FAA Structural Health Monitoring SHM

Presented to: Airlines for America NDT Forum

By: Paul Swindell

Date: 19 September 2018

Federal Aviation Administration

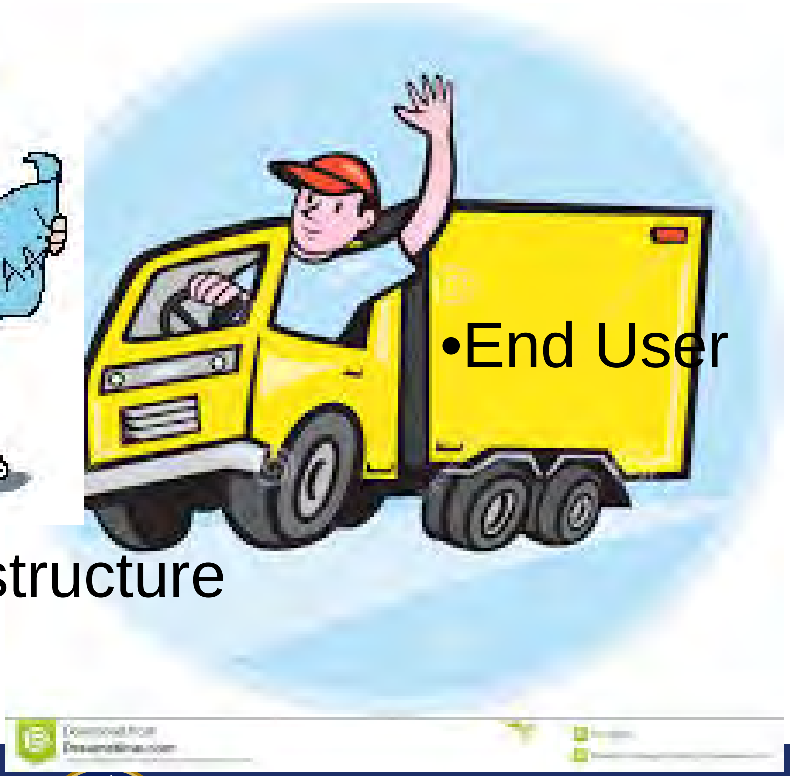
Outline

- Past
- Present
- Future
- Conclusion

•Paving the Path for SHM Innovation

FAA

•SHM programs & guidance



•End User

•Building the Infrastructure

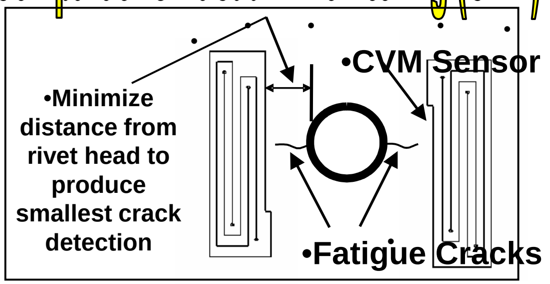
Past

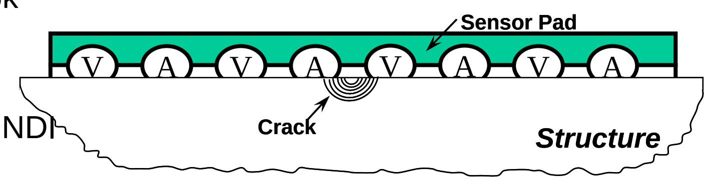
- **Why does the FAA care about SHM?**
- **Transport Standards Branch (Transport Aircraft Directorate)**
  - Certification Issues
- **FY11 with AANC**
- **Started with survey, review of SHM capabilities, gap analysis**
- **Perform a mock certification**

Past-Emerging Technologies

- Objective: Partner with the AANC, Delta Air Lines, SMS/AEM and Boeing to conduct trial SHM certification & integration activity
- Application: Boeing737 NG Wing Box fitting cracking problem as application Boeing issued a service bulletin as a result of cracking after 21k cycles
- Accomplishments:
  - Install on Delta's 737-700 Fleet going thru Atlanta for 5 ½ day checks (6k cycles)
  - 7 aircraft completed in Feb/March 2014
  - Delta collected CVM data every 90 days as well as performing required NDI inspection
  - Boeing approved CVM Dec 2015 use –updated SB - June 2016
  - Review CVM project against SAE guidelines and determine what has been validated
  - Assess FAA rules and determine if adequate for SHM use
- Outcome:
  - Ensure safe implementation of emerging technologies
  - Develop FAA webinar for FAA ACO engineers
  - Delta/Boeing investigating further SHM numerous platforms

•Comparative Vacuum Monitoring (CVM)





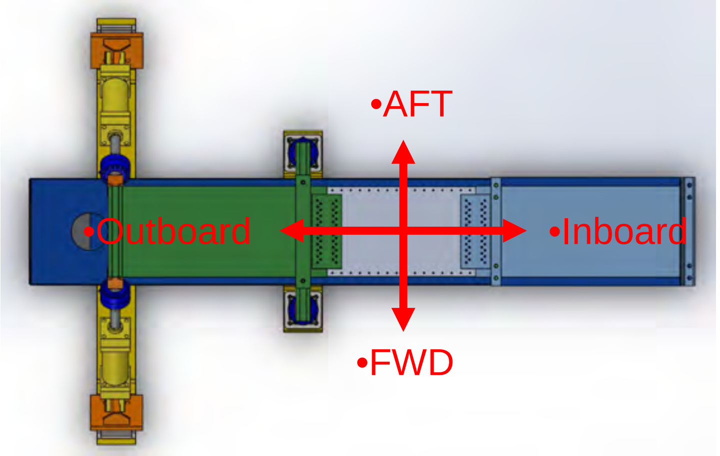
•Monitoring Cracks in B737 Wing Box Fitting

SAE AISCSHM Committee

- **Develop standards for SHM for aviation community**
- **ARP6461 "Guidelines for Implementation of Structural Health Monitoring on Fixed Wing Aircraft" published Sept 2013**
- **Probability of Detection area of concern**
- **Reliability workshop April 2015 to determine path forward**
- **Developed 2 POD methodologies for SHM**
- **ARP being developed for POD**
- **Planning a second workshop in 2019**
  - Develop the test program for validation of the methodologies
  - Develop useable data for public use

Present-Emerging Technologies

- **To provide SHM capability to the TC Labs:**
  - Emerging Technologies (Al-Li Panels)
  - Wing Box (ABST)



- **To assess SHM capabilities and collect data**

Full-Scale Aircraft Structural Test Evaluation and Research (FASTER)

•History and Background:

Established: Dec. 1998 through partnership with Boeing

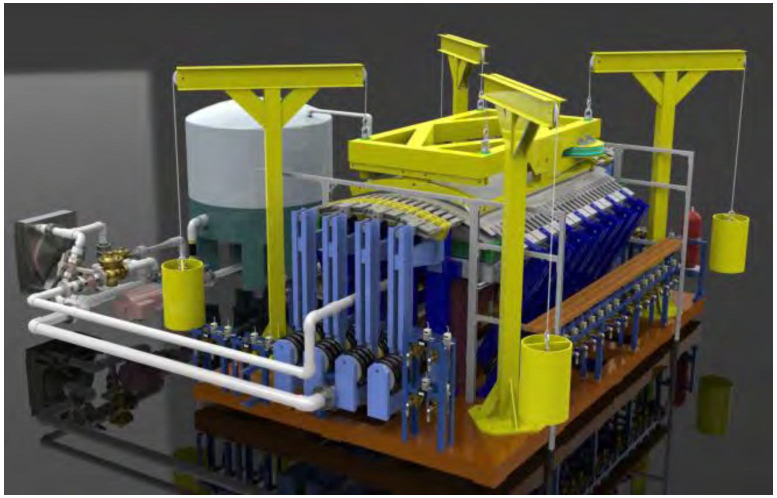
•Applies Major Modes of Loading to Fuselage Panels:

–Pressure

–Hoop

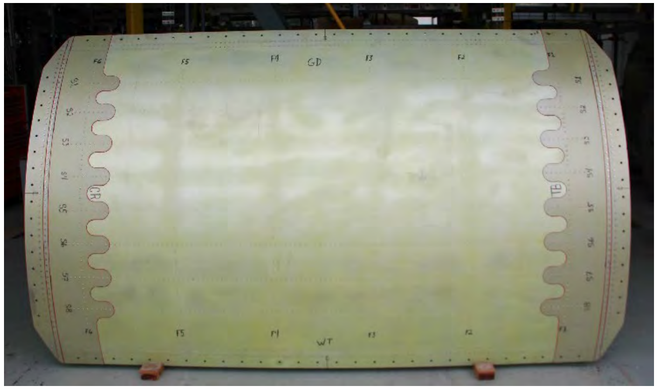
–Axial

–Shear



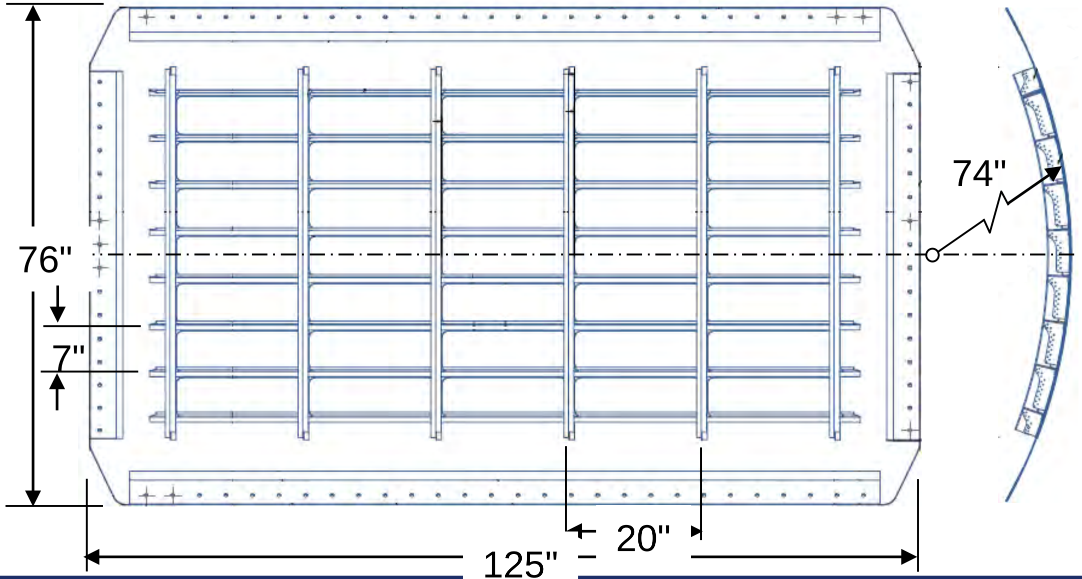
Baseline Panel Design

•Internal View



•External View

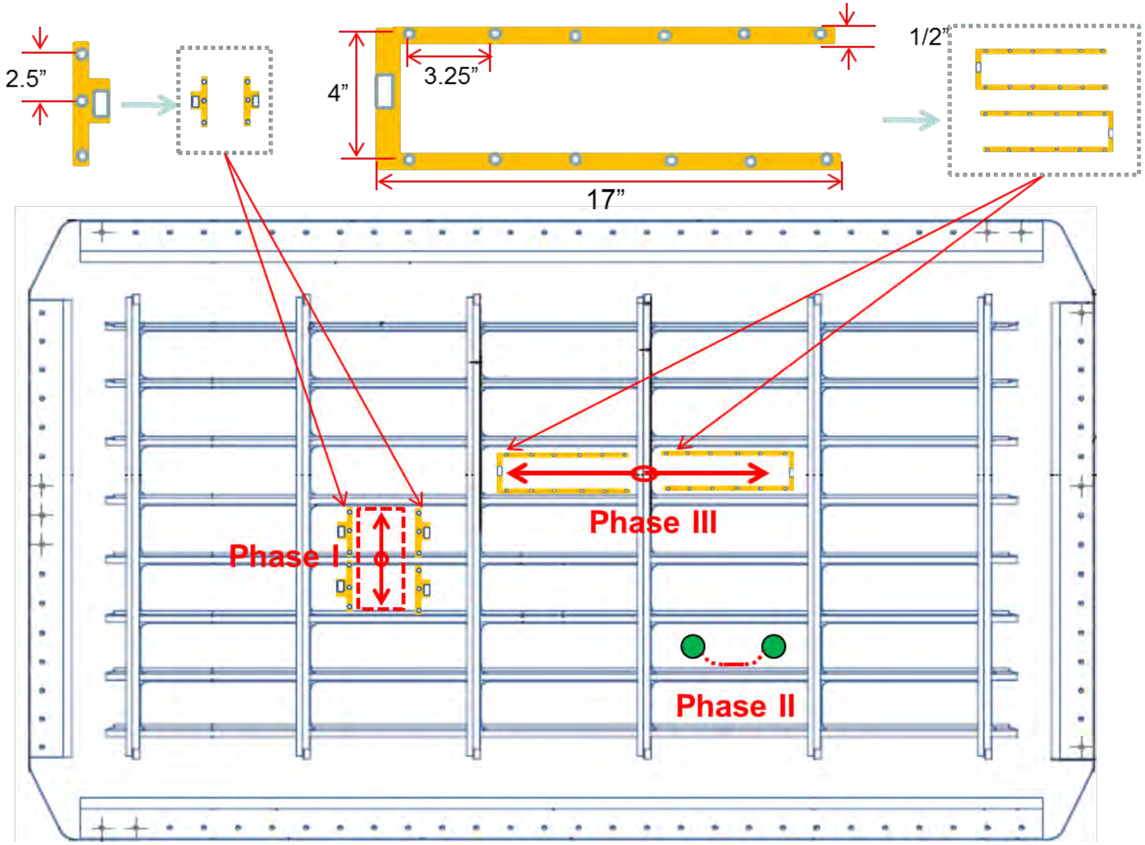
Panel Length	125 inch
Panel Width	76 inch
Panel Radius	74 inch
No. of Frames	6
No. of Stringers	8
Frame Spacing	20 inch
Stringer Spacing	7.0 inch
Skin Thickness	0.055 inch



