Progress and current status of SHM implementation in aerospace.

Professor Peter Foote

10th February 2016

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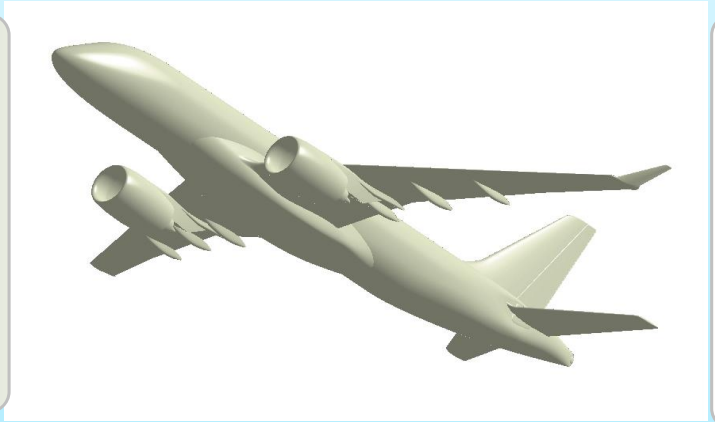
Functional features of structural health monitoring

Cranfield UNIVERSITY

STRUCTURAL HEALTH MONITORING (SHM) ARCHITECTURE

OPERATIONAL MONITORING

- Fatigue Monitoring
- Incident Monitoring
- Environmental Monitoring



DAMAGE MONITORING

- Fatigue damage sensing
- Environmental damage sensing
- Accidental damage sensing

OUTPUTS

- Usage Evaluation
- Advisory Indication
- Inspection Result

BENEFITS

- Improve Repair Planning
- Increase Inspection Intervals
- Reduce Inspection Time and Cost

