Presented by

**Holger Speckmann**

***Focal Point for SHM***

Airbus
Bremen, Germany

# Structural Health Monitoring (SHM)

AIRBUS

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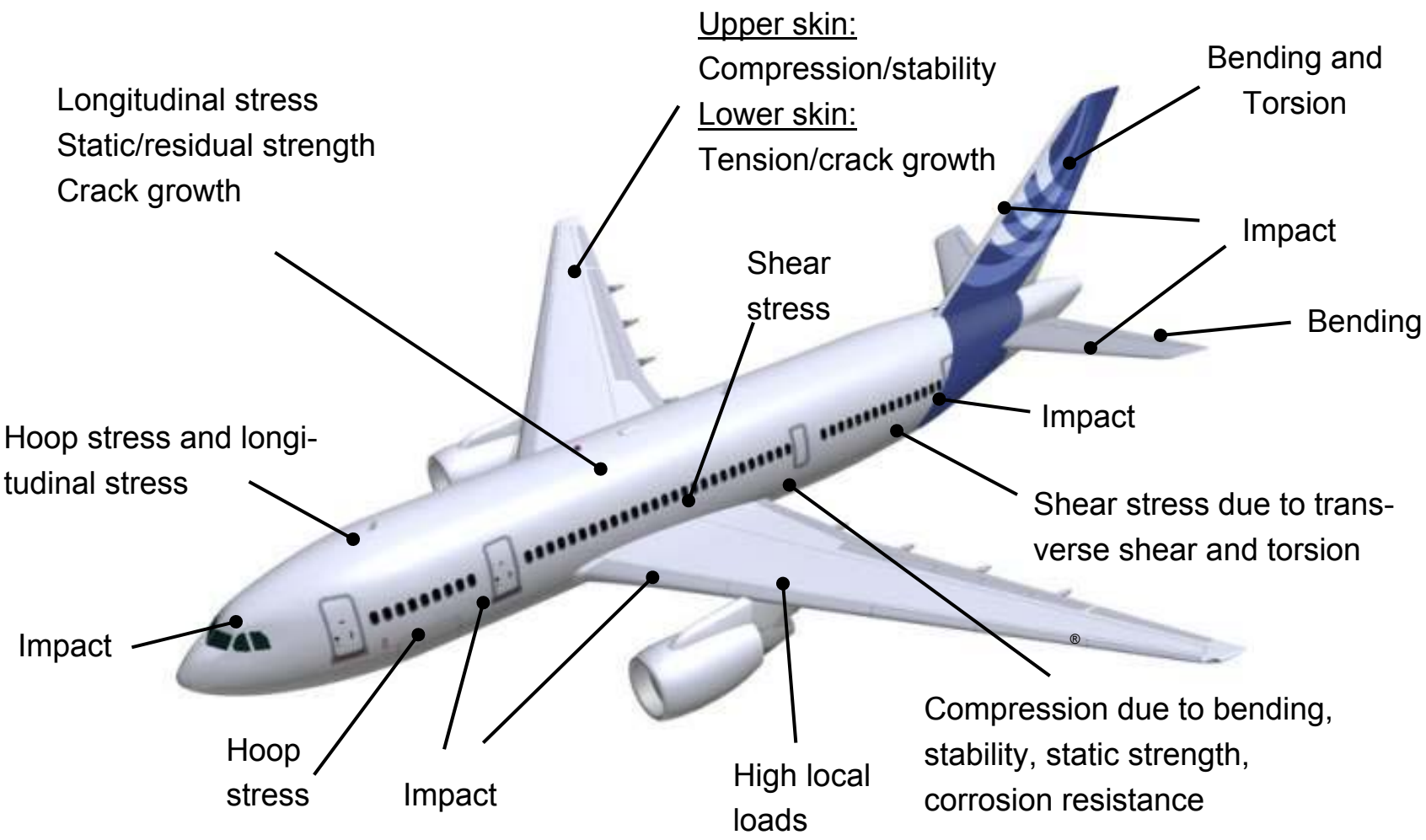
# What is SHM?

# Airframe Loading / Non-Destructive Testing




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

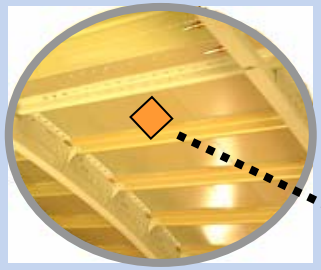
# Possibilities for NDI inspection

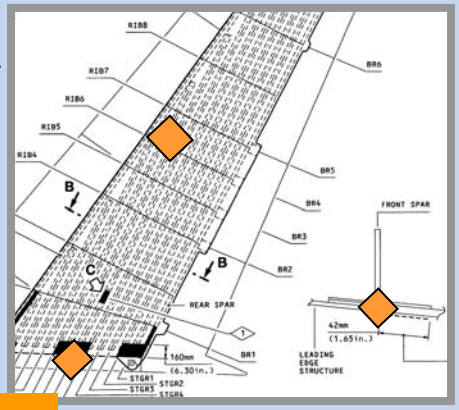
1. Visual Inspection (VI)
2. Non-Destructive Testing (NDT)
3. Structural Health Monitoring (SHM)