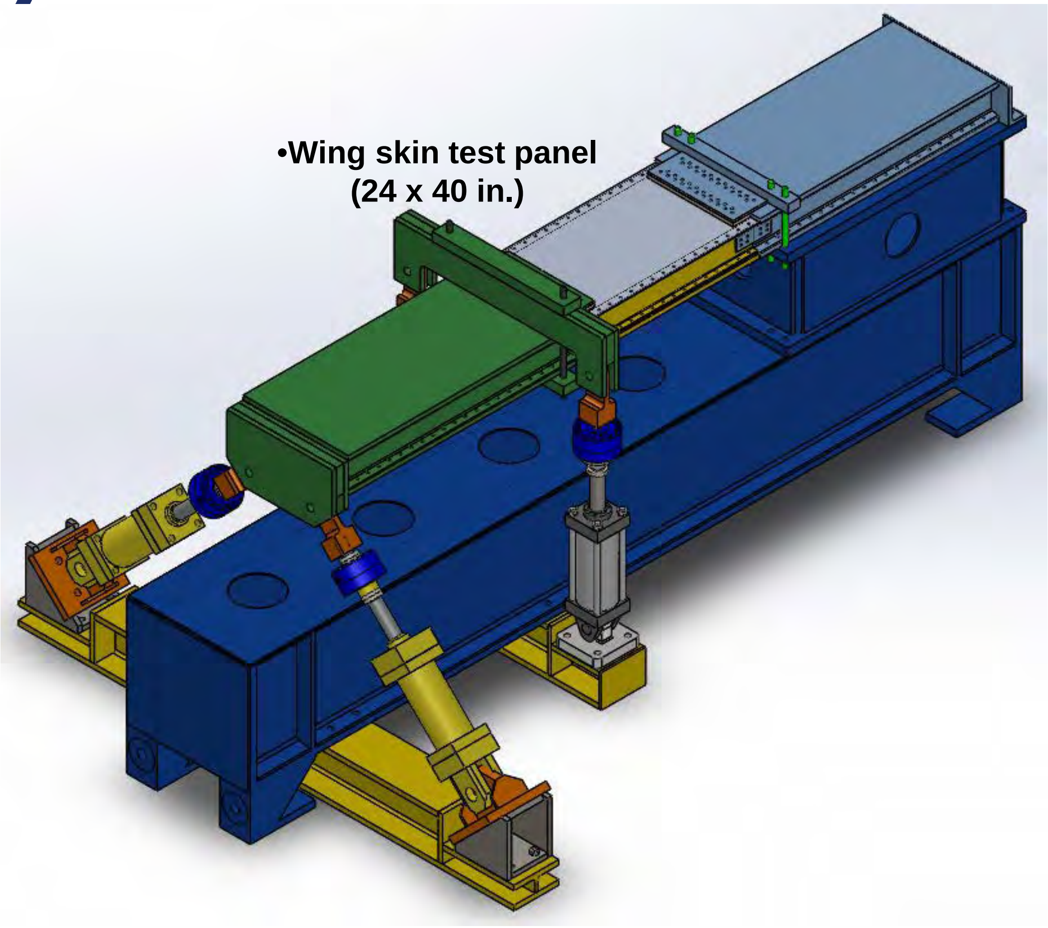
Test Matrix – Panels

Component		1 Baseline	2 Advanced Density Reduction	3 Advanced Materials	4 Advanced Materials, FSW	5 FSW and Bonded Stringers	6 Baseline MSD	7 Advanced Density Reduction MSD
Component	Skin	2524-T3 sheet	2060 - T8 Al-Li sheet	2029-T3 sheet	2029-T3 sheet, FSW	2060 Al-Li sheet, FSW joint and bonded FML straps	2524-T3 sheet	2060 - T8 Al-Li sheet
	Stringer	7150 extrusions, riveted	2055 or 2099 Al-Li extrusions, riveted	2055 or 2099 Al-Li extrusions, riveted	2055 or 2099 Al-Li extrusions, FSW	2055 or 2099 Al-Li extrusions, bonded	7150 extrusions, riveted	2055 or 2099 Al-Li extrusions, riveted
	Frame	7075-T62 - shear tied, extruded, riveted	2055 or 2099 Al-Li integral extrusions, riveted	2055 or 2099 Al-Li integral extrusions, riveted	2055 or 2099 Al-Li integral extrusions, FSW	2055 or 2099 Al-Li integral extrusions, riveted	7075-T62 - shear tied, extruded, riveted	2055 or 2099 Al-Li integral extrusions, riveted

SHM INSTALLED ON PANEL 1



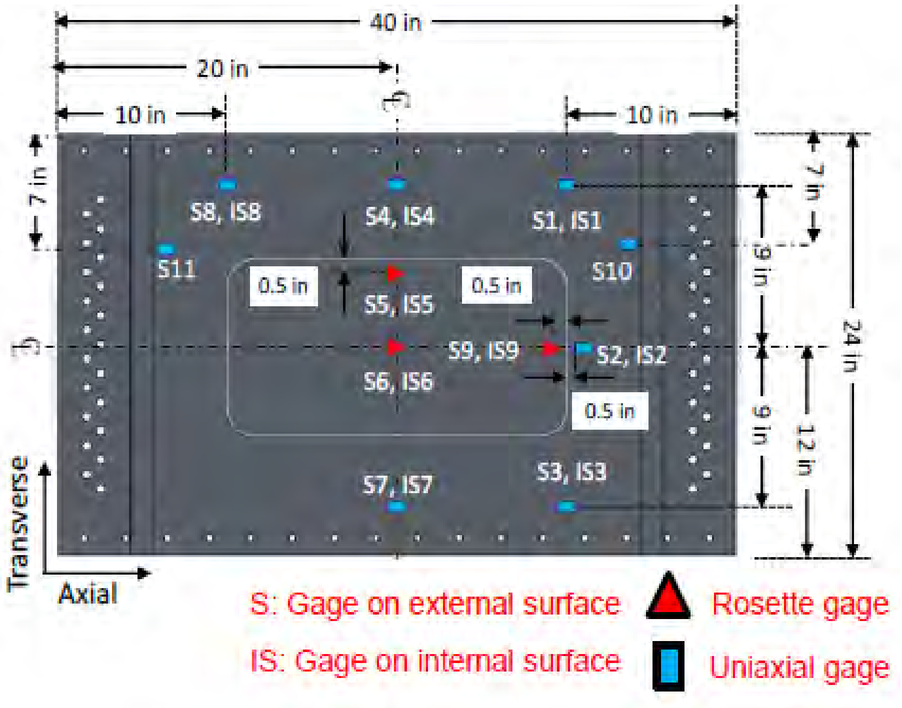
Airframe Beam Structural Test (ABST) Fixture

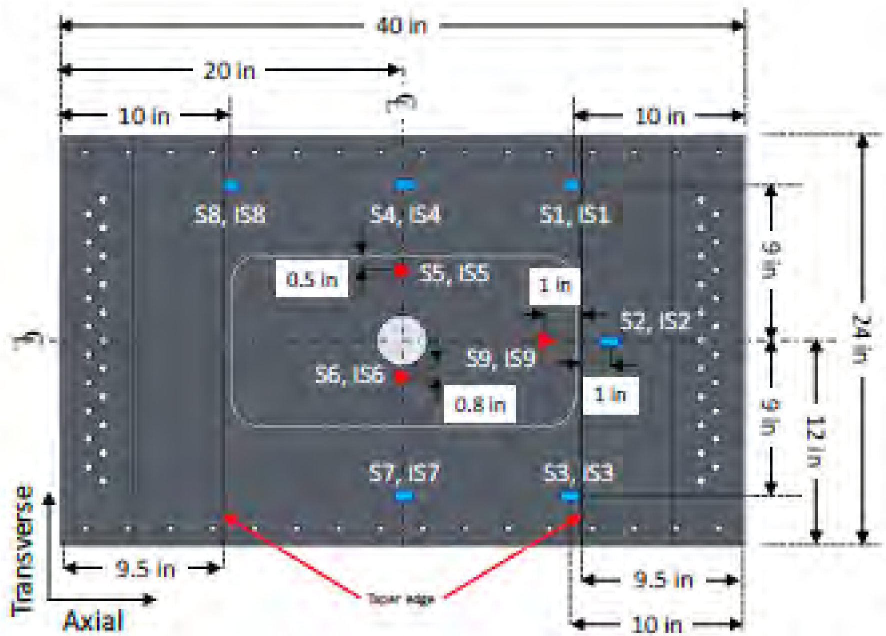


ABST Test Program

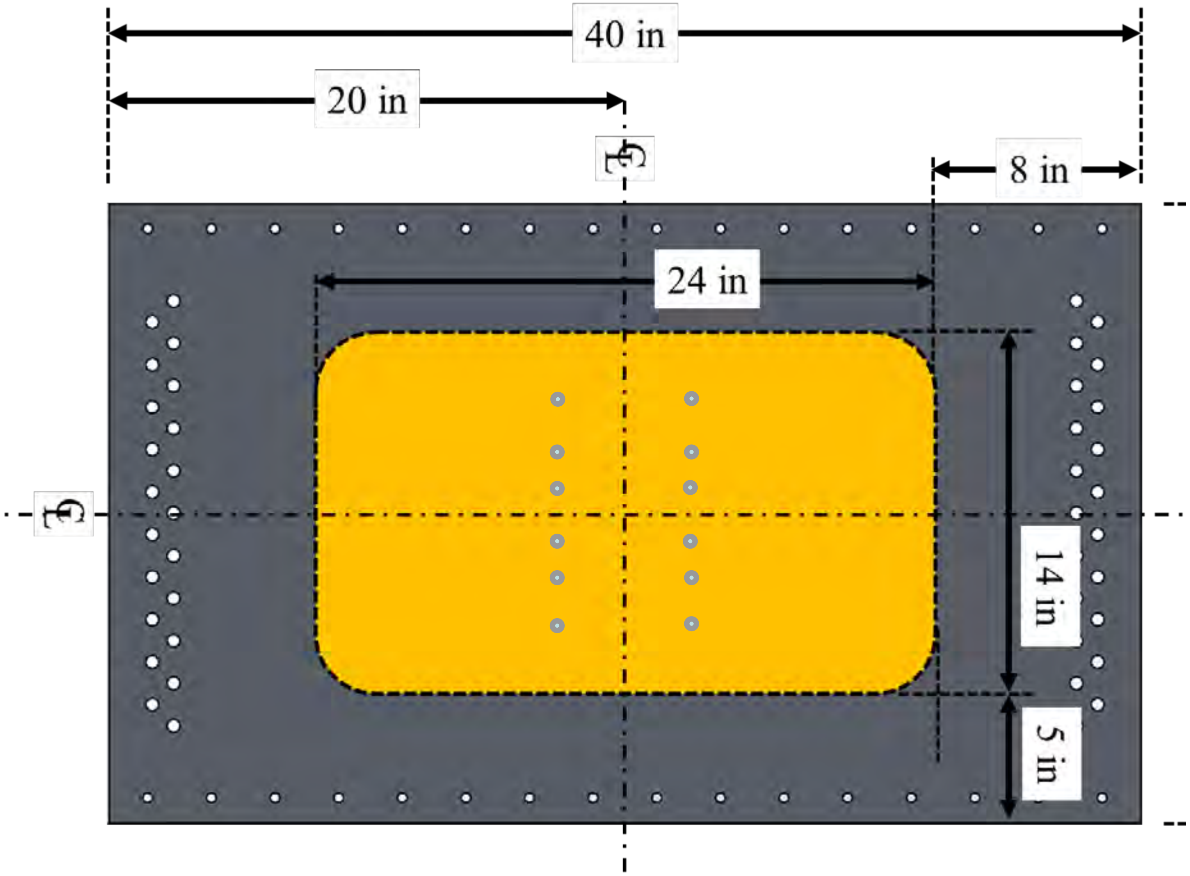
- Phase 1: Baseline mechanical and fatigue behavior of
- composite panels (pristine and open hole)
- Phase 2: Bonded Repair Size Limits
- Phase 3 (proposed): Fatigue and DT performance of bonded repairs intentional made deficient to encouraging damage growth
  - Calibrate analysis methods
  - Assess NDI and SHM to detect and monitor damage growth

Phase 1: Panels 1 and 2





SHM Sensor Layout-PZT



Future: Reliability

- Developed 2 methodologies for POD for SHM
- Data from FASTER and ABST tests may be of use to this effort
- Working with NASA to develop a model of the FASTER test fixture with SHM
- Working with SAE to develop industry std

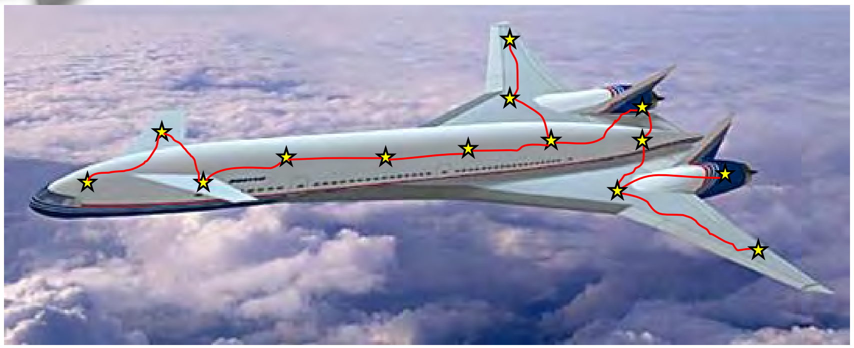
Conclusion

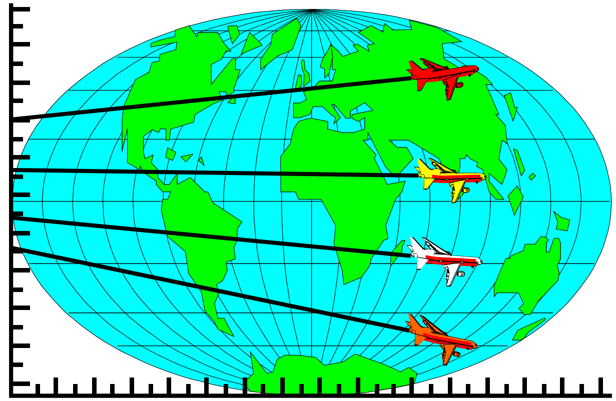
- **Boeing/Delta/AANC met in January 2018 in Seattle to discuss future SHM applications: SB - AD.**
- **SHM: "in situ" NDI. Equal or better. No new guidance needed. Evaluate on case by case basis.**
- **Dual inspections still required when SHM replaces NDI**

