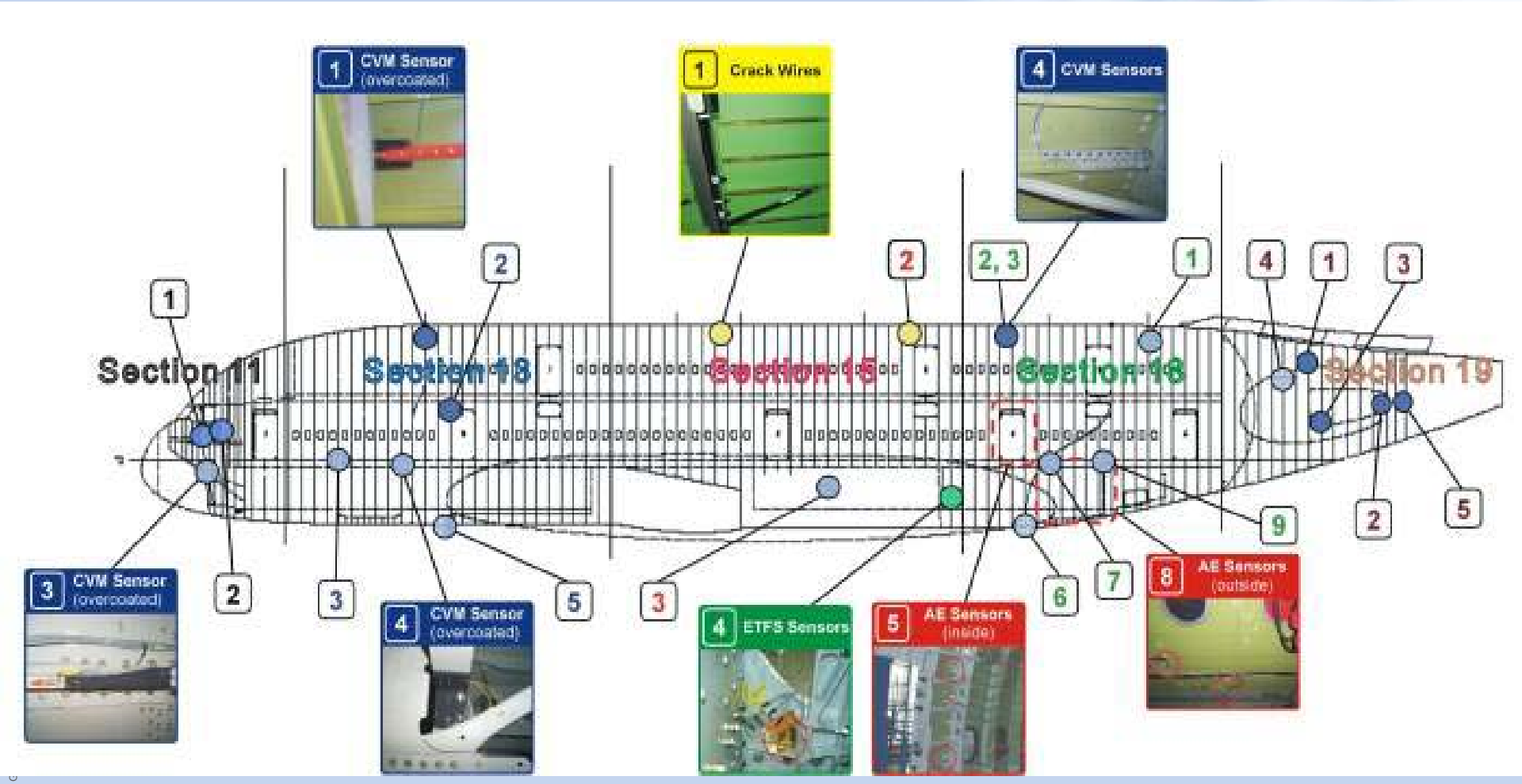


Durability, Robustness and Environmental Tests

POD and Environmental Tests on Coupons

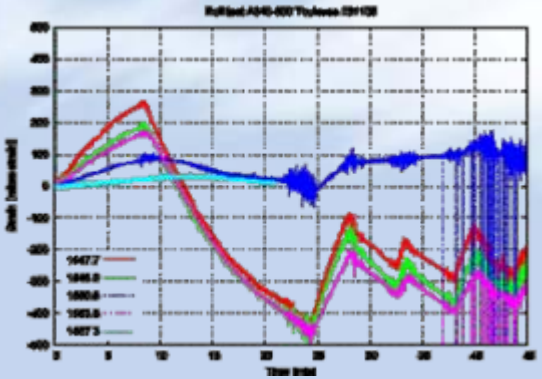


Durability testing of sensor technologies
A380 Full Scale Fatigue Test



Durability Tests on Airbus Aircrafts

A340-600
Testing of Fibre-Bragg-Gratings



A320, MSN 1
Technology ‘Carrier’ for SHM

Airbus Roadmap

Structural Health Monitoring (SHM)

Vision on future airframe technology

Generation 0

- Structure testing application (TR: 2003)
- Benefit: structure analysis & testing

Generation 1

- Alternative to conv. NDT: off-board and off-line (TR: 2008)
- Benefit: maintenance

Generation 2

- Automated SHM, Integrated into system (TR: 2013)
- Benefit: -first weight saving component level -maintenance

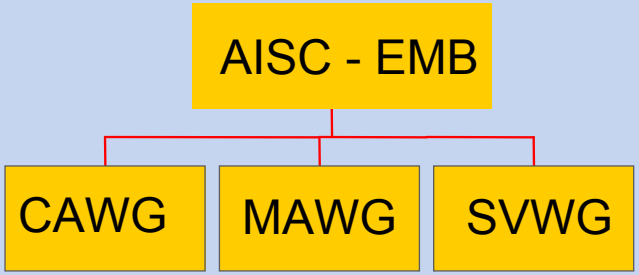
Generation 3

- Neuronal Network, Fully integrated system (TR: 2018)
- Benefit: -weight saving on aircraft level -maintenance

Stepwise approach towards SHM application is essential

AISC
Aerospace Industry Steering Committee

AISC – SHM
Aerospace Industry Steering Committee for SHM



Mission:

- Creating a guideline and recommendation on how to use Structural Health Management (SHM) on various aircraft platforms, in order to improve operability and optimize maintenance plan where structures are concerned, considering their regulatory aspects.