Direct Maintenance Cost

- Reduce Weight, Cost & Downtime

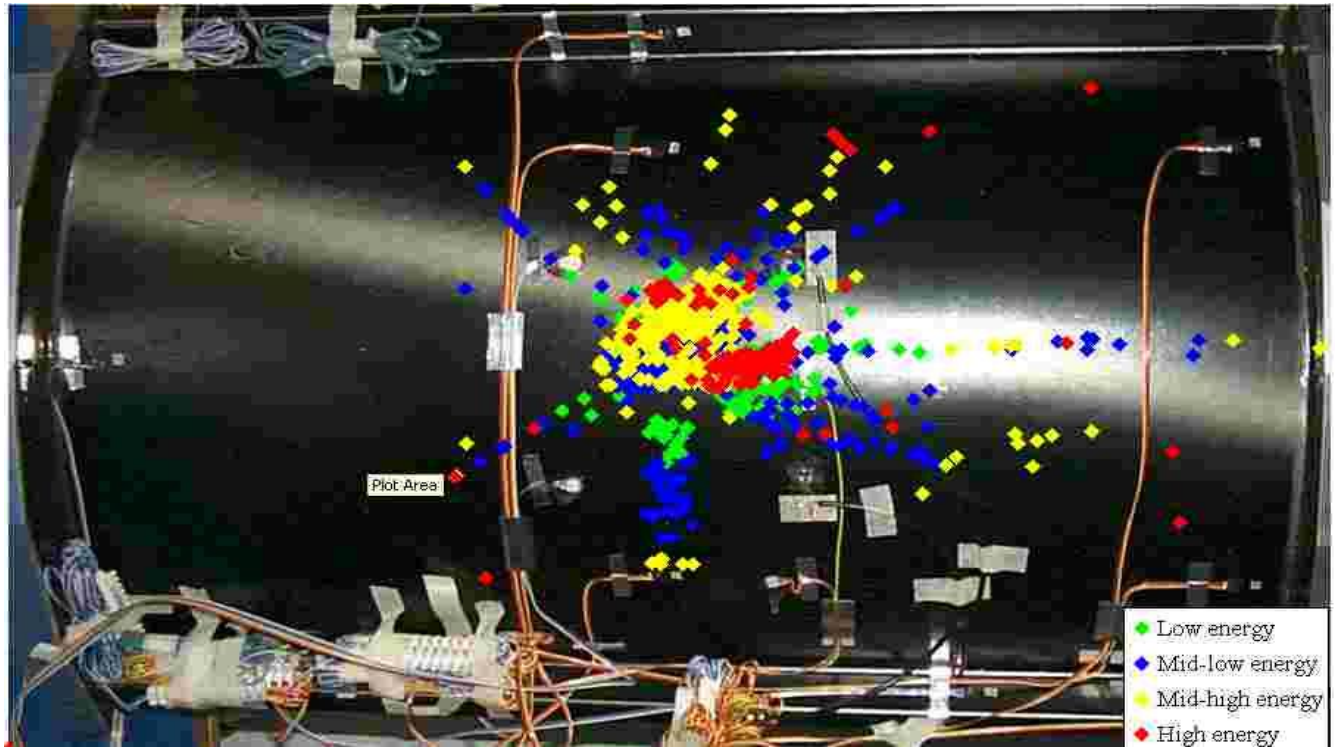
Direct Operating Cost

- Increase Residual Value
- Life Extension

Ownership Cost

Future design enhancements

Q: Can SHM detect damage in composite structures?



Answer: Yes

CFC autoclave composite structure: compression after impact causing BVID.

Individual AE 'Hits' from 5 sensors colour coded according to integrated signal energy. Circa 1m^2 coverage.

Credit: BAE Systems, QinetiQ

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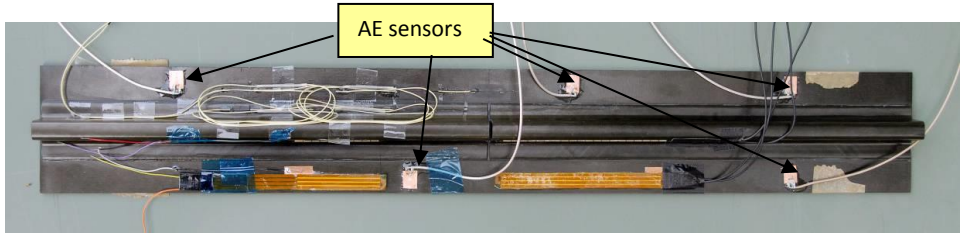
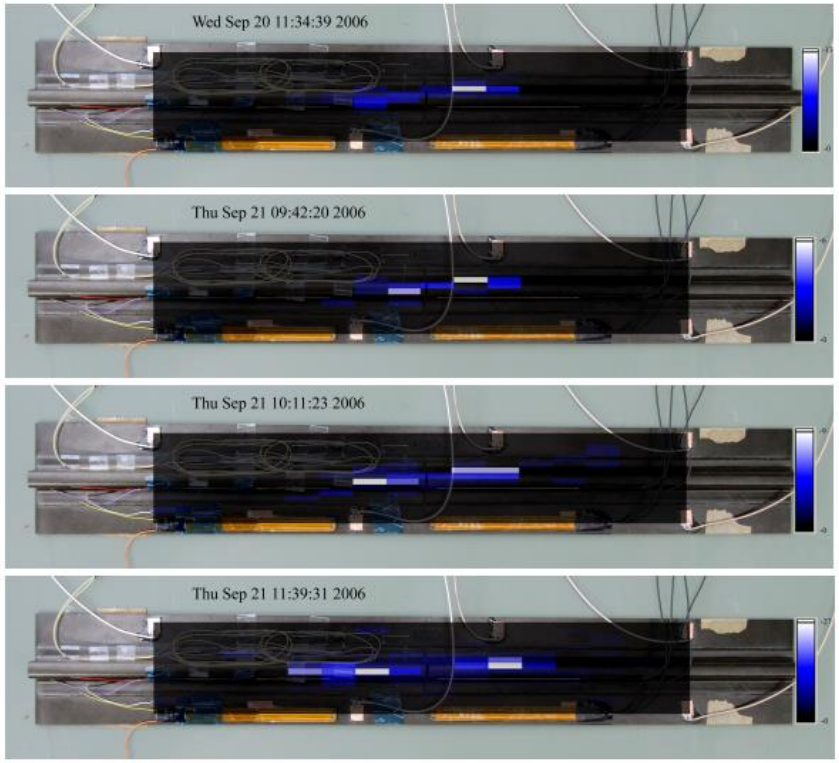
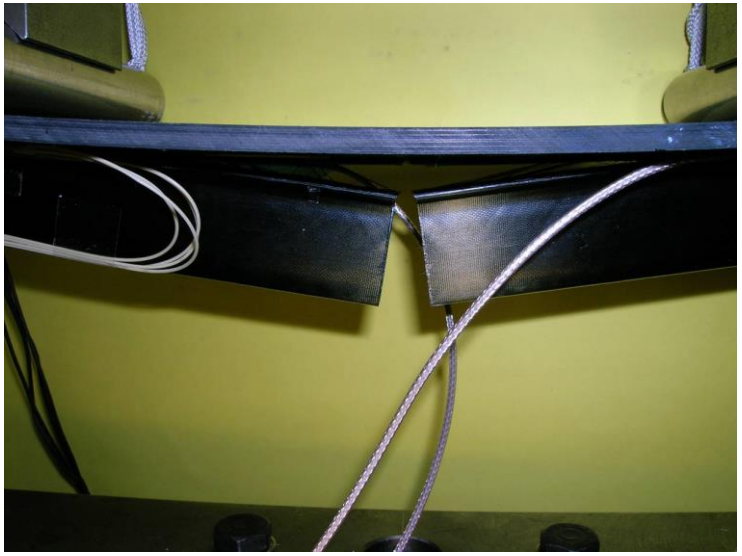