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

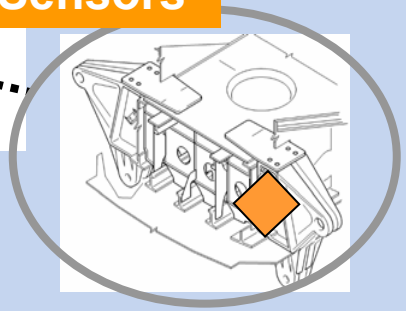
# SHM (Structural Health Monitoring)

- 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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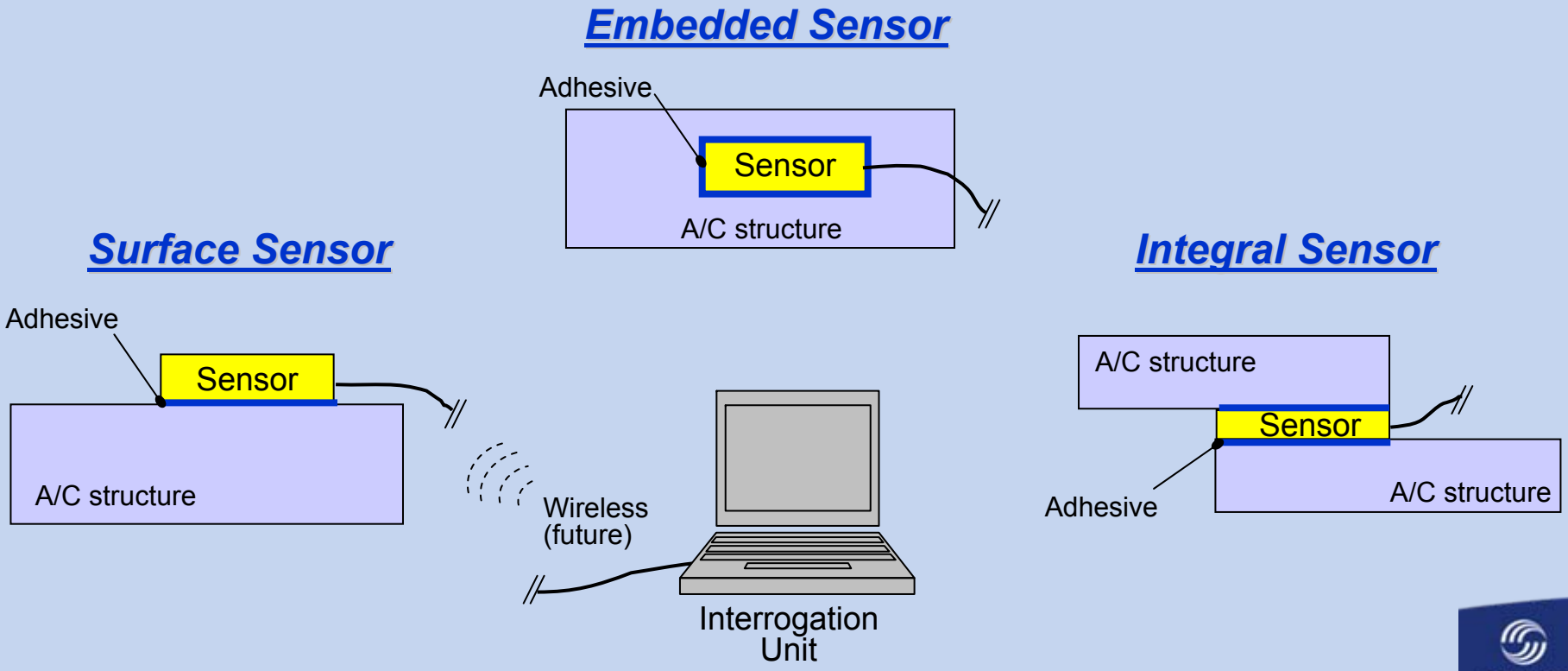
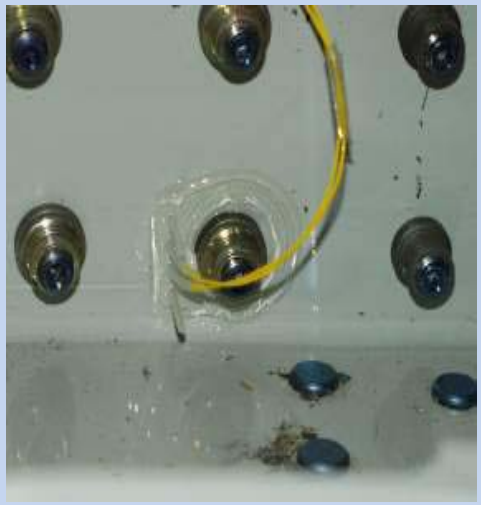
# SHM System – Principle and Set-up