Member EMB:

- OEM
  - Airbus, EADS, Boeing, Embraer
  - Bombardier, Lockheed-Martin, BAe-Systems,
- Government
  - FAA, EASA, Sandia Labs
- Customer
  - Air Force, US Army
  - NASA
  - ATA, AEA
- Academia
  - Stanford Univ.
  - Univ. of Tokyo
- Industry
  - Honeywell, Fuji HI

SHM Specification under preparation

- SHM specification needed
  - Worldwide harmonization of wording, synonyms, philosophies, etc.
  - One “guideline” for all OEM’s
- Basic document to refer from other maintenance documents (MSG3, etc.)
- Managed by SAE (negotiations ongoing)
- Approved by authorities
  - Structures&Materials
  - Maintenance
  - Systems ?

MSG 3 changes

Non Destructive Inspection possibilities

3 kind of NDI exist to ensure the structural integrity

1. Visual Inspection

- GVI (General Visual)
- DET (Detailed)
- Steered by MPD
- Performed in according to AMM, etc.

2. NDT (Non Destructive Testing)

- SDET (Special Detailed)
- Using of Tools and equipment
- Procedures mainly in NTM
- Steered by MPD, SB, etc.

3. SHM

NEW

- SDET (alternative to NDT) Issue Paper 1
- Permanent installed sensors
- Procedures for Off-Board use in NTM
- On-Board and/or On-Line use via IVHM architecture "Automated SHM"

Issue Paper 2

To cover new options for maintenance, MSG3 has to be changed