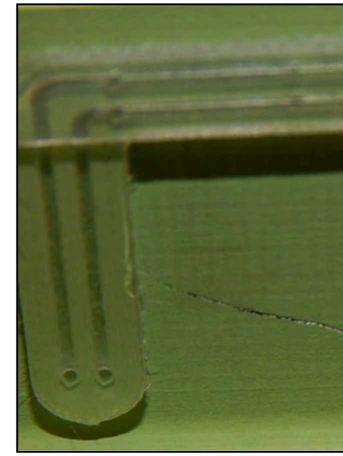
Questions

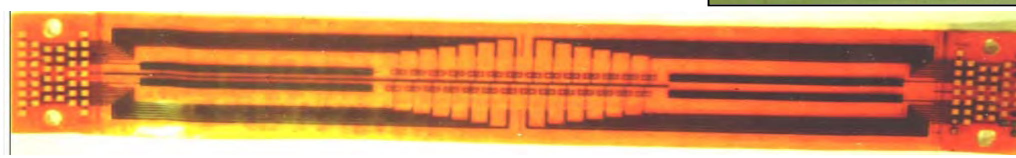
- Paul.Swindell@faa.gov
- William J Hughes Technical Center
- Atlantic City, NJ
- 609-485-8973

SHM Utilization – Validation, Certification and Airline Perspective for Implementation









DELTA

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Paving the Path for SHM Innovation

Building the Infrastructure

NDI vs. SHM – Definition

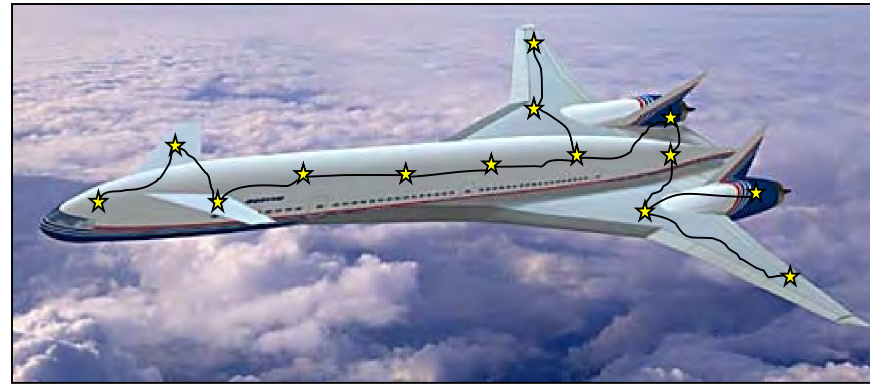
Nondestructive Inspection (NDI) – examination of a material to determine geometry, damage, or composition by using technology that does not affect its future usefulness

- High degree of human interaction
- Local, focused inspections
- Requires access to area of interest (applied at select intervals)

Structural Health Monitoring (SHM) – "Smart Structures;" use of NDI principles coupled with in-situ sensing to allow for rapid, remote, and real-time condition assessments (flaw detection); goal is to reduce operational costs and increase lifetime of structures

- Greater vigilance in key areas – address DTA needs
- Overcome accessibility limitations, complex geometries, depth of hidden damage
- Eliminate costly & potentially damaging disassembly
- Early flaw detection to enhance safety & facilitate less costly repairs
- Minimize human factors with automated data analysis
- Move towards condition-based maintenance

Structural Health Monitoring



Structural Damage Sensing (in-situ NDI)

Structural Models and Analyses

Loads and Environmental Monitoring

Reasoner

Structural Health

Prognostic Health Management

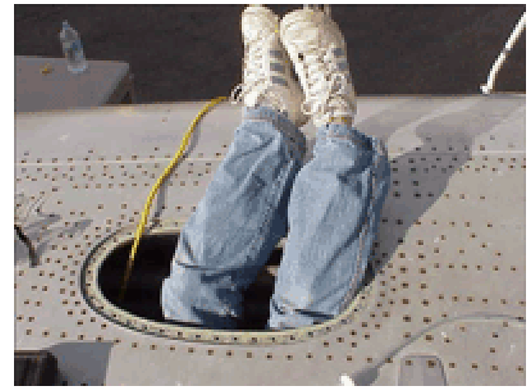
SHM for:

- Flaw detection
- Flaw location
- Flaw characterization
- Condition Based Maintenance

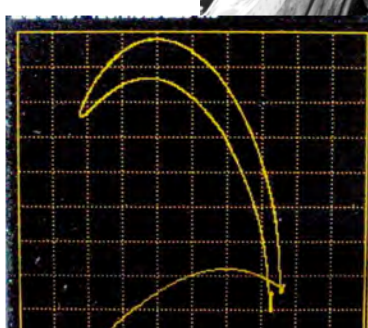
SHM Solutions & NDI Challenges

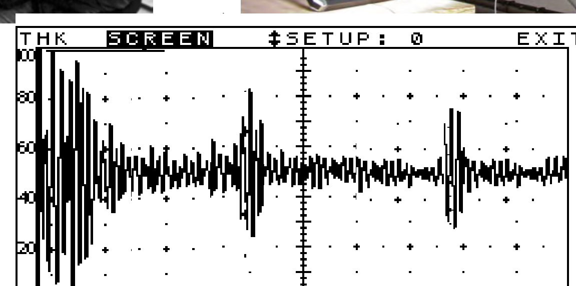
Difficulty in loads assignment, stress and fatigue calculations produces demands on NDI - **“You want me to find a flaw where, and how small??”**

Difficult Conditions



Lots of Rapid Data Interpretation





Structural Health Monitoring – Integration into Routine Maintenance

Sandia National Laboratories — Dennis Roach, Tom Rice, Stephen Neidigk

Federal Aviation Administration — Paul Swindell, Dave Galella, Ian Won, Mark Freisthler

Delta Air Lines — David Piotrowski, Alex Melton, John Bohler, Joe Reeves, Chris Coleman, John Hays

Air Canada — Bernie Adamache, Joe Zee

Boeing — Jeff Kollgaard, JB Ihn, Walt Jarecki, John Linn, Matt Miller, Mike Wineland

Structural Monitoring Systems — Toby Chandler, Mike Reveley

Anodyne Electronics Manufacturing Corp. (AEM) — Trevor Lynch-Staunton, Henry Kroker, Brian Shiagec, Dave Veitch

Sikorsky — Mark Davis, Andrew Brookhart, Preston Bates, Ray Beale

Transport Canada — John Mitchell, Hin Tsang, Maurizio Molinari, Marc Lord

Embraer — Ricardo Rulli, Fernando Dotta, Paulo Anchieta, Luis Santos

Acellent — Amrita Kumar, Fu-Kuo Chang, Howard Chung, Franklin Li

Bombardier — Jérôme Pinsonnault, Colin Vollrath, Yves Theriault

Testia (an Airbus Group company) — Holger Speckmann

Airbus — Clemens Bockenheimer, Benjamin Eckstein, Marie-Anne De Smet, Lorenz Wenk

Azul Linhas Aéreas Brasileiras, KLM, Air France, Ryanair, United Airlines, Southwest Airlines

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Synopsis of CVM Validation/Utilization Programs Supporting Safe Adoption of SHM Systems

Timeline

2005 — FAA: General SHM Validation

- Assess performance for fuselage applications
- Lab & field testing
- CVM adoption into Boeing NDT Standard Practices Manual

2008 — FAA: SHM R&D Roadmap

- Industry survey
- SHM TRL assessment
- Industry perspectives
- Validation methodology
- Considerations for regulatory guidance

2010 — FAA: SHM for Commuter Aircraft

- Trial on known damage prone area
- Successful detection on-aircraft
- Transport Canada participation
- Assess repair as-needed

2012 — Embraer: Certification for Families of SHM

- CVM & PZT usage over range of A/C applications
- Quantify performance
- Use approval via SBs
- ANAC & FAA interface

2014 — FAA: SHM Certification & Adoption by Airlines

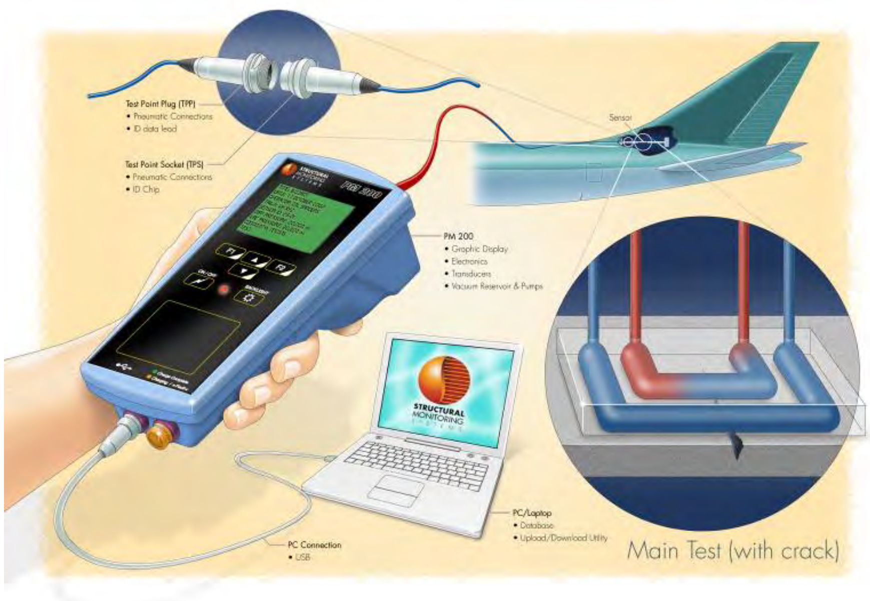
- Specific CVM application
- Joint with FAA, Sandia Labs, Delta Air Lines & Boeing
- Formal validation & flight tests
- CVM added to NDT Manual
- SB released – first routine use of SHM

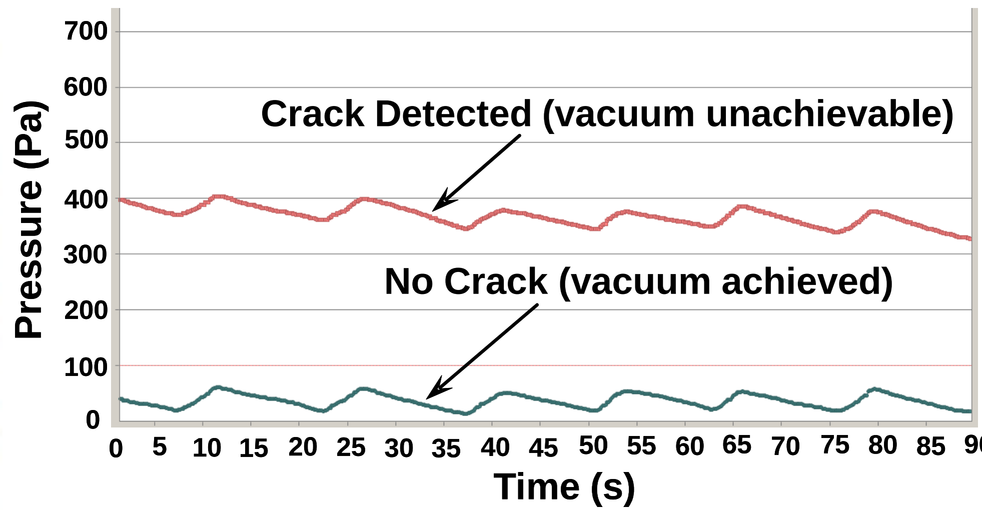
2016 — FAA: SHM for Rotorcraft

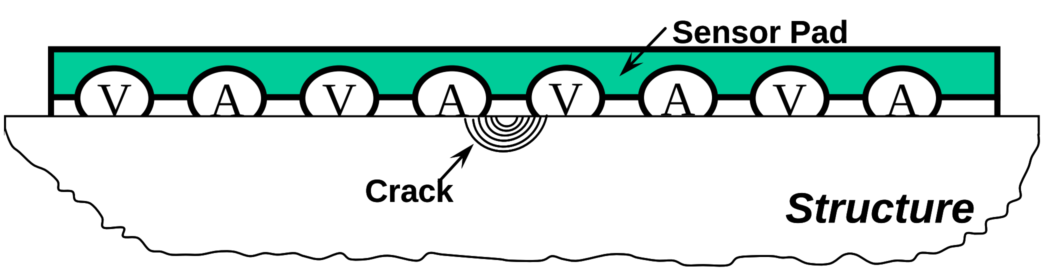
- Validation of local & global SHM approach
- Process for routine use
- Integration into rotor maint.
- Mock certification with FAA
- Integration into HUMS

Comparative Vacuum Monitoring System

- Sensors contain fine channels - vacuum is applied to embedded galleries so no electrical excitation required
- Overcome accessibility problems - real-time information or more frequent, remote interrogation

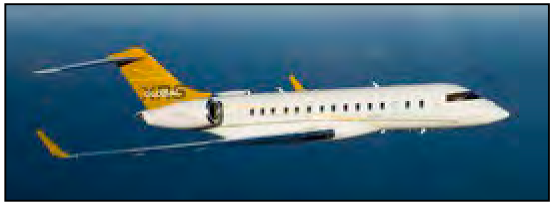




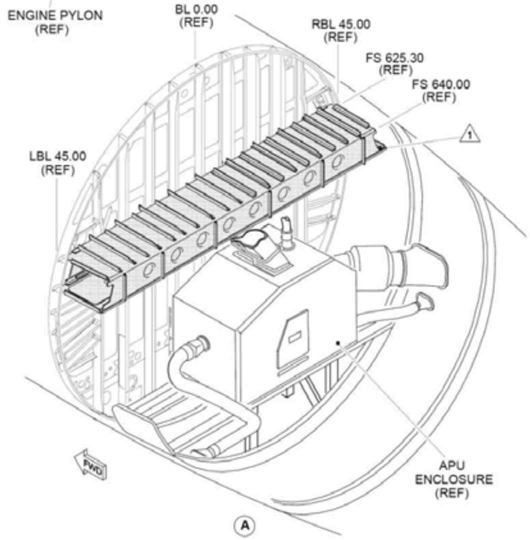


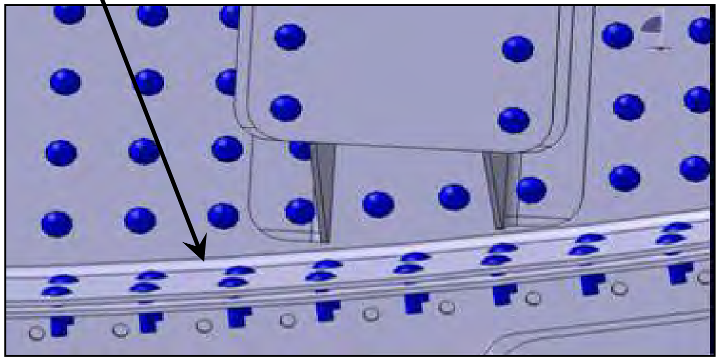
Crack Engaging CVM Sensor

CVM Success on CRJ Aircraft



Pilot program with Bombardier and Air Canada

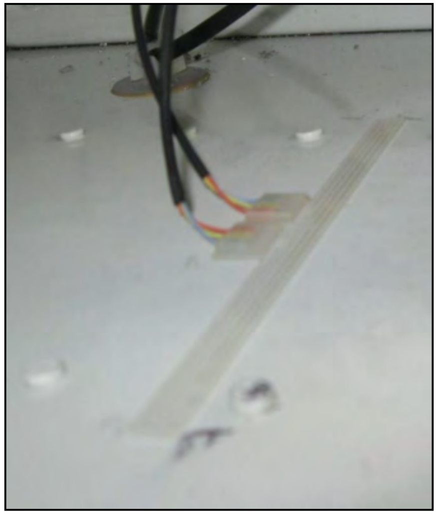


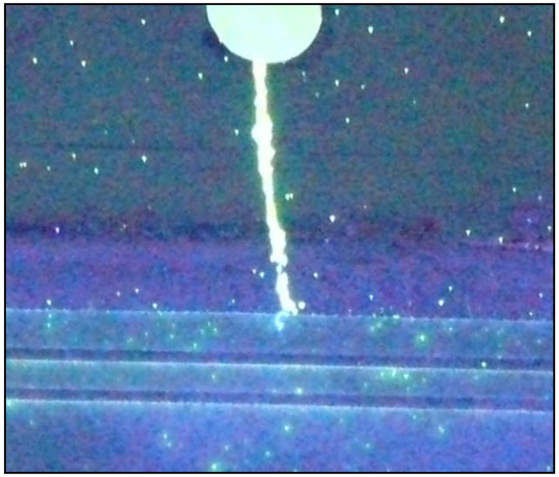


Sensor Issues:

- Design
- Surface preparation
- Access
- Connection
- Quality control

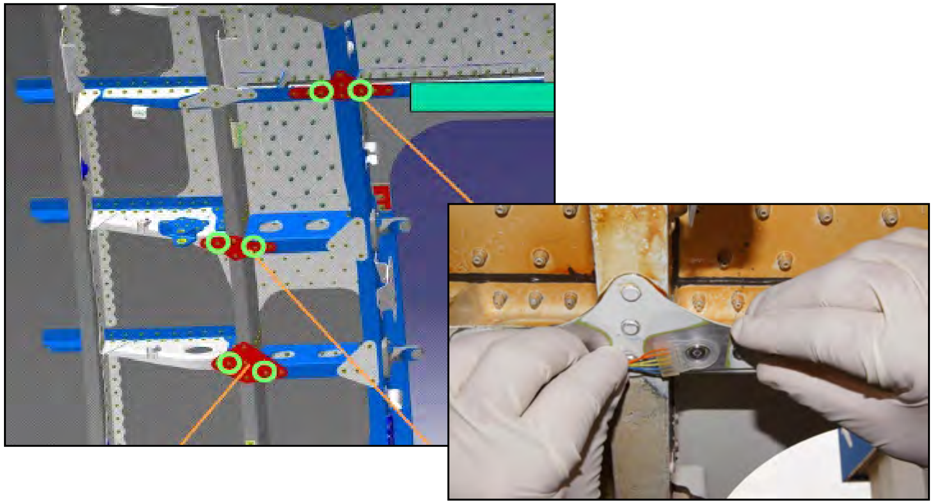
Aft Equipment Bay





Embraer Damage Detection Applications – CVM & PZT Flight Tests – Azul Aircraft PR-AYW

CVM Application on Forward Fuselage PAX Door Bracket

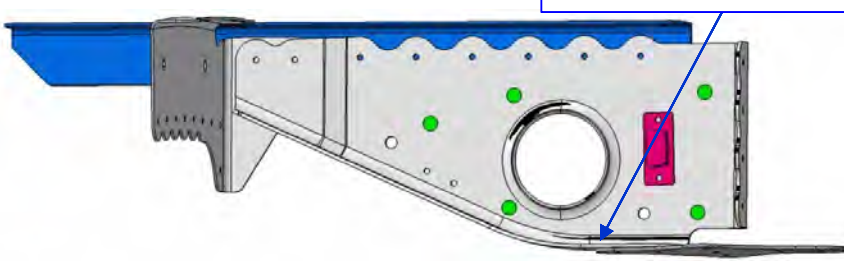


Installation Summary

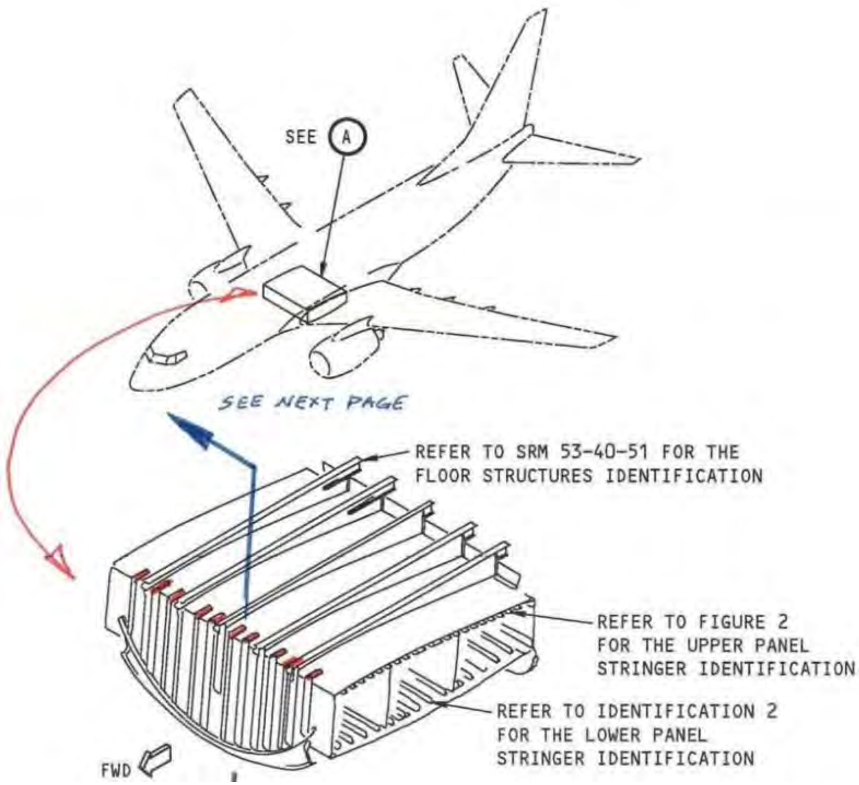
- Date of Installation: Nov 2014
- Service Bulletin: SB190-00-0029
- Zone: Central Fuselage II
- PZT & CVM on Center Fuselage End Fittings

PZT Application on Forward Fuselage PAX Door Stringer

Possible damage scenario to be monitored



SHM Certification & Integration Activity - 737 Wing Box Fitting

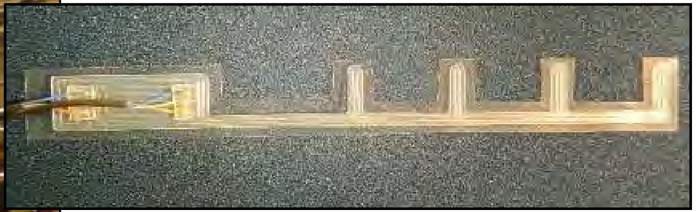


Delta-Boeing-FAA-Sandia joint effort to leverage airline activities

- **Evolve the SHM certification path – address all "cradle-to-grave" issues for airlines, OEMs, and regulators**
- **Complete SHM indoctrination and training for Delta personnel (engineering, maintenance, NDI) and FAA as needed**
- **Hardware specifications, installation procedures, operation processes, continued airworthiness instructions**
- **Complete modifications to Delta maintenance program for SHM use**
- **Assess aircraft maintenance depots' ability to adopt SHM and the FAA support needed to ensure airworthiness**

CVM Sensor Network Applied to 737 Wing Box Fittings

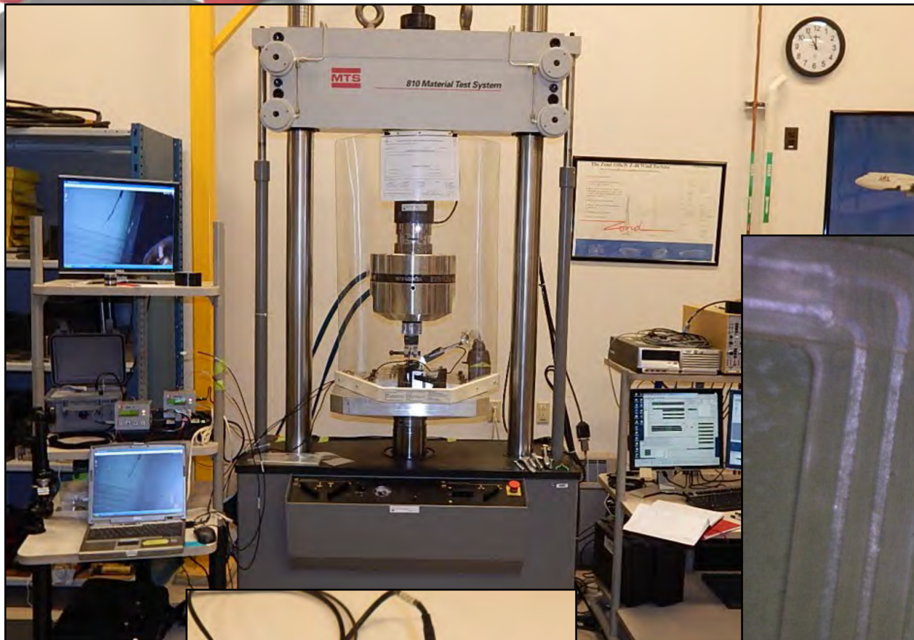
- Multiple aircraft applications addressed
- Comprehensive performance assessments completed – sensitivity, reliability, durability
- Over 50 combined years of successful operation on flying aircraft
- Formal approval from aircraft manufacturers and aviation regulators
- Reached routine use on aircraft

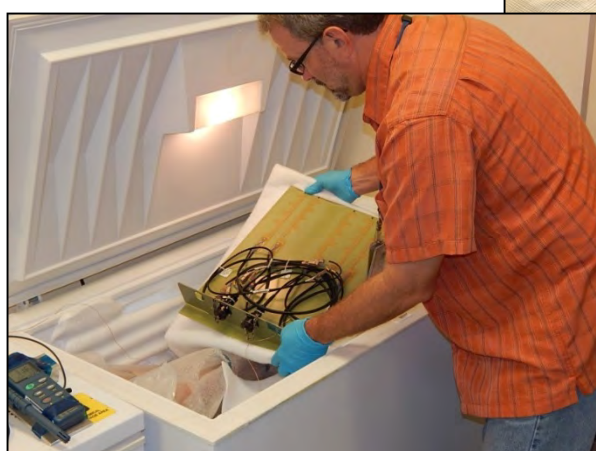


CVM Sensor

CVM Sensor Installed on Structure to be Monitored

737NG Center Wing Box – CVM Performance Tests

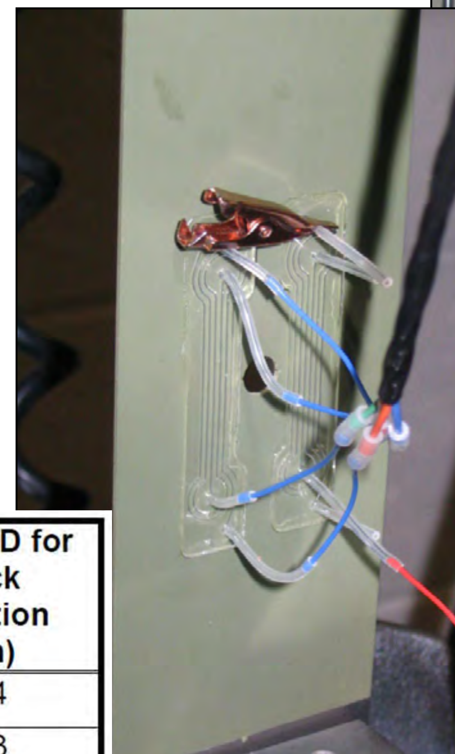


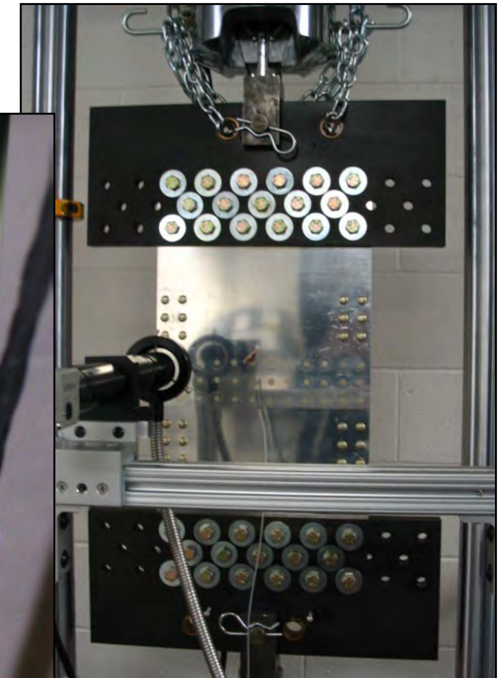


Quantifying Probability of Crack Detection

Test Scenarios:

Material	Thickness	Coating
2024-T3	0.040”	bare
2024-T3	0.040”	primer
2024-T3	0.071”	primer
2024-T3	0.100”	bare
2024-T3	0.100”	primer
7075-T6	0.040”	primer
7075-T6	0.071”	primer
7075-T6	0.100”	primer





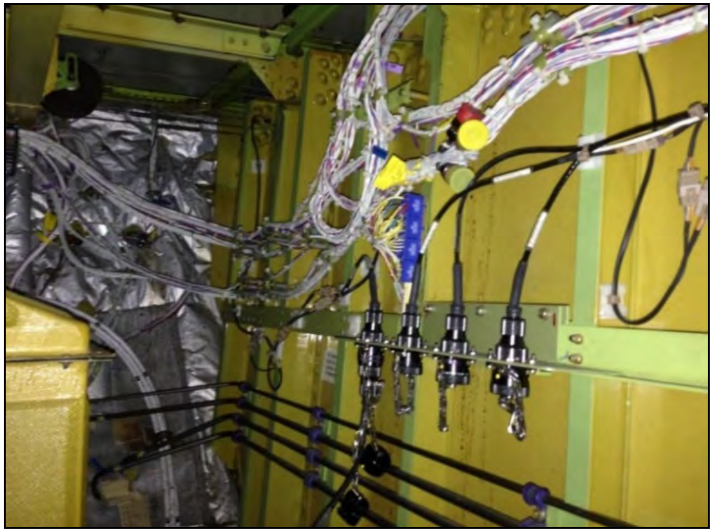
Material	Plate Thickness (mm)	Coating	90% POD for Crack Detection (mm)
2024-T3	1.02	Bare	1.24
2024-T3	1.02	Primer	0.53
2024-T3	1.80	Primer	1.07
2024-T3	2.54	Bare	6.91
2024-T3	2.54	Primer	2.29
7075-T6	1.02	Primer	0.66
7075-T6	1.8	Primer	0.84
7075-T6	2.54	Primer	0.58

Summary of Crack POD Levels for CVM Deployed on Different Materials, Surface Coatings, and Plate Thicknesses

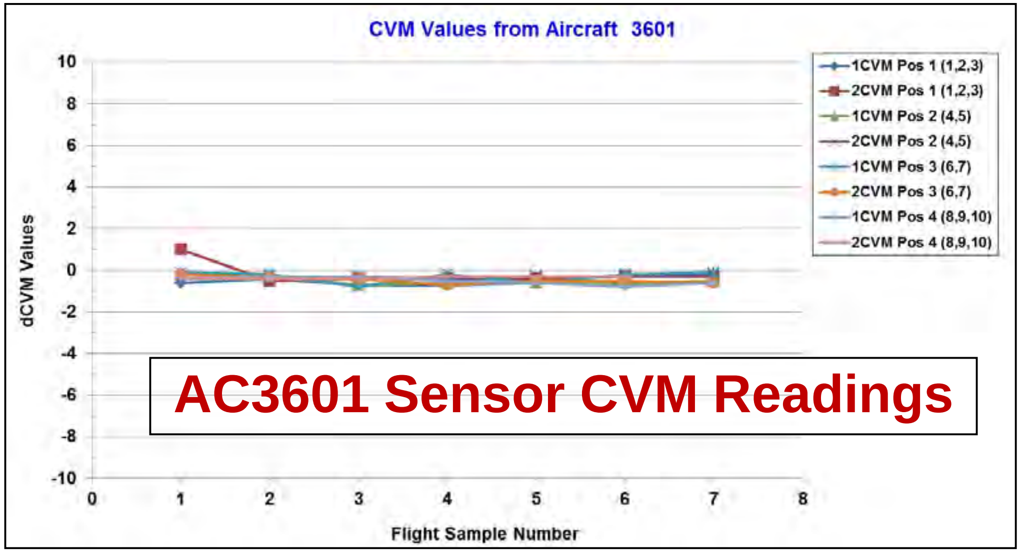
737NG Center Wing Box – Accumulating Successful Flight History

Aircraft Parked at Gate After Final Flight of the Day

Access to SLS Connectors Through Forward Baggage Compartment



Connecting SLS Leads to PM-200 to Monitoring Sensor Network



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737 NDT Manual - New SHM Chapter Published (Nov 2015)

Building Block to Approval for Routine Use of SHM

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- ☑ PART 09 - THERMOGRAPHY
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Chapter 1 – Comparative Vacuum Monitoring

737 NDT Manual – CVM Procedures Added (Jan 2016)

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Installation and Operation Instructions

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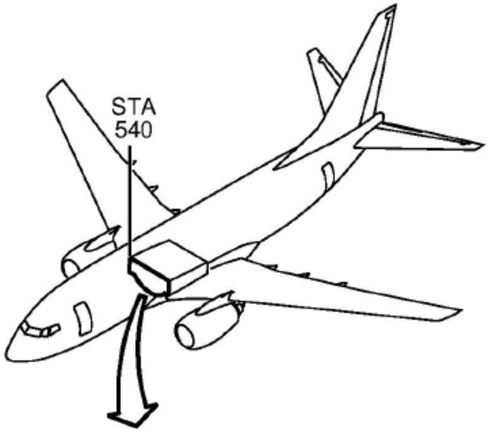
NON-DESTRUCTIVE TEST MANUAL
PART 5 - COMPARATIVE VACUUM MONITORING

Boeing Service Bulletin – Modification to Allow for Routine Use of SHM Solution (June 2016)



DO A DETAILED INSPECTION OR COMPARATIVE VACUUM MONITORING (CVM) INSPECTION OF THE CENTER WING BOX FRONT SPAR SHEAR FITTINGS FOR ANY CRACKS. IF ANY CRACK IS FOUND, REMOVE THE DAMAGED SHEAR FITTING, MAKE SURE THERE IS NO CRACKING IN THE UPPER PANEL AND INSTALL A NEW SHEAR FITTING AS GIVEN IN THIS SERVICE BULLETIN.

AT EACH SHEAR FITTING, IF NO CRACKING IS FOUND IT IS OPTIONAL TO ACCOMPLISH THE PREVENTIVE MODIFICATION BY REPLACING THE SHEAR FITTINGS.

BOEING SERVICE BULLETIN 737-57-1309

BOEING Commercial Airplanes

737
Service Bulletin

Number: **737-57-1309**
Original Issue: January 28, 2011
Revision 1: June 27, 2016
ATA System: 5714

Revision Transmittal Sheet

SUBJECT: WINGS - Center Wing Box - Front Spar Shear Fitting - Inspection, Repair and Preventive Modification

This revision includes all pages of the service bulletin.

COMPLIANCE INFORMATION RELATED TO THIS REVISION

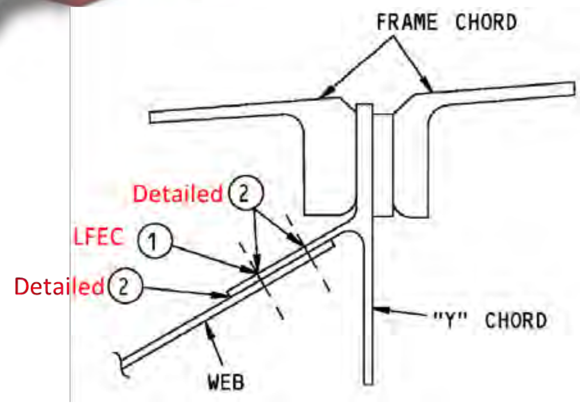
Effects of this Revision on airplanes on which Original Issue was previously done:

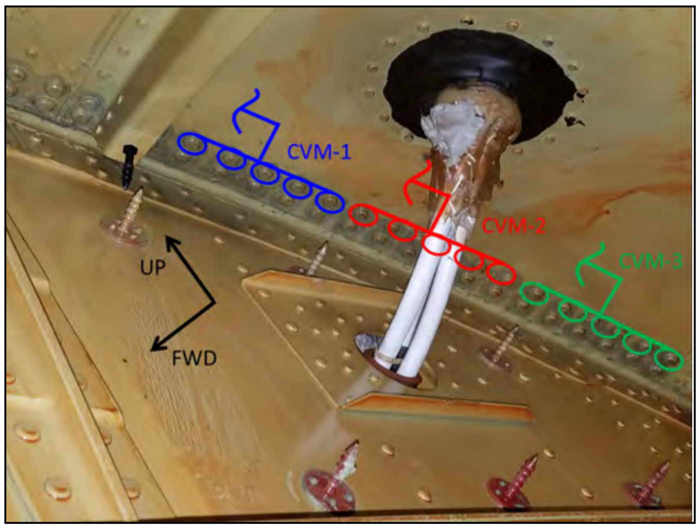
None.

REASON FOR REVISION

This revision is sent to add a Comparative Vacuum Monitoring (CVM) inspection as an alternative inspection method for the front spar shear fitting. In addition, illustrations in figures are changed to show correct views, footnotes are added in fastener tables for clarification and footnotes in figures are changed to clarify sealing instructions.

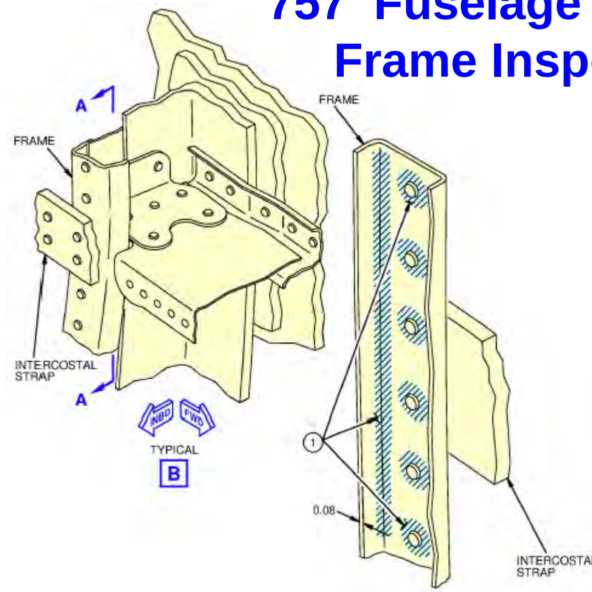
Moving Forward – Identified SHM Applications

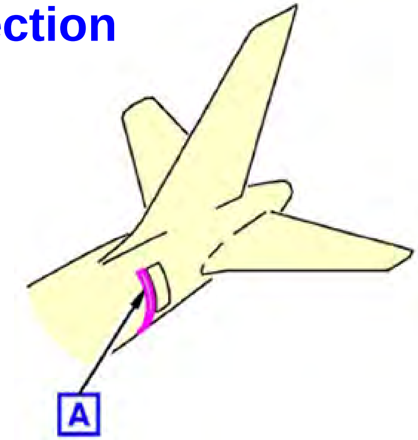


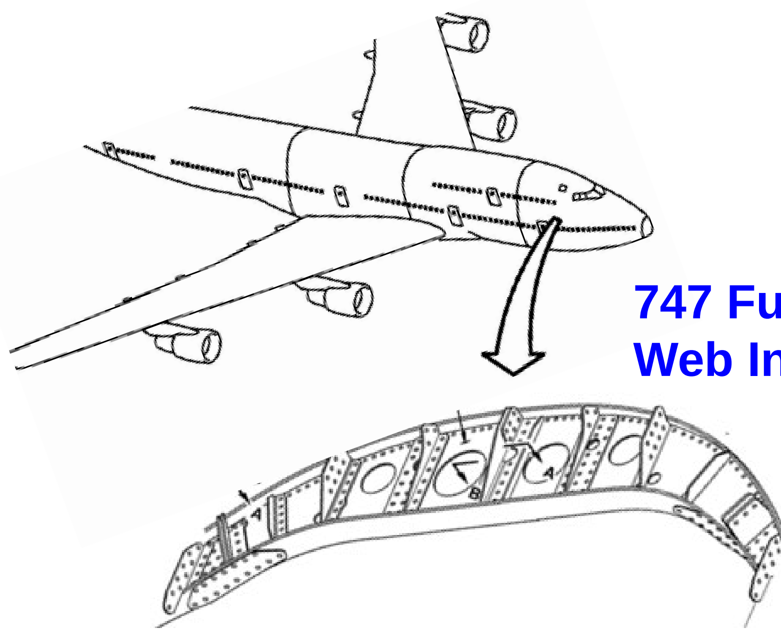


737 APB - Inspection of the Web at the "Y" Chord

757 Fuselage Section - Frame Inspection







747 Fuselage Frame - Web Inspection

FAA William J. Hughes
Technical Center

Sandia National Laboratories

Conclusions on Use of SHM Approach

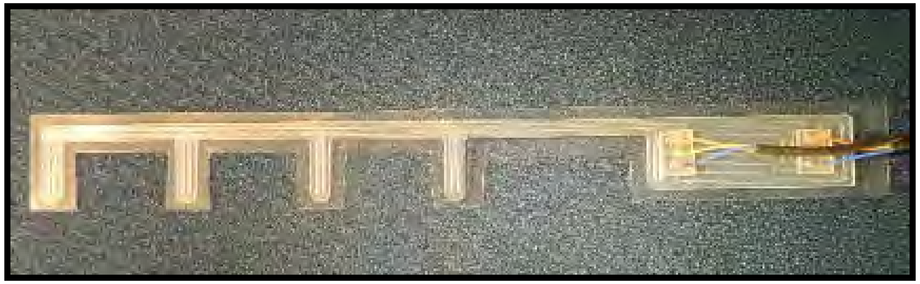
- Overall, there is a strong interest in SHM – multitude of applications covering all aircraft structural, engine, and systems areas
- Recent advances in health monitoring methods have produced viable SHM systems for on-board aircraft inspections. SHM maturity has grown exponentially so desired usage and need for certification is expected to rise rapidly.
- Sensors must be low-profile, easily mountable, durable, reliable & fail-safe
- Calibration for flaw identification (damage signatures) is key
- Validation - Reliability/POD assessments and successful flight history are necessary
- Ease of use allows for more frequent inspections – minimize repair costs
- SHM can decrease maintenance costs (NDI man-hours; disassembly) & allow for condition-based maintenance
- Application-oriented studies have led to approval for routine aircraft use & spawned larger, families of SHM applications (SHM Chapter in Boeing NDT Manual, Service Bulletins)

Conclusions on Use of SHM Approach

- **AMOC for SBs and ADs or STCs – safety driven use is achieved in concert with OEMS & regulatory agencies; approval through regulatory framework established with Delta-Boeing-FAA-Sandia program**
- **Performance Database – testing levels expected to be higher until sufficient database is obtained (ref. NDI and POD currently)**
- **Airline SHM Usage –**
  - ➢ **Proven ability to adopt SHM solutions – maintenance program mods**
  - ➢ **Delta internal Engineering Documents and Job Cards created**
  - ➢ **Education Process - personnel trained, then carried out SHM**

"SHM can be the next level of NDT"
- Delta Air Lines

Validation of a Structural Health Monitoring (SHM) System and Integration Into an Airline Maintenance Program



SHM Utilization – Validation, Certification and Airline Perspective for Implementation

Dennis Roach, Sandia National Labs
David Piotrowski, Delta Airlines
Paul Swindell, Federal Aviation Administration

Reliable structural health monitoring (SHM) systems can automatically process data, assess structural condition and signal the need for human intervention. While ad-hoc efforts to introduce SHM into routine aircraft maintenance practices are valuable in leading the way for more widespread SHM use, there is a significant need for formal SHM technology validation and certification processes to uniformly and comprehensively support the evolution and adoption of SHM practices. Such a plan must contain input from aircraft manufacturers, regulators, operators and research organizations so that the full spectrum of issues including design, deployment, performance and certification is appropriately considered. The FAA has sponsored SHM system validation programs over the years to produce quantitative assessments for sensitivity, durability, and repeatability. This has provided a database on SHM performance and laid the foundation for implementation of SHM solutions. Several aircraft manufacturers (OEMs) have embraced SHM with some even incorporating it into their NDT Manuals. This paper presents an OEM—airline-Sandia Labs-regulator effort to move SHM into routine use for aircraft maintenance procedures. This program addressed formal SHM technology validation and certification issues so that the full spectrum of concerns, including design, performance, deployment, and certification is appropriately considered.

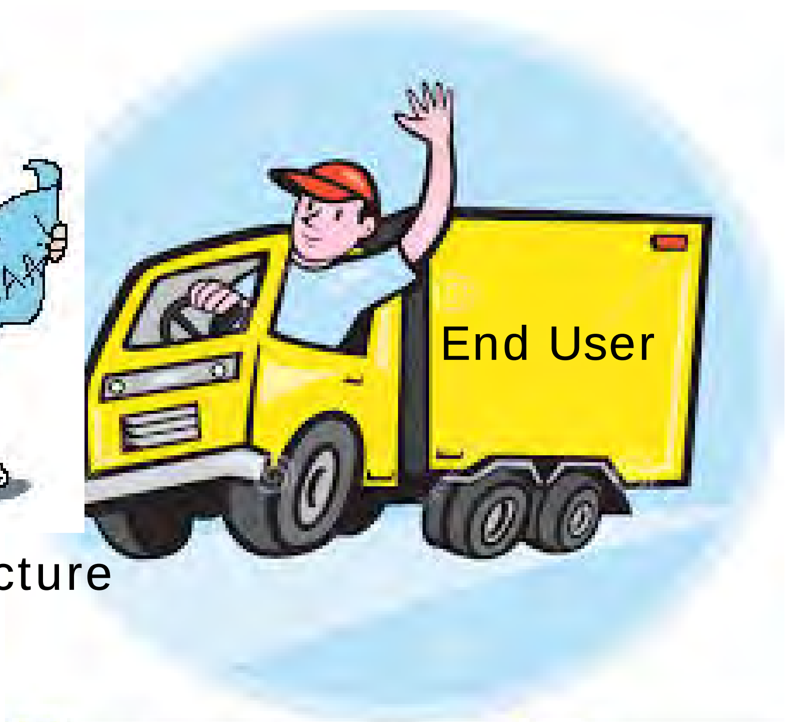
The FAA Airworthiness Assurance Center (AANC) at Sandia Labs, partnered with Delta Air Lines, the FAA, Boeing, Anodyne Electronics Manufacturing Corp, and Structural Measurement Systems on a study to develop and carry out a certification process for SHM. Validation tasks were designed to address the SHM equipment, the health monitoring task, the resolution required, the sensor interrogation procedures, and the conditions under which the monitoring will occur. Comparative Vacuum Monitoring (CVM) sensors were applied to seven B737-700s on the 10 Wing Center Section Shear Fittings, a known area of cracking. The passive system has been flown since February 2014 with periodic interrogation. The data from the flight tests were mated with a comprehensive suite of laboratory performance tests to produce a data package which ultimately led to formal approval for routine use of CVM sensors on aircraft.

Formal SHM validation also allows the aviation industry to confidently make informed decisions about the proper utilization of SHM. It streamlines the regulatory actions and formal certification measures needed to assure the safe application of SHM solutions. The activities conducted in these programs demonstrated the feasibility of routine SHM usage and supported the development of industry guidelines and advisory materials to reliably and safely allow widespread adoption of SHM across the commercial aviation industry. This paper will discuss the validation data needs for SHM approval, perspectives from regulators regarding approvals and all the process/documents needed for airlines to adopt SHM. The issues range from Financial and Strategic to Engineering and Maintenance Job Task Cards. Additionally, lessons learned from several SHM programs will be covered to assist the industry with the adoption of SHM solutions.

SHM Utilization – Validation, Certification and Airline Perspective for Implementation

David Piotrowski
Senior Principal Engineer

Paving the Path for SHM Innovation



Building the Infrastructure

So, where are we going?

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Reset

- A lot has been done, the infrastructure is in place and the **applications are available.**

- Seattle FAA meetings conclusions
  - “Hot spot” inspection is "like" in situ NDI so the FAA could address certification like it does with any NDI method.
  - Guidance being generated by AISC-SHM
  - FAA feels that that it does not need to jump in and produce a lot of FAA-based guidance

- So what now? What are the applications?

Finding Applications – "Hot Spot"

Deep Dive on:

- Mtc Planning Document
- ALI/SSID Document
- ADs

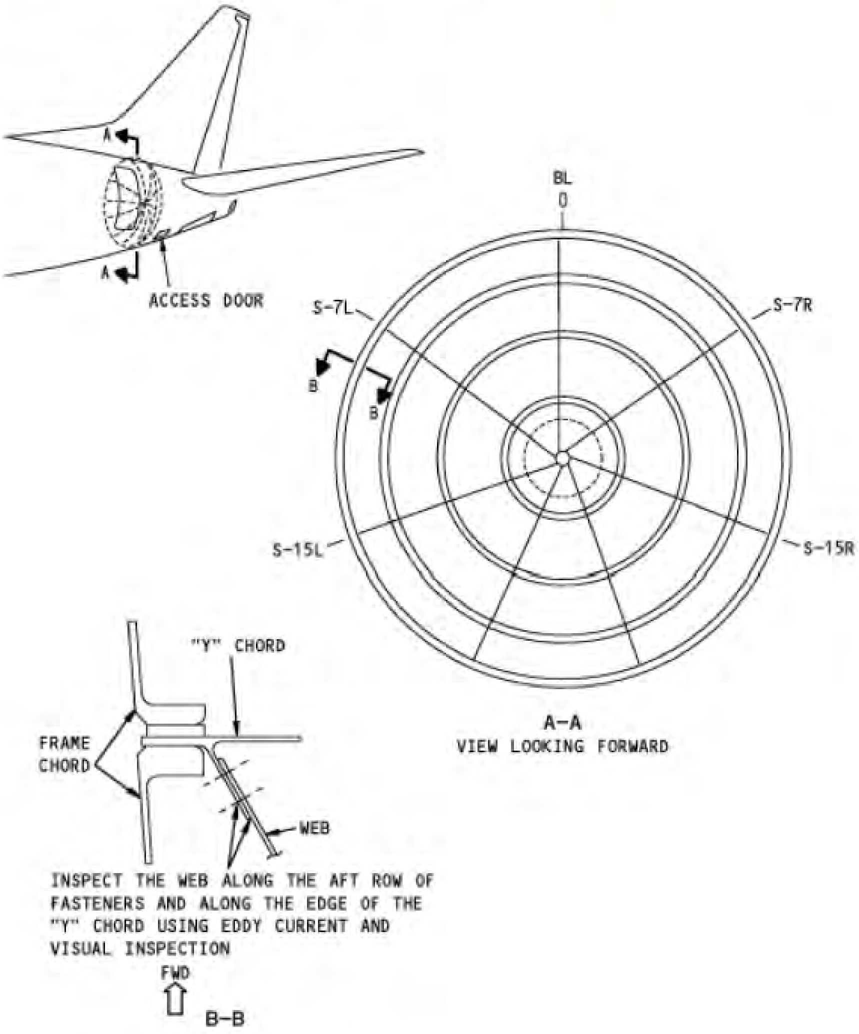
Application musts:

- Hard to access area
- Not at convenient mtc visits
- Short repetitive intervals
- Damage knowledge requirements
- Consistent , repeatable problem

Boeing B737 applications found!

737 Fus Aft Pressure Bulkhead

- SB 737-53A1248
  - Threshold 25,000 FC
  - Repeat Intervals
    - LFEC 1,200 FC
    - HFEC 3,800 FC
- Airworthiness Directive AD 2005-21-06
- Airplane Models: 737-600, 737-700, 737-700C, 737-800, 737-900



Boeing B757 applications found!

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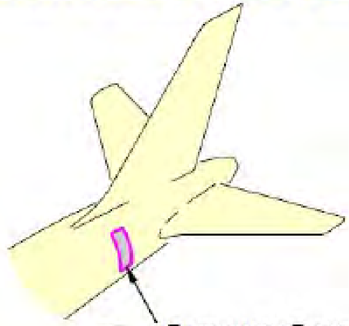
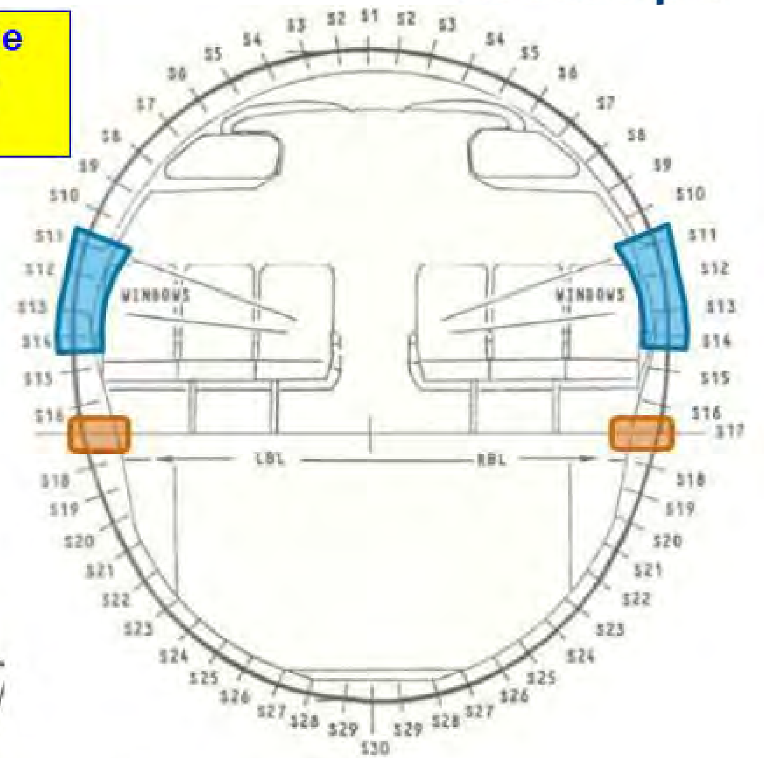
BS 1640 and BS 1681 Frame Inspections Are Typically Accomplished Together

Frame 1640
SB 757-53A0108





Frame 1640 inspection areas

Frame 1681 inspection areas

Boeing B757 applications found!

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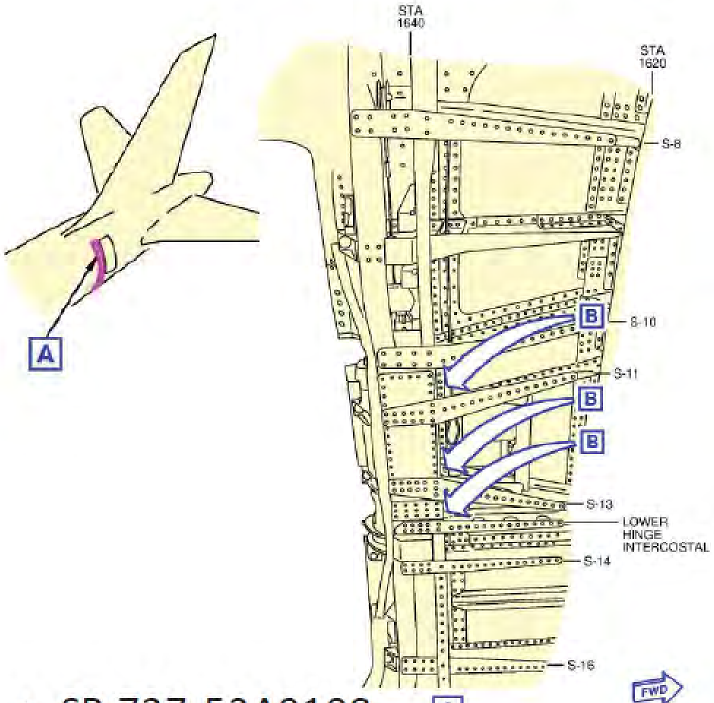
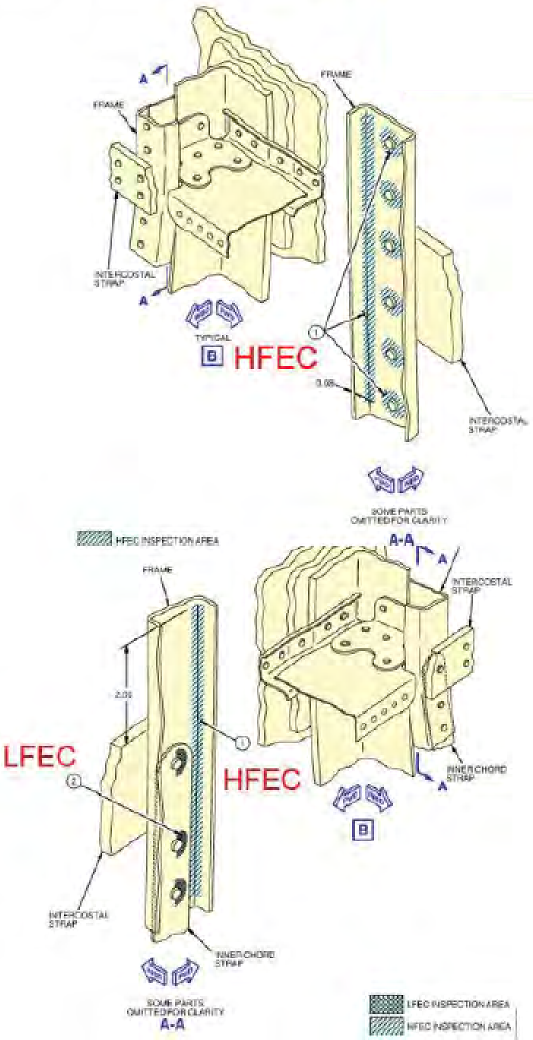
757 Fus Section 46 - Body Station 1640 Frame Inspection





- SB 737-53A0108 A
  - Threshold: 20,000 flight cycles
  - Repeat Intervals 3,000 – 6,000 FC

Boeing B757 applications found!

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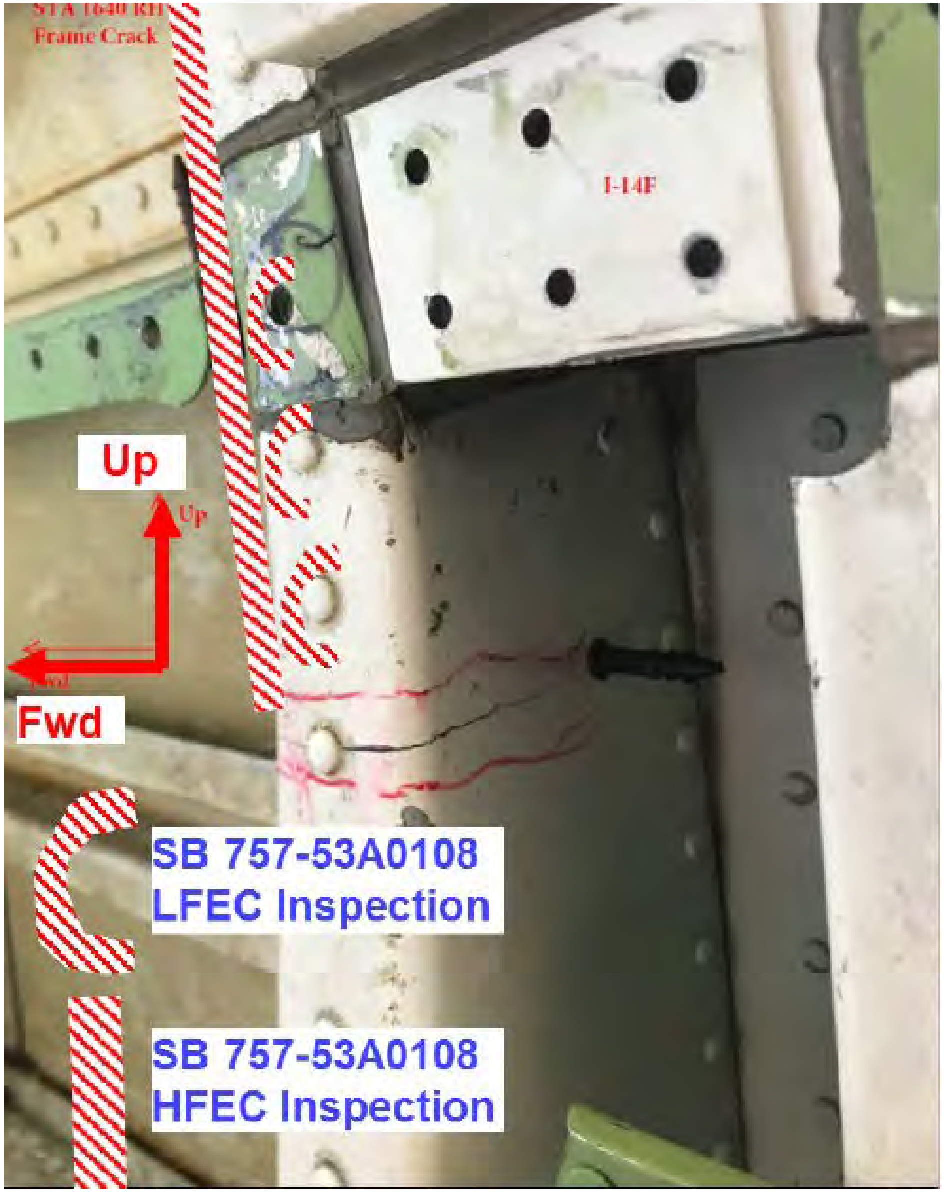
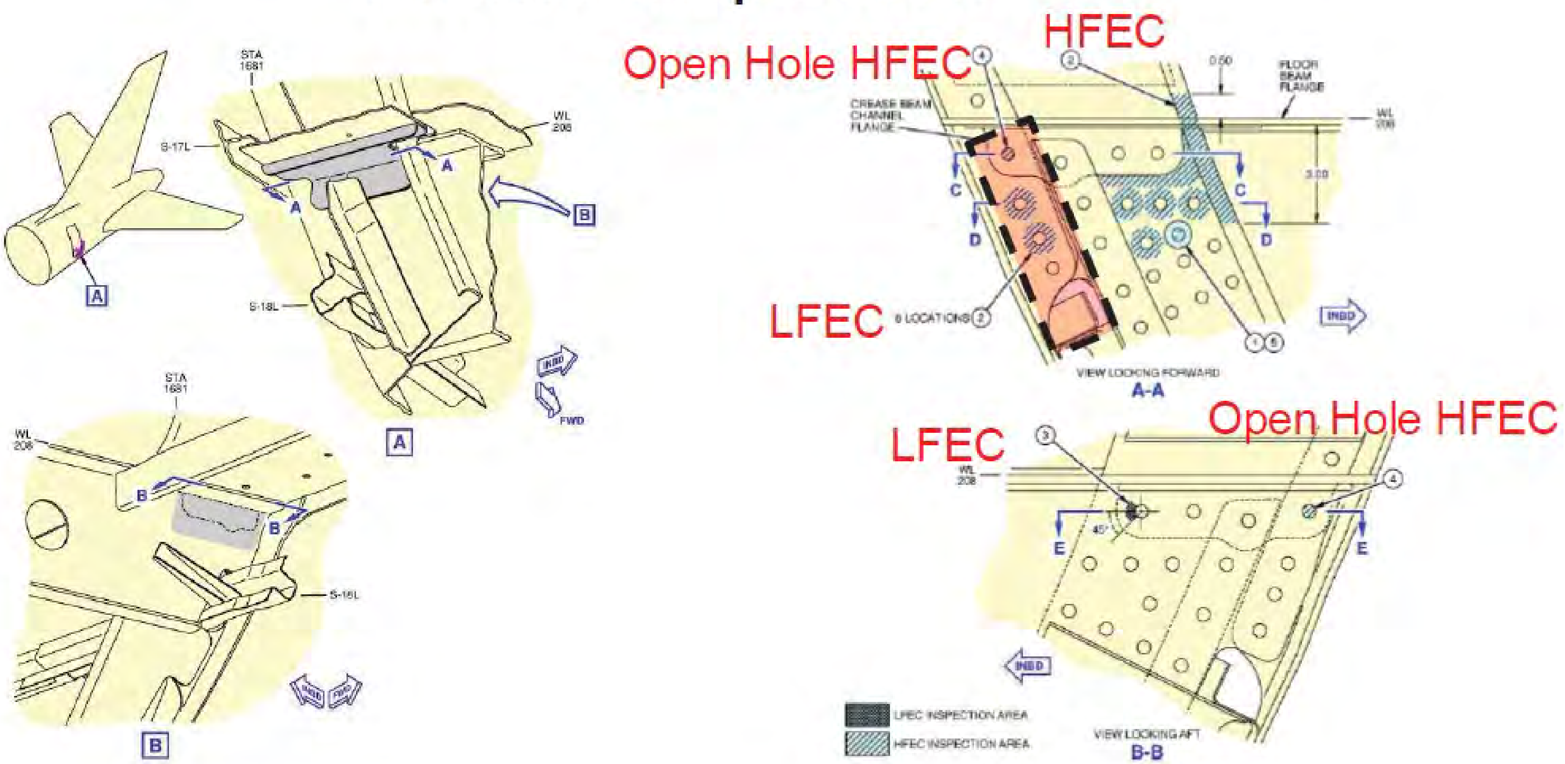


Boeing B757 applications found!

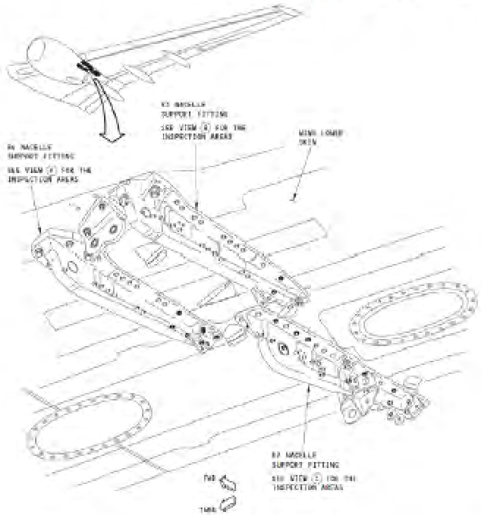
757 Fus Section 46 - Body Station 1681 Frame Inspection



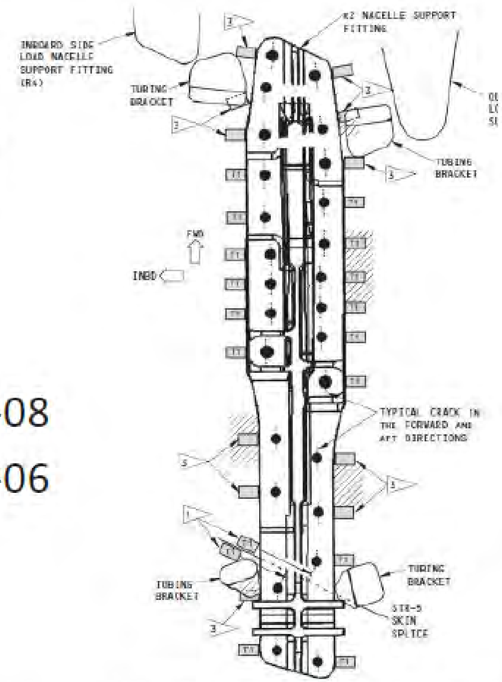
- SB 757-53A0100
  - Threshold: 31,000.
  - Repeat Intervals: HFEC ~3.200 FC Repeat Intervals

Boeing 737NG applications found!

737 Maintenance Planning Data (MPD)
DTR 57-20-09 UT/HFEC Inspections

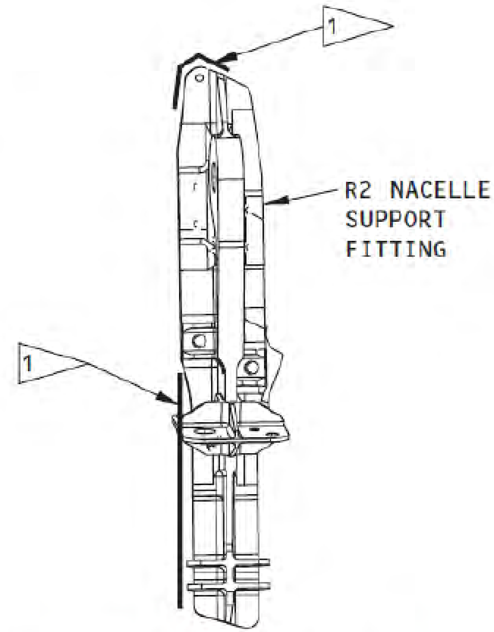


- 737 NDTM PART 6 57-30-08
- 737 NDTM PART 4 57-10-06
- Repeat Intervals
  - 2,400 FC HFEC
  - 4,300 FC UT
- Airplane Models: 737-600, 737-700, 737-700C, 737-800, 737-900



INSPECTION AREAS OF THE R2 NACELLE SUPPORT FITTIN

UT

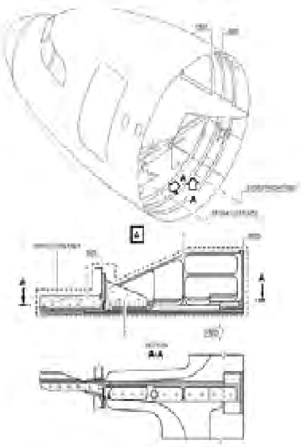


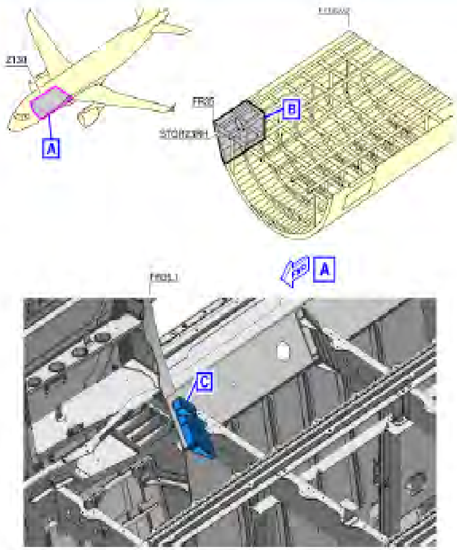
INSPECTION AREA AT THE R2

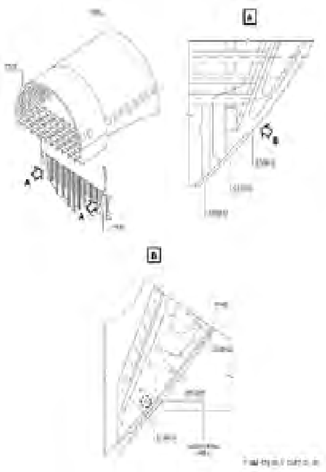
HFEC

Airbus applications found!

A320FAM	A321	A330
DET: FR20-21 continuity fitting	Cabin floor beam junction	DET: CWB - FR40 fitting
MPD 531157-01 TH:24000FC/INT:7000FC	MPD 532220/21/22/23-01 TH:36900FC	MPD 571102-01 TH:24200FC/INT:5500FC or TH:22400FC/INT:5100FC







STC applications found!

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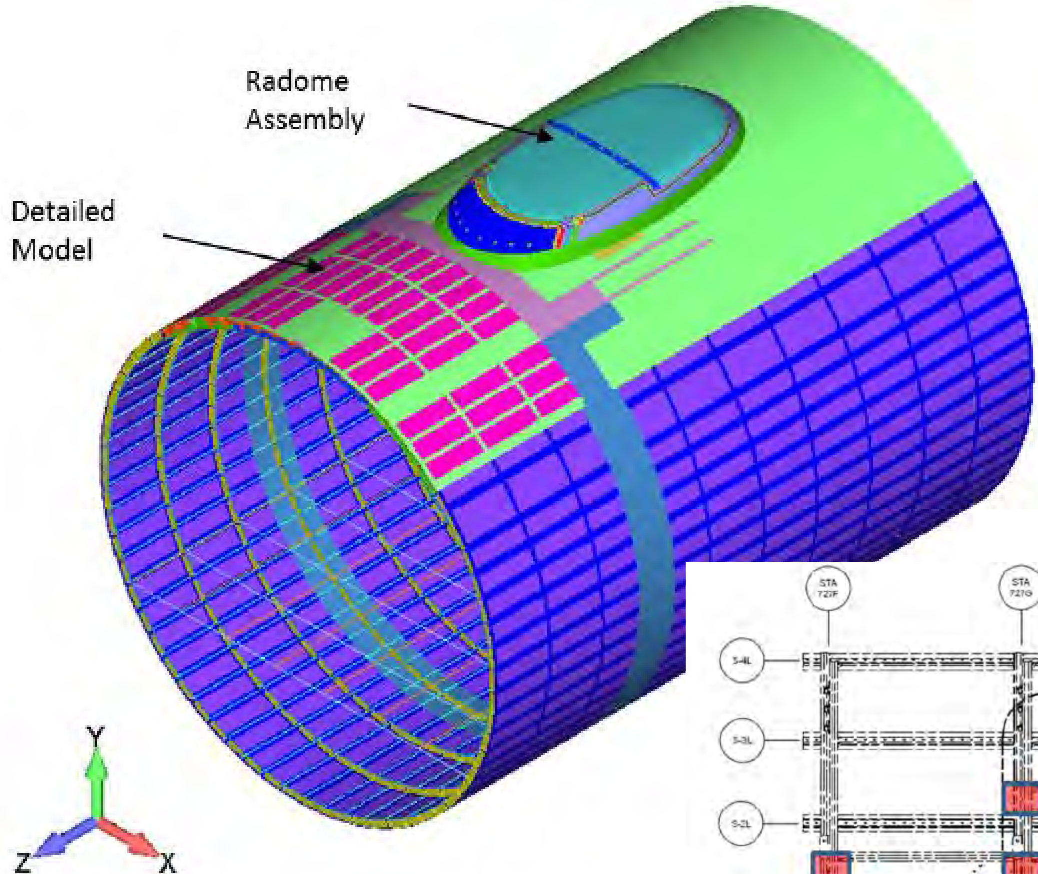
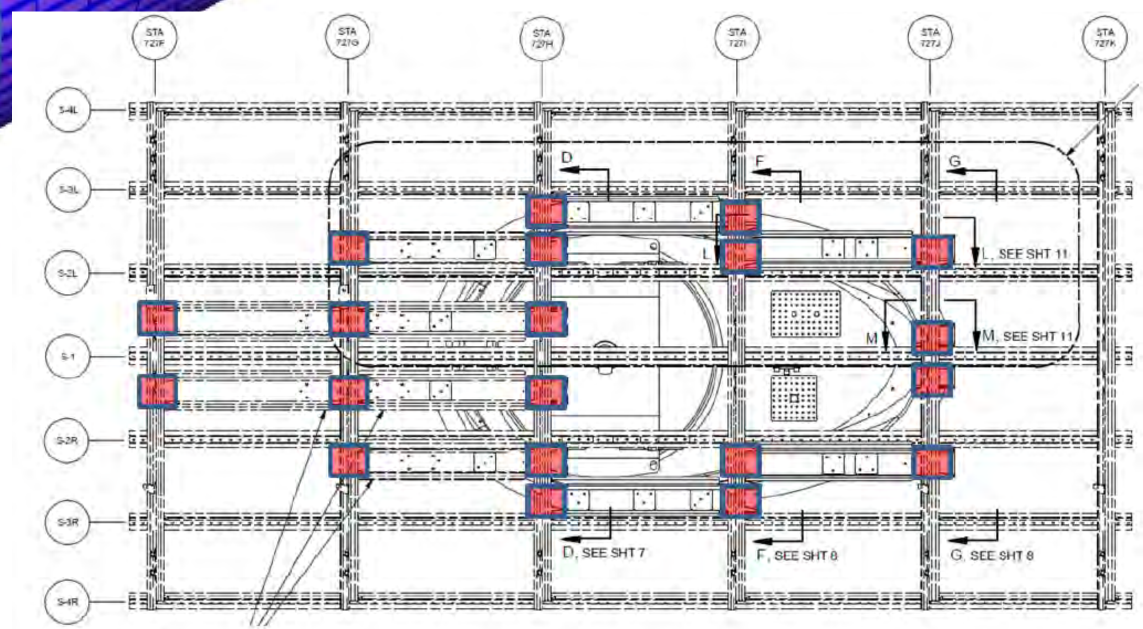


- Panasonic
- Gogo
- Viasat



Safety is #1 Concern

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- FAA tasking = Safety!

- AD for many ‘hot spots’

- Which is a safer philosophy?
  - #1 Cracking found at Heavy Check
    - Area only opened once every 6 years
    - Onerous access, Visual Insp, Eddy current inspection
    - Damage extensive, frame severed by the time damage is found (Major repair)
    - ‘Blind’ to damage until scheduled task
    - Possible AD?

  - #2 SHM system
    - Data taken frequently (or even daily)
    - Early warning of an issue
    - Ability to ‘monitor’ until can examine at next convenient opportunity
    - ‘Unscheduled’ mtc can become ‘scheduled’ mtc
    - Minor repair at next convenient visit
    - Apply new knowledge to rest of fleet (proactive instead of reactive)

Industry Efforts to Formalize SHM

- AISC-SHM Committee Efforts expanded
  - o Use IVHM & other committees for increased exposure

- IATA, A4A MPIG group
  - o Position paper 180

  MSG-3 logic should be amended to realize the benefits from AHM capabilities in scheduled maintenance development and to create a consistent industry approach. Relevant industry standards have been considered in developing this IP (e.g. SAE documents ARP6803, ARP5120, ARP6275 and AS4831A).

- SAE HM-1 Committee = Maintenance Credits

- Data-driven & enhancement to safety
  - o Tail specific

International Maintenance Review Board Policy Board (IMRBPB)
Issue Paper (IP)

Initial Date: 27 Apr 2018
IP Number: IP 180
Revision / Date: 0

Title: Aircraft Health Monitoring (AHM) integration in MSG-3

Submitter: Industry (MPIG based on AHM WG proposal)

Applies To:	
MSG-3 Vol 1	X
MSG-3 Vol 2	
IMPS	X

Issue:

MSG-3 logic does not currently make use of AHM.

Airlines for America™
We Connect the World

AHM Adoption in MSG-3

- Update for IMRBPB from MPIG AHM WG -

Regulators are key stakeholders!

AIR 6900 ready for release!

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SAE Aerospace — An SAE International Group

AEROSPACE

AEROSPACE INFORMATION REPORT

SAE AIR6900	REV
Issued Revised	

APPLICABLE INTEGRATED VEHICLE HEALTH MANAGEMENT (IVHM)

REGULATIONS, POLICY, AND GUIDANCE

RATIONALE

There is a gap between the technical capabilities of IVHM technology and the application of this technology at the aircraft operating certificate holder to affect the scheduling of and actions performed during aircraft maintenance operations. Several contributing factors to this gap include the required levels of IVHM airborne and ground hardware and software certification, and changes to an aircraft operator's maintenance program within the existing set of regulations, policy, and guidance.

TABLE OF CONTENTS

1. SCOPE

This AIR establishes a collection of regulations, policy, and guidance applicable to design approval applicants, aircraft operating certificate holders, and maintenance repair and overhaul (MRO) organizations enabling adoption of IVHM technology for use in aircraft maintenance. One of the AIR's objectives is to set the foundation for aircraft operating certificate holders to engage with regulators to get approval for simpler IVHM applications leading to improved maintenance operations. This document may serve as a tool to explore the efficiencies within the existing regulatory environment as well as the need for regulation, policy, and guidance changes in the long-term to accommodate more complex IVHM solutions.

SAE Aerospace Standard Types

AS Aerospace Standards – specific performance requirements used for design standards, parts standards, minimum performance standards, quality and other areas conforming to broadly accepted engineering practices or specs for a material, product, process, procedure or test method

ARP Aerospace Recommended Practices – documentations of practice, procedures, and technology that are intended as guides to standard engineering practices. May be of a more general nature or propound data that have not yet gained broad acceptance.

AIR Aerospace Information Reports – compilations of engineering reference data, historical information, or educational material useful to the technical community

Need to push this from AIR to ARP to AS!

What’s next for SHM?

- Technology ready, ***philosophy*** is not
  - **Industry education, awareness**
  - MSG3 documents => ‘NDT’ replaced with ‘NDT/SHM’
  - NDT, SHM not in CFRs (and should not be)
  - Easier acceptance when Industry Stds (ARP 6461) are utilized

<u>3 parts envisioned on operator end</u>:

- Part 1: S-SHM for ‘alternate inspection approvals’
  - “Hot spot monitoring”
  - Perform SHM reading at same scheduled interval (S-SHM)
- Part 2: Blend of S-SHM and ‘predictive/prognostics’
  - Early warning system (Proactive mtc.)
  - Extension of intervals (escalation)
- Part 3: ‘Condition based maintenance’
  - Philosophy shift to allow ‘monitoring’ or CBM; heavy OEM involvement
  - AD 2007-10-04/SB MD80-55A065 AMOC – Monitoring stop drilled holes
- Speed is dependent upon OEM and FAA ‘side-by-side’ timeframe.
  - Get comfortable with new technology/philosophy
  - Operator pay-back, financials directly dependent upon this!

Firmly in Phase 1, looking to Phase 2

Operator Concerns

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- Side-by-side inspections (even temporary)
  - Kills Business Case; will not move forward
  - Technology dead-on-arrival
  - Blended program compromise?

- OEMs dominant
  - Aftermarket push = Sell as a ‘service’
  - IP ownership
  - Being charged for our own data

- Vendors/OEMs/Operator Relationships
  - Must be win/win/win

- Legal Ramifications
  - Systems could be used for punitive actions from FAA
  - No guidance for ‘inspection data’ retention – SHM data similar?

Summary

- FAA-no new rules needed for SHM as in situ NDI (local applications)
- FAA will handle SHM applications on case by case basis
- Airline SHM Usage
  - o Proven ability to adopt SHM solutions –maintenance program mods
- SHM can decrease maintenance costs (NDI man-hours; disassembly) & allow for condition-based maintenance
- AMOC for SBs and ADs or STCs
  - o Safety driven use is achieved in concert with OEMS & regulatory agencies
  - o Approval through regulatory framework established with Delta-Boeing-FAA-Sandia program
- Plenty of applications!
- Royal flush