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



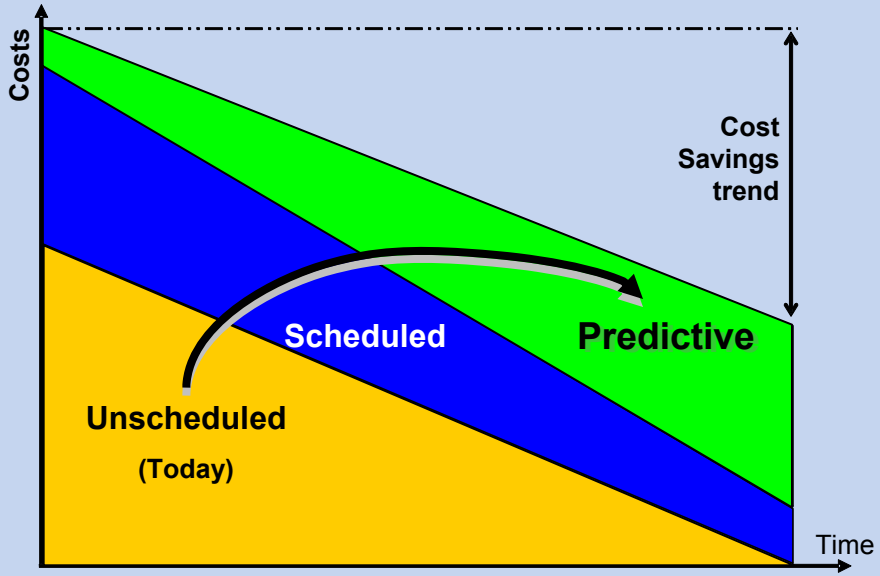
# Parameters/Events to monitor

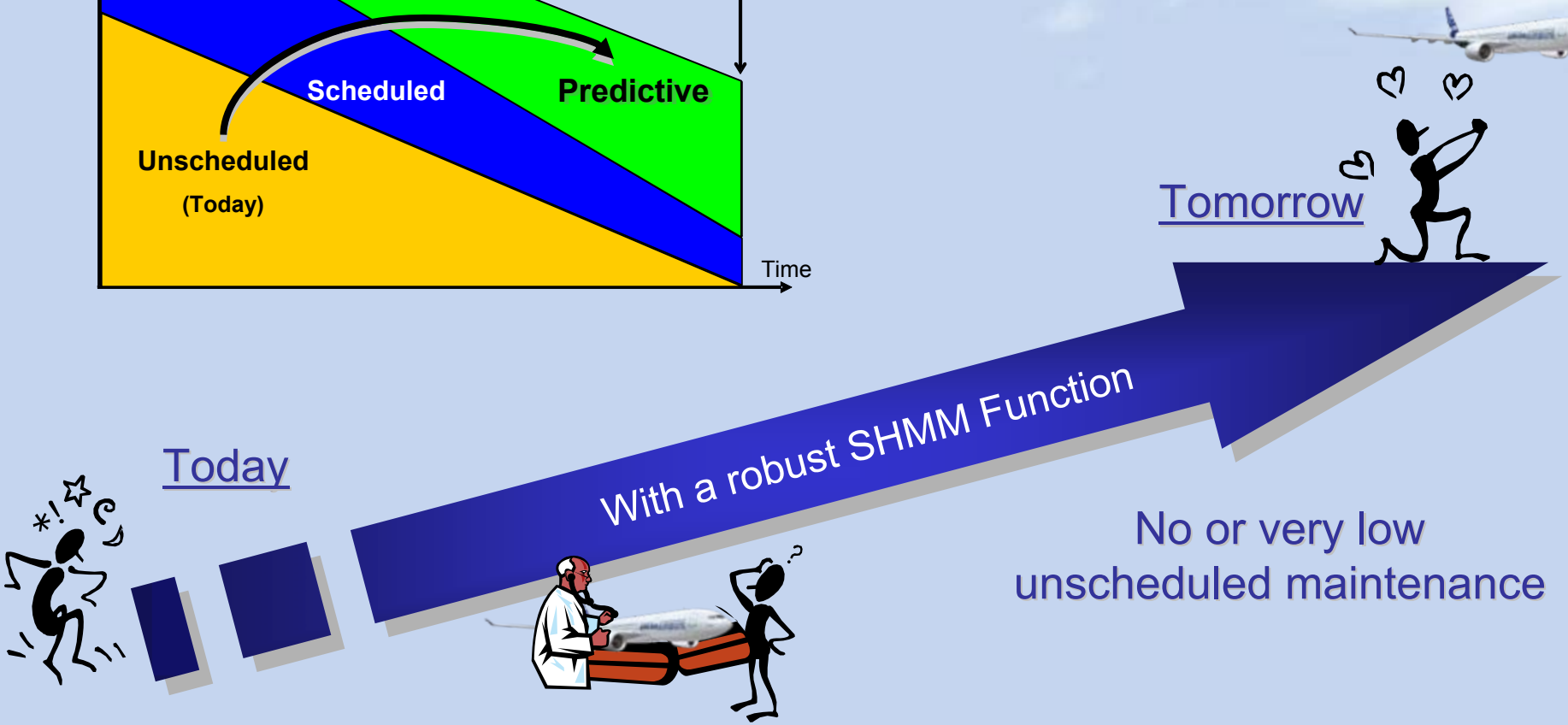
- ***Damages***
- ***Loads/Strains*** NEW
- ***Flight parameters and conditions*** NEW
- ***Environmental conditions*** NEW
- ***Production parameters*** NEW