CFC skin and top hat stiffener specimen with AE SHM sensors





Detection of damaged stiffener disbond and disbond growth under fatigue loading

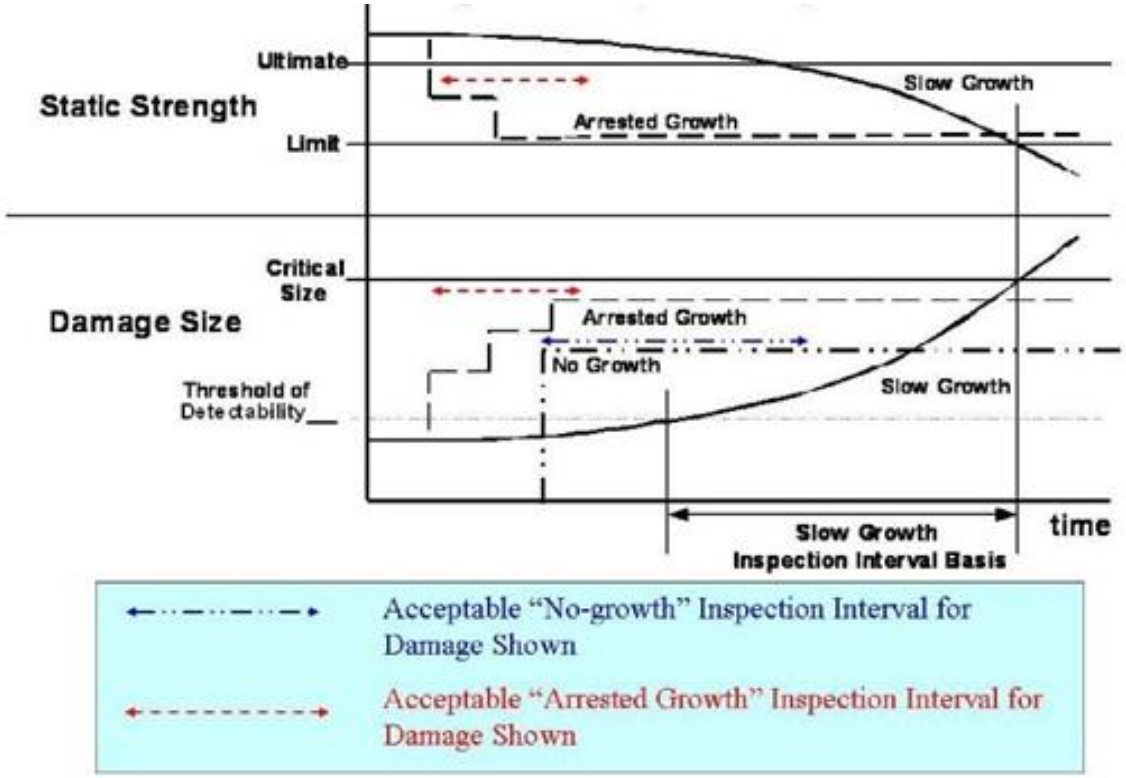
Credit: BAE Systems, RISO (DTU)

