Developments to Facilitate Routine Use of SHM on Commercial Aircraft

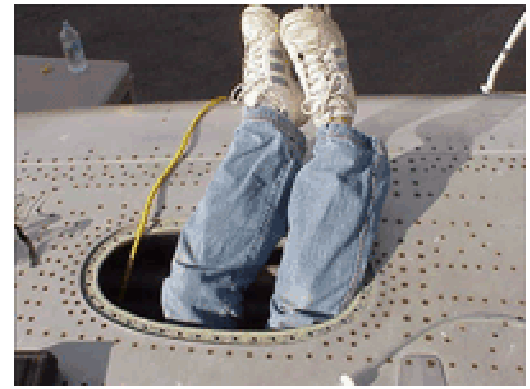
Dennis Roach
Trevor Lynch-Staunton

STRUCTURAL MONITORING SYSTEMS

SHM Solutions & NDI Challenges

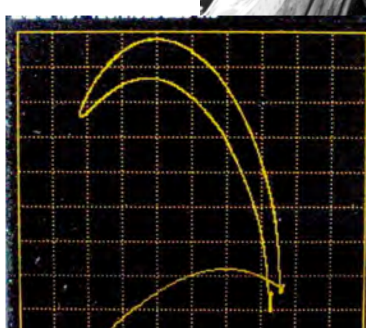
Difficulty in loads assignment, stress and fatigue calculations produces demands on NDI - **"You want me to find a flaw where, and how small??"**

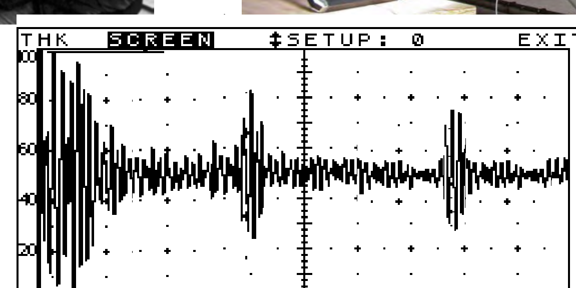
Difficult Conditions



Lots of Rapid Data Interpretation

Viable NDI Signal??





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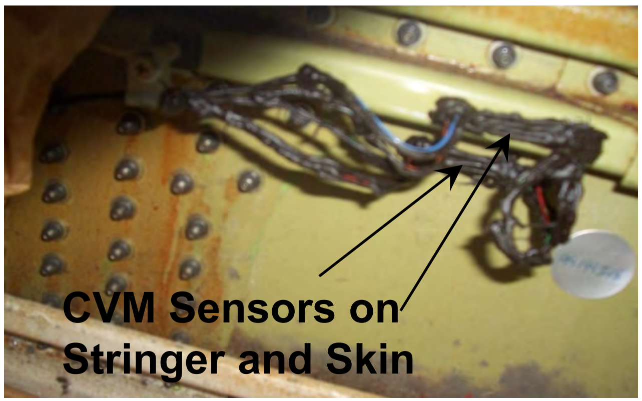
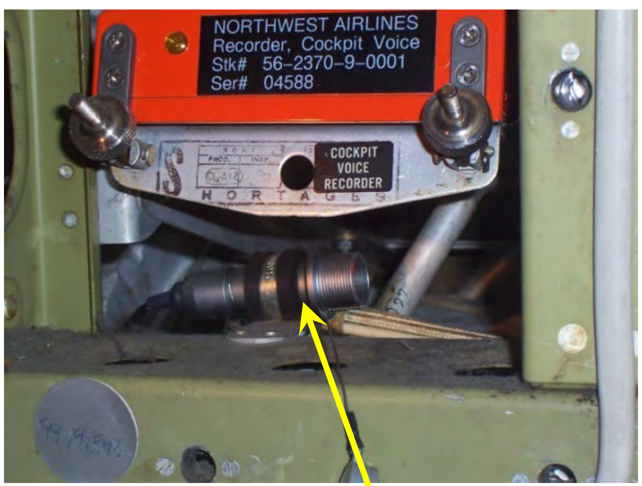
Field Evaluation of CVM Sensor Applications – Decal Mode

Function & Durability Testing - To assess the long-term viability of CVM sensors in an actual operating environment, 22 sensors were installed on DC-9, 757 & 767 aircraft for functional evaluation:





SLS connector routed to access panel

Monitoring CVM

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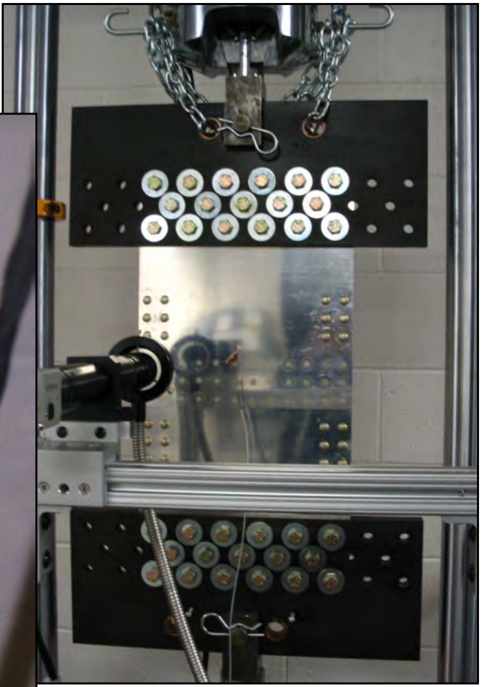
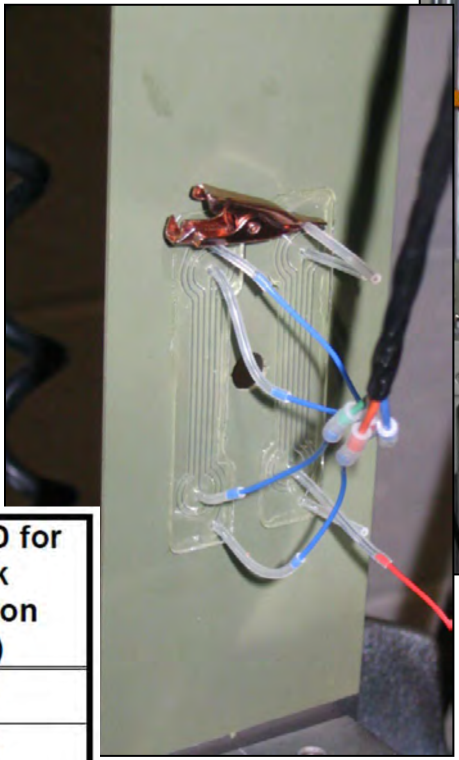
Quantifying Probability of Crack Detection

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

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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

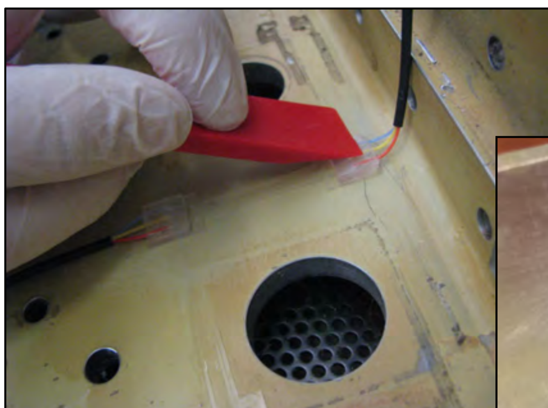
- Greater vigilance in key areas – address DTA needs
- Overcome accessibility limitations, complex geometries, depth of hidden damage
- Eliminate costly & potentially damaging disassembly
- Minimize human factors with automated data analysis
- Reduced operating and maintenance costs
- Early flaw detection to enhance safety and allow for less costly repairs

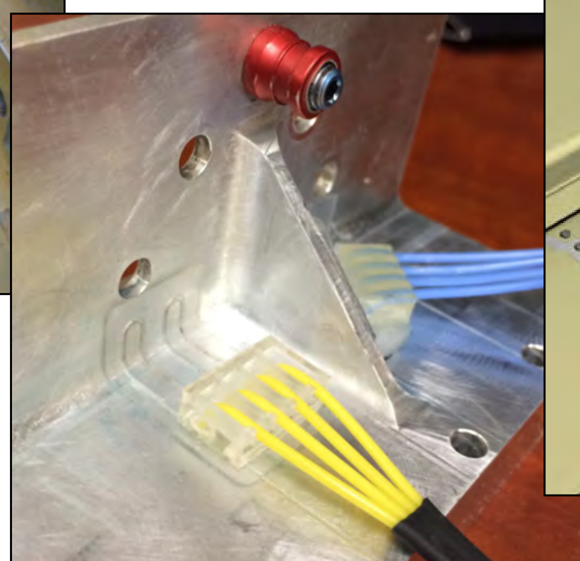
SHM: process of acquiring and analyzing data from on-board sensors to determine the health of a structure (AISC-SHM)

STRUCTURAL MONITORING SYSTEMS

Comparative Vacuum Monitoring (CVM) Technology Deployment

- **Sensors conformable to complex contours**
- **Easy installation process**
- **Sensors designed with a fail-safe mode**
- **Monitoring process with PM200 device is simple (two keystrokes)**
- **Certification Completed with FAA – routine use approved (Service Bulletins, OEM Manuals, STC, AMOC)**
- **Easy adoption of technology demonstrated by airlines**