# 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…

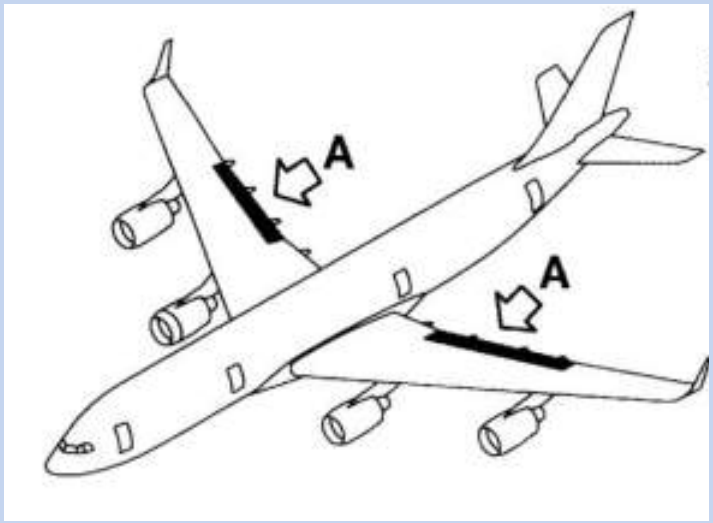
- Cracks (localisation, size)
- Crack growth (localisation, size)
- Accidental damage (localisation, intensity)
- Corrosion (localisation, severeness)
- Loads/Strain (localisation, intensity)

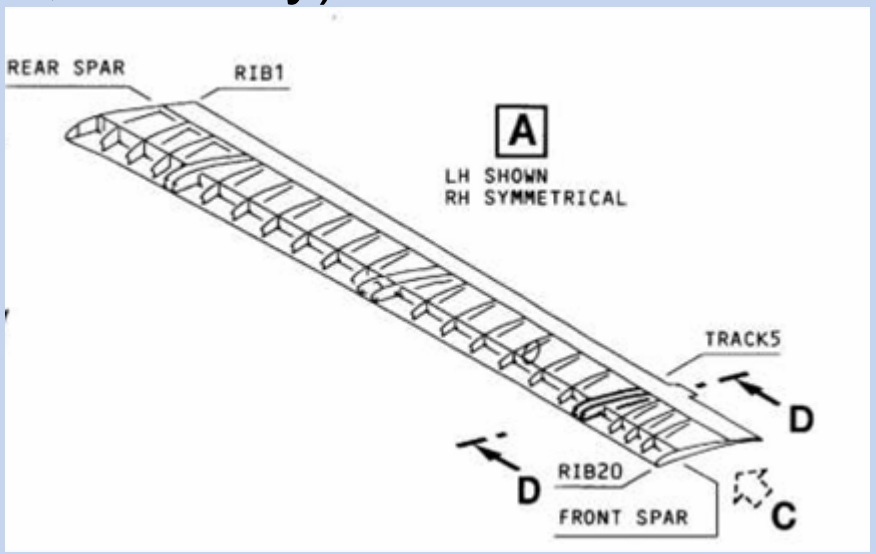
# SHM Technologies for Composite Applications.

## *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

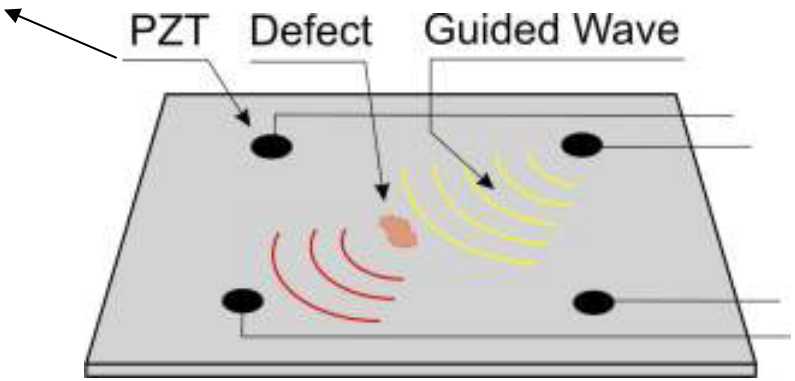
# Acousto-Ultrasonics (AU) for Composite Structures