Current guidance on damage tolerant design w.r.t. damage detection

Damage growth, the Damage Tolerance approach and Structural Health Monitoring

Acceptable Damage Tolerant approaches

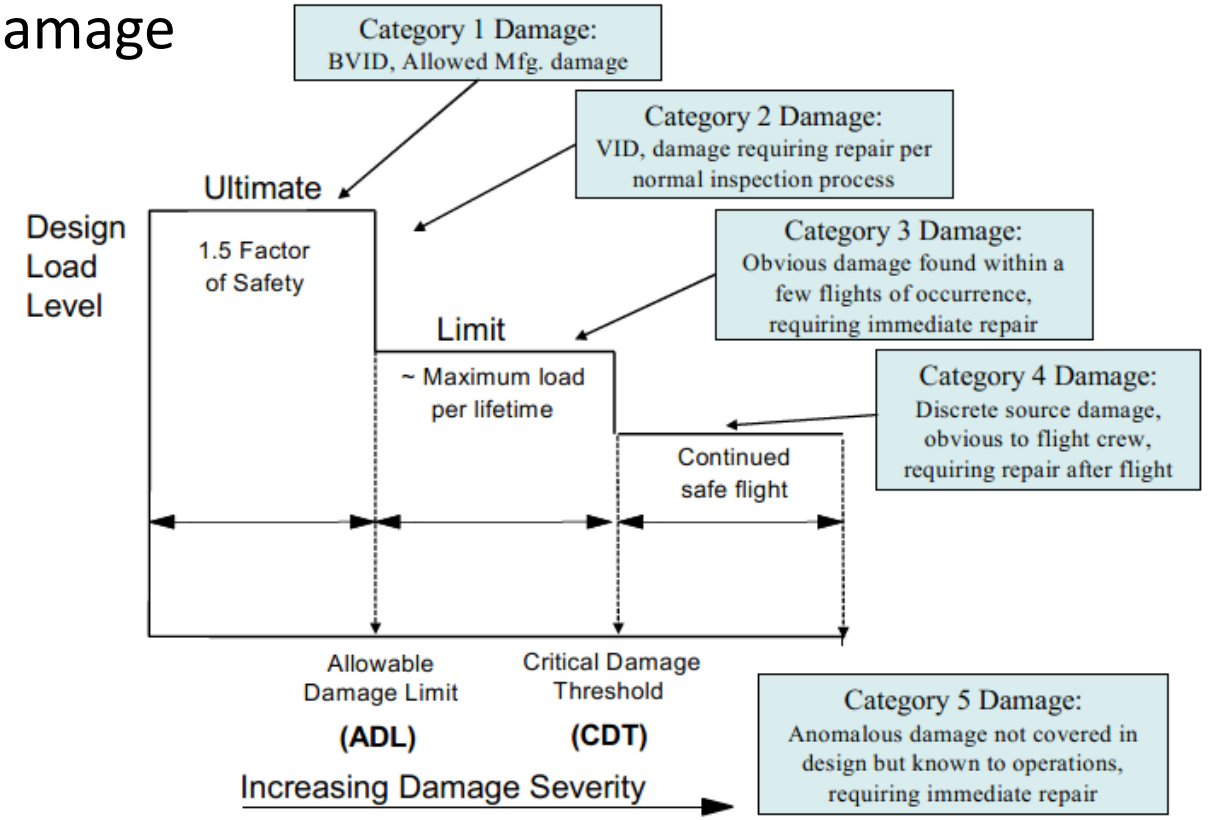
- No Growth Approach
- Slow Growth Approach
- Arrested Growth Approach



FAA: AC20-107B *Advisory Circular – Composite aircraft structure*

Current guidance on damage tolerant design w.r.t. damage detection

Design loads versus categories of damage severity



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Maintenance Planning Industry Group (commercial aviation) have adopted SHM

Introduced and expanded on the A4A MSG-3 (revision 2009-1) in which a definition of Scheduled SHM (S-SHM) was added:

* ‘S-SHM is the act of using/running/reading out a SHM device at an interval set at a fixed schedule.’

* The structure section of the A4A MSG-3 document was revised to select S-SHM tasks and interval in lieu of classic inspections.

* Structure inspection tasks for Accidental Damage (AD), Environmental Damage (ED) and/or Fatigue Damage (FD) can be replaced by a scheduled interaction with a SHM device demonstrated to be applicable and effective.

The Case for SHM: Industry guidance

SAE International
Aerospace Recommended Practices docu
ARP6461 'Guidelines on the Implemen
of Structural Health M
Aircraft'

On sale now!


SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP6461

Issued Proposed Draft 2012-11-28

Guidelines for Implementation of Structural Health Monitoring on Fixed Wing Aircraft

RATIONALE

The development of Structural Health Monitoring (SHM) technologies to achieve Vehicle Health Management objectives in aerospace applications is an activity that spans multiple engineering disciplines. It is also recognized that many stakeholders: Regulatory Agencies, Airlines, Original Equipment Manufacturers (OEM), Academia and Equipment Suppliers are crucial to the process of certifying viable SHM solutions. Thus a common language (definitions), framework for solution types, and recommended practices for reaching those solutions, are needed to promote fruitful and efficient technology development.

TABLE OF CONTENTS

STRUCTURES DESIGN AND MAINTENANCE

Structures Maintenance Principles

SG-3 Document

AC 121-22 "Maintenance Review Board Procedures"

r Instructions for Continued Airworthiness

ummary

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

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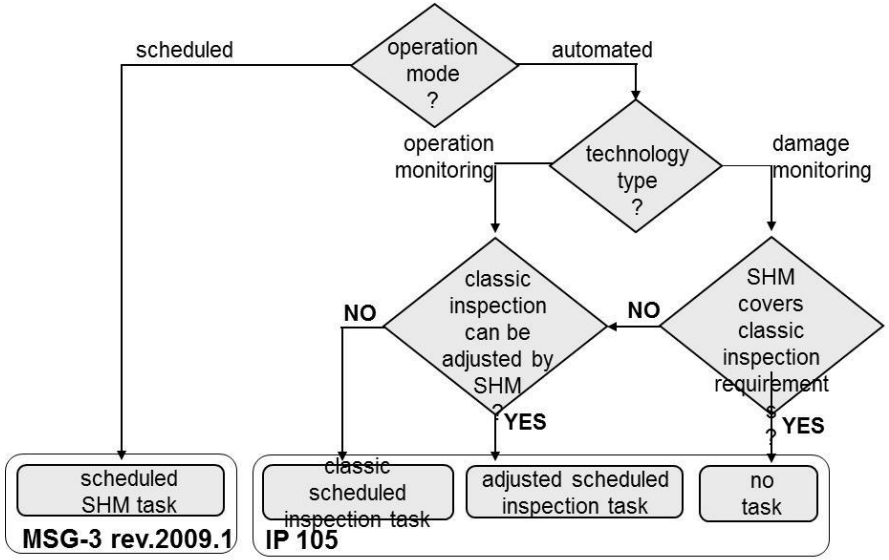
SHM in MSG-3 IP105

SHM Operation Mode

- *Scheduled SHM (S-SHM) – from IP92, no change*
- *Automated SHM - SHM technology which does not have a pre-determined interval at which maintenance action much takes place, but instead relies on the system to inform maintenance personnel that action must take place*



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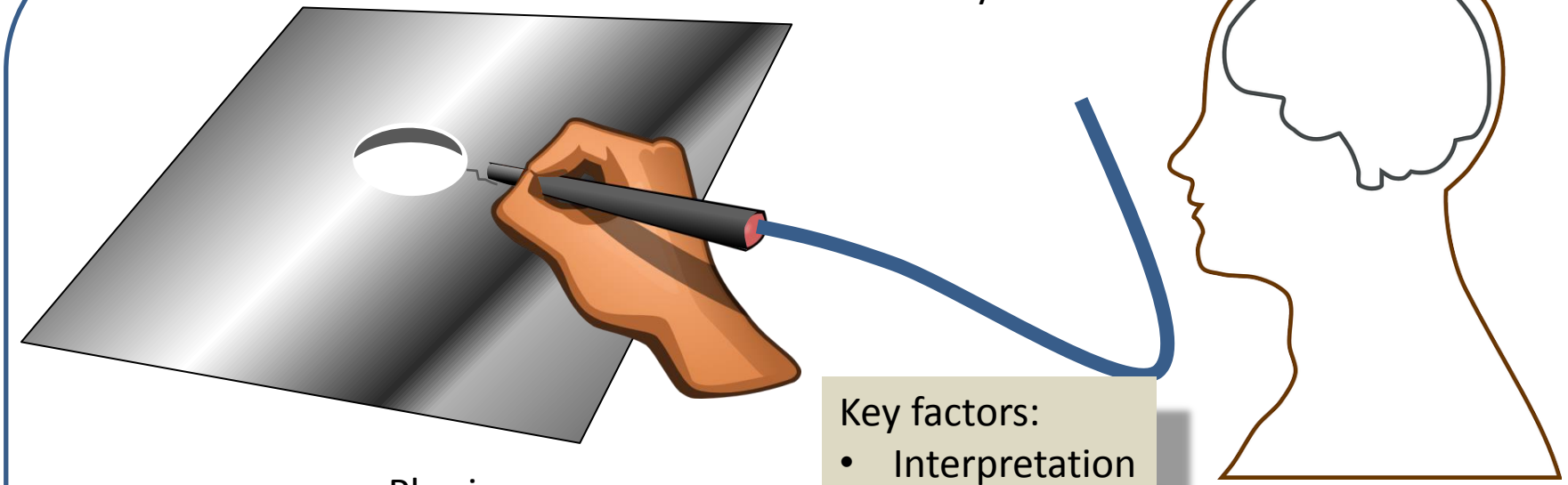
SHM is not like NDT……