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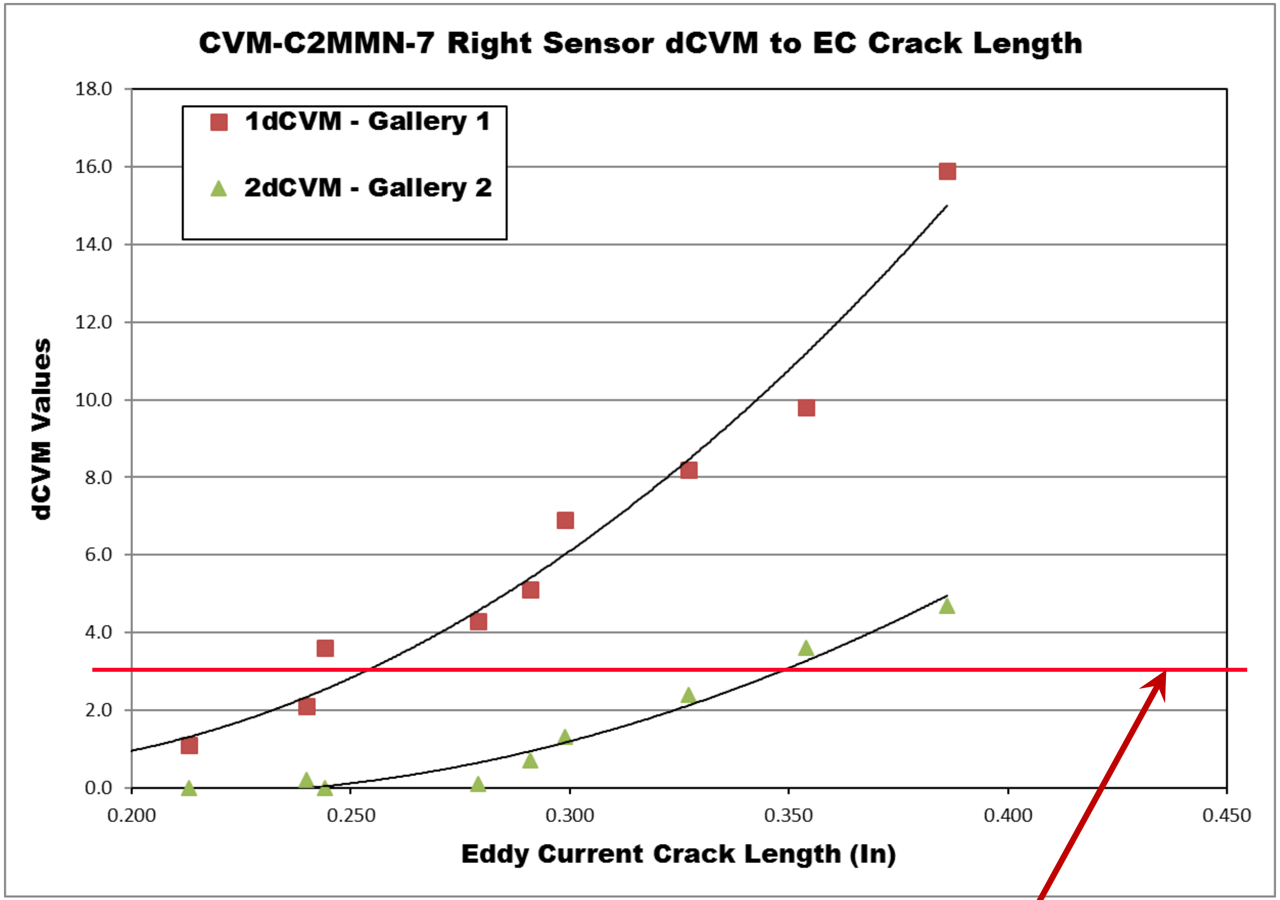
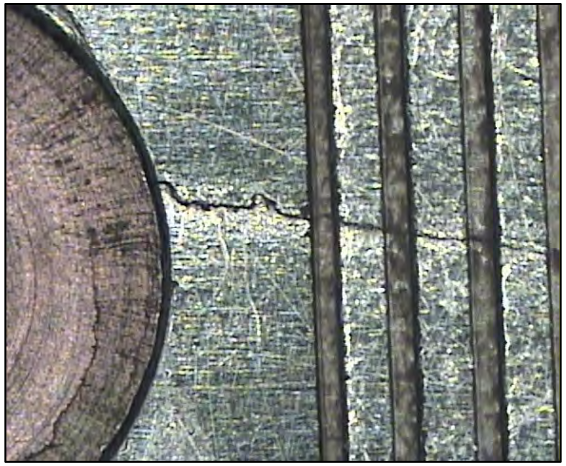