## 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**

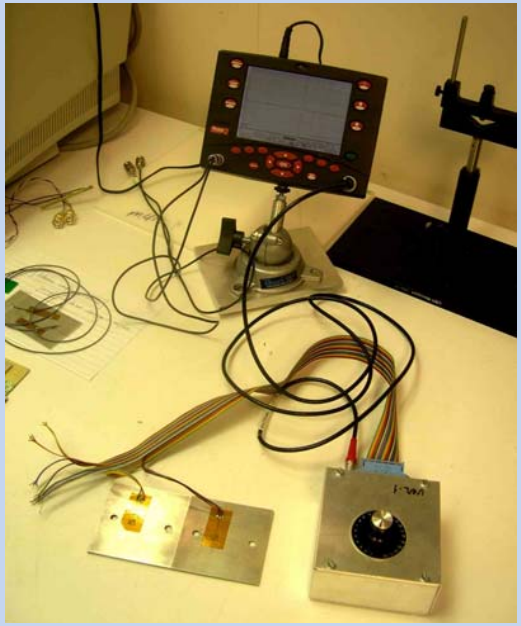


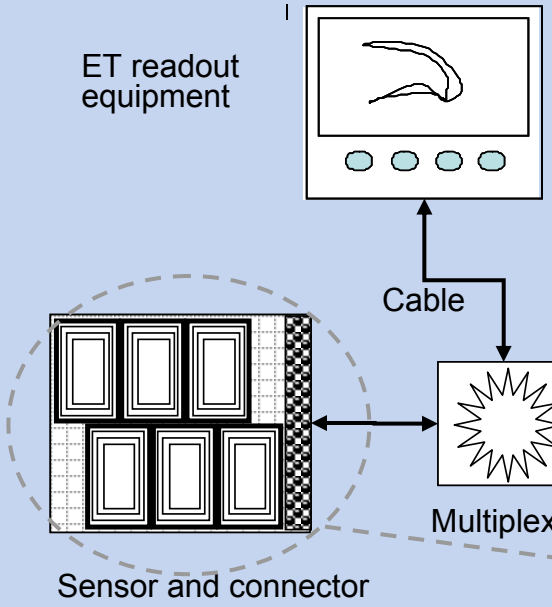

**SMART Suitcase (data acquisition unit)**

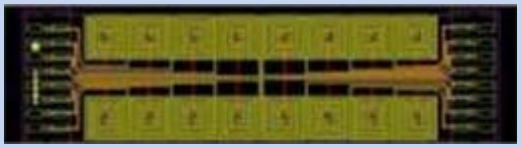
# Eddy Current Testing Foil Sensors (ETFS)

- 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

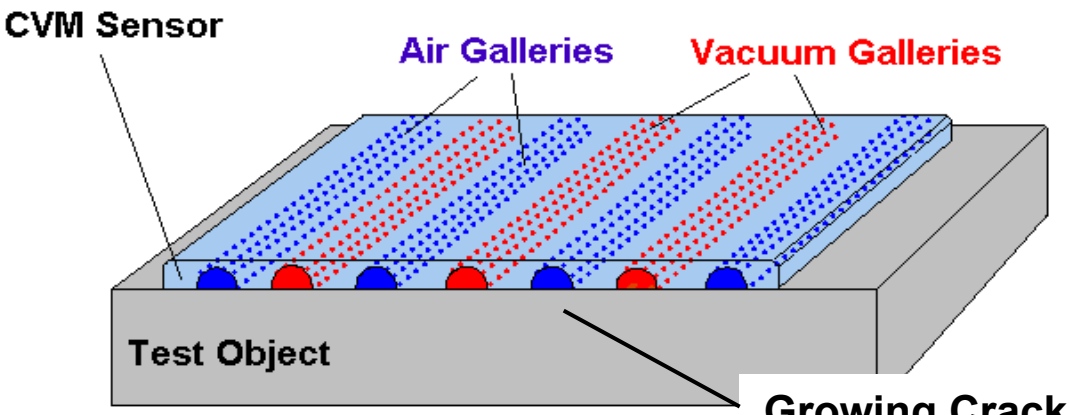
ETFS - Data readout equipment

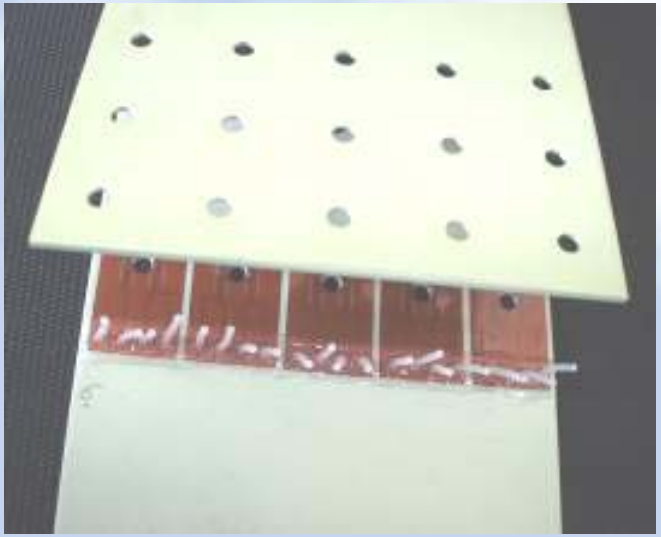




# CVM-Technology



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

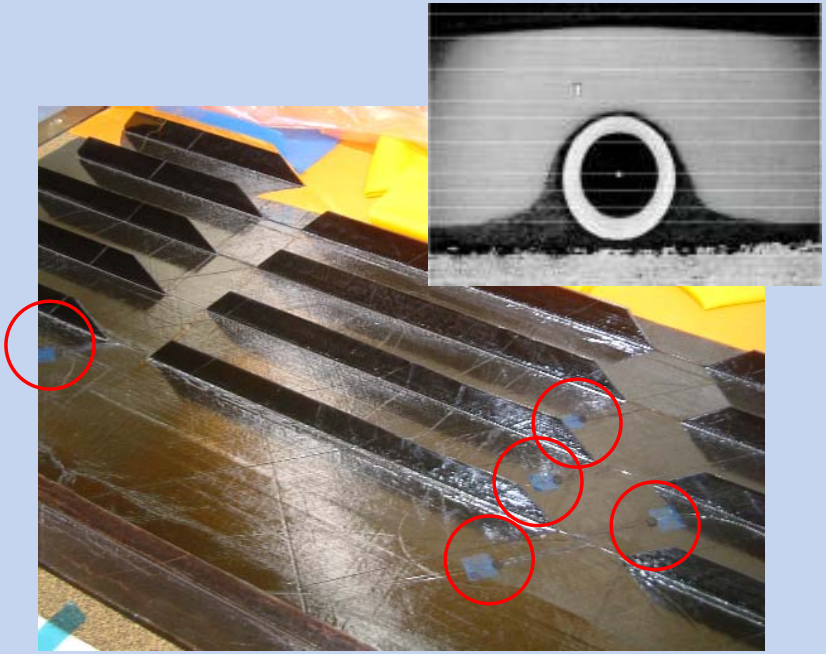
# Optical fiber sensors – potential applications

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

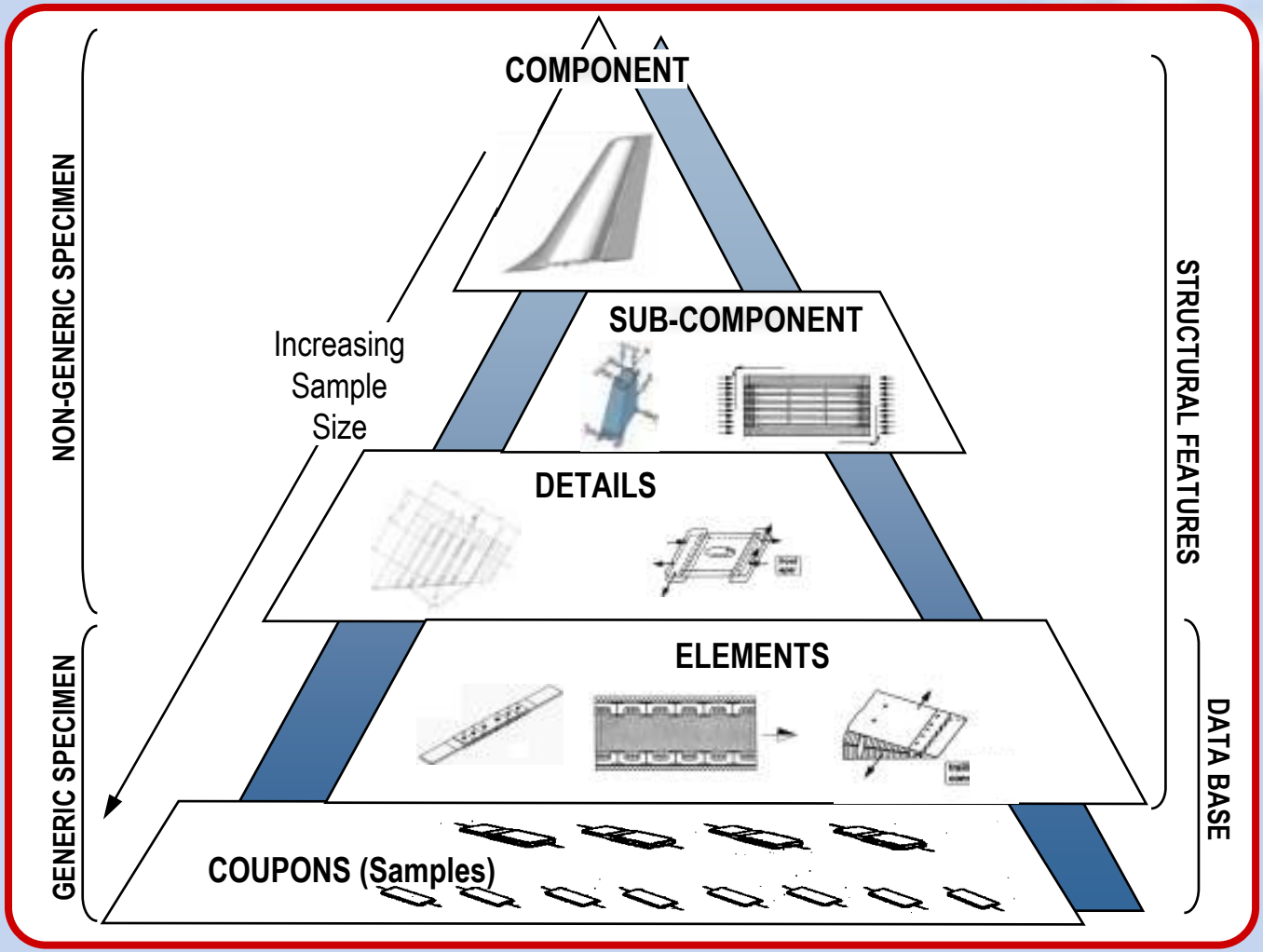
# Qualification of Technology: Requirements

## *Basic Technology Requirements Range*

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

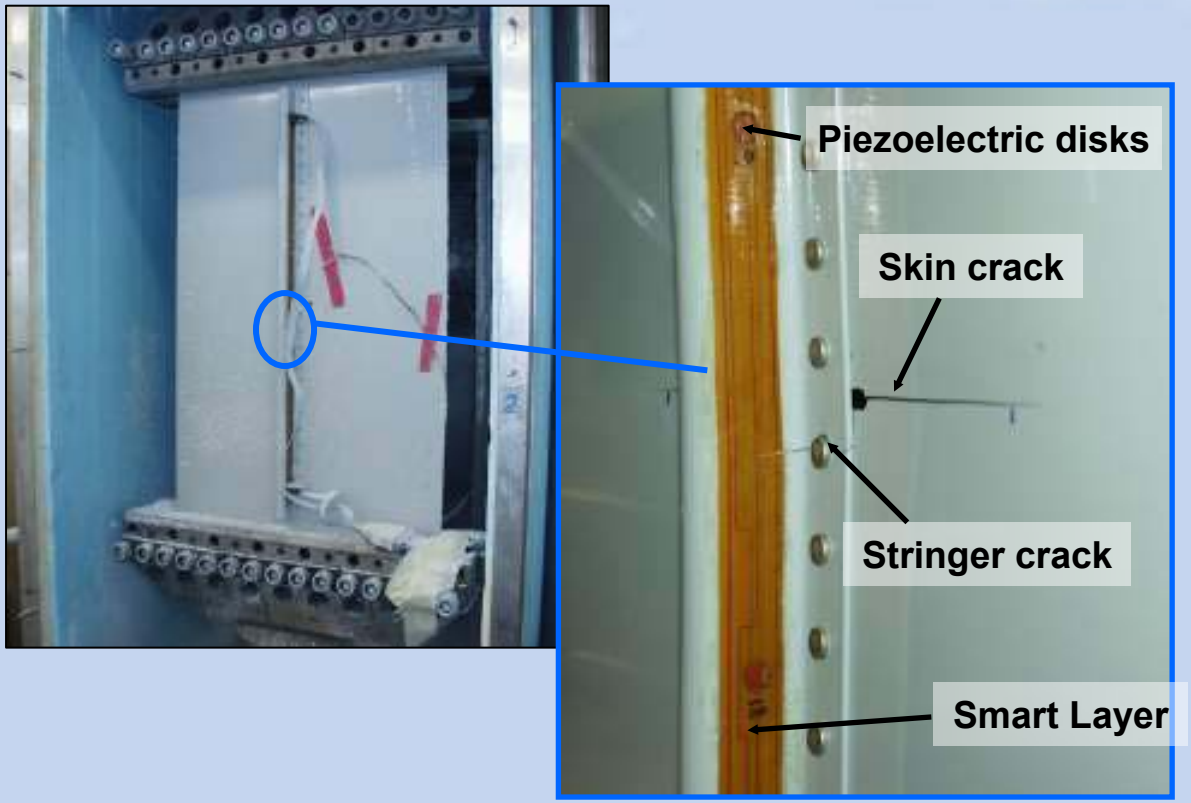
  } ***Reliability > 30 years***
- Manufacturing aspect
- System integration aspect
- Maintainability
- Reparability
- Self-diagnostic capability

# Technology Development Plan

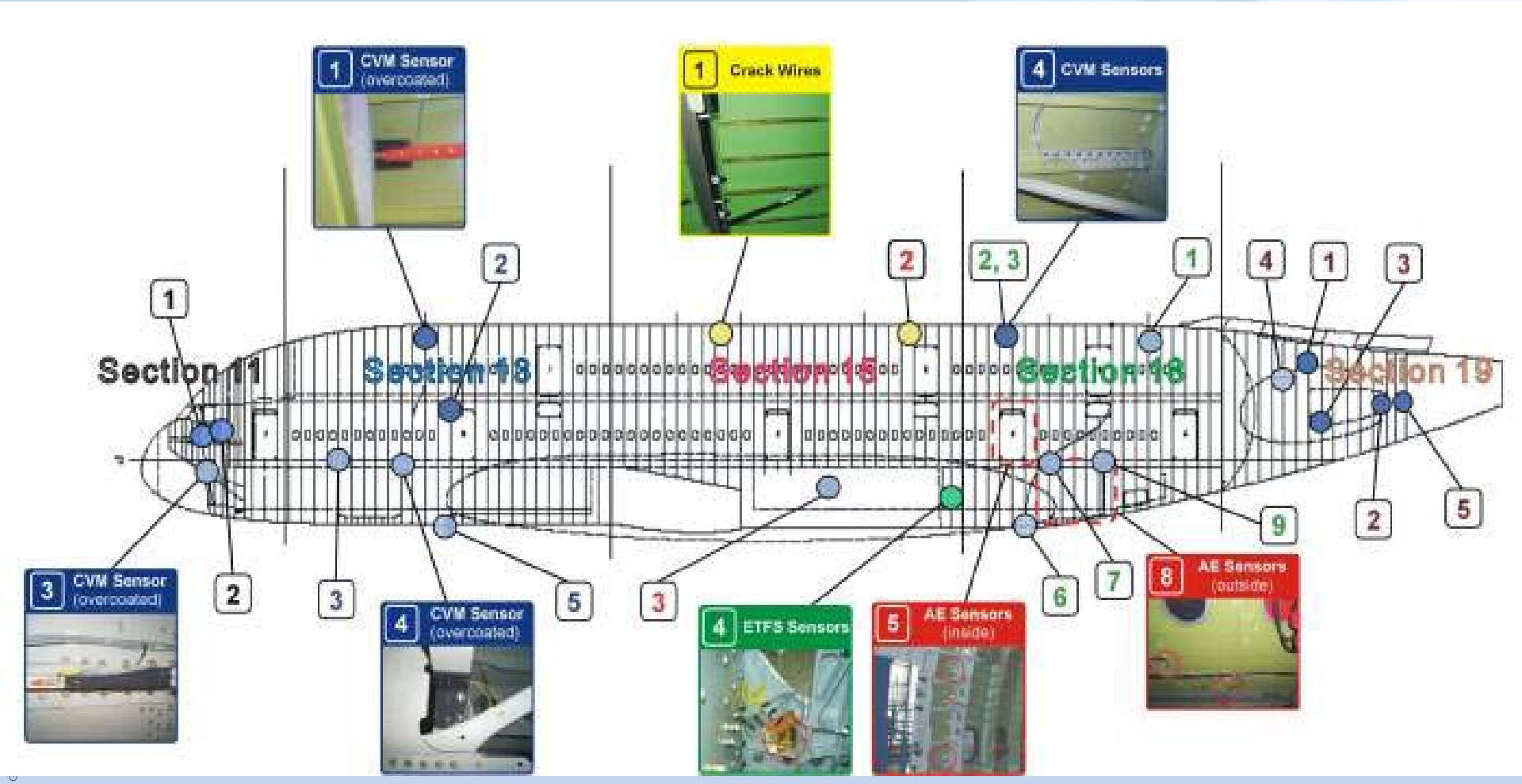



Durability, Robustness and Environmental Tests

# POD and Environmental Tests on Coupons

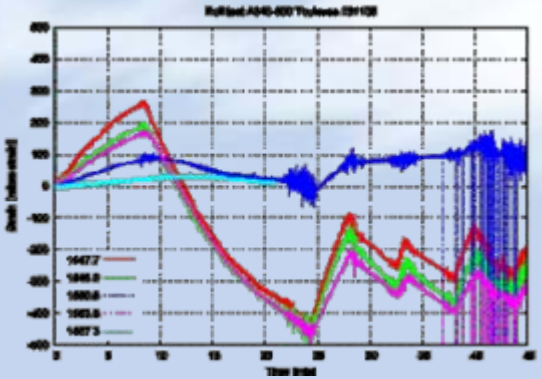


# Durability testing of sensor technologies
# A380 Full Scale Fatigue Test



# 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

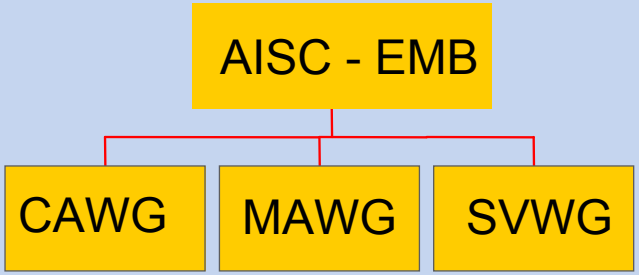
**Generation 3**

- 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**