NDT is a human activity



Physics

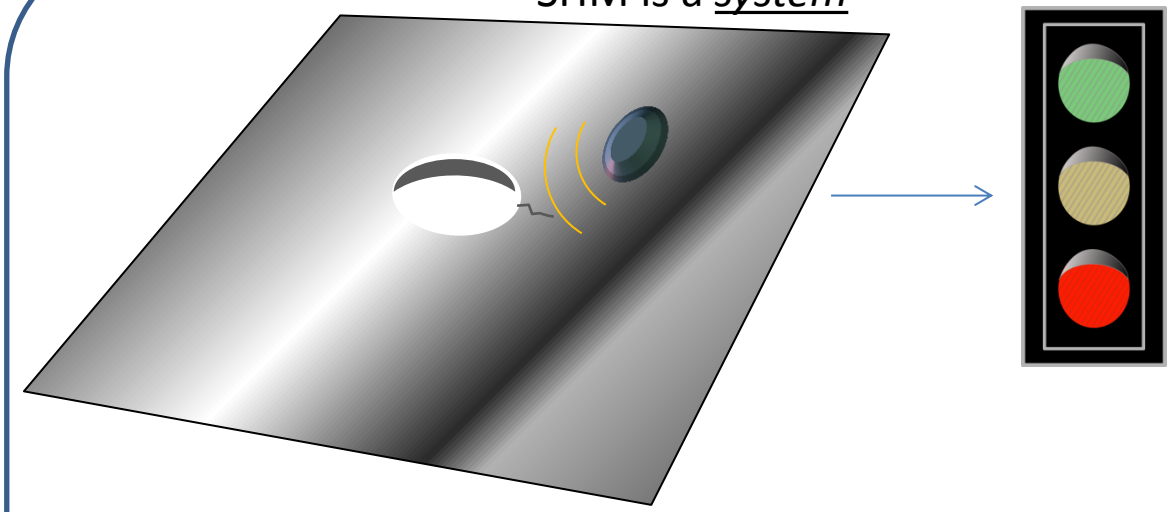
Key factors:

- Interpretation
- Knowledge
- Skill
- Training

Human performance is a critical, parameter in the activity

SHM is not like NDT……

SHM is a *system*



Physics

Is the major parameter in the system

Key factors:

- System specification
- System design
- System validation
- System verification

To PoD or not to PoD

- SHM *can* provide deterministic damage indicators.
- Challenge to technologists: ‘what is the largest size of defect (of arbitrary morphology, under full envelop of conditions) that can be missed with your technique?’
- Then specify the performance

To PoD or not to PoD

- SHM *is a system just like any other a/c system (e.g. BIT in flight critical avionics)*

- Concentrate on the physics of the interaction between defect and sensor. Demonstrate deterministic relationships between flaw dimension and SHM response.
- SHM installations for specific monitoring tasks can then be designed based on this capability.
- Detection sensitivities need not be as high as NDT because there are limitless inspection opportunities with SHM.
- For example, critical flaw sizes can be large in damage tolerant structures e.g. assumption of failed stiffeners in non-inspectable regions: the Large Damage Capability criteria)

Current state of the art implementation of SHM in commercial aircraft operations.

- See the following URL for decsirption of SHM installation in Delta Boeing 737 fleet.
- http://www.smsystems.com.au/_content/documents/928.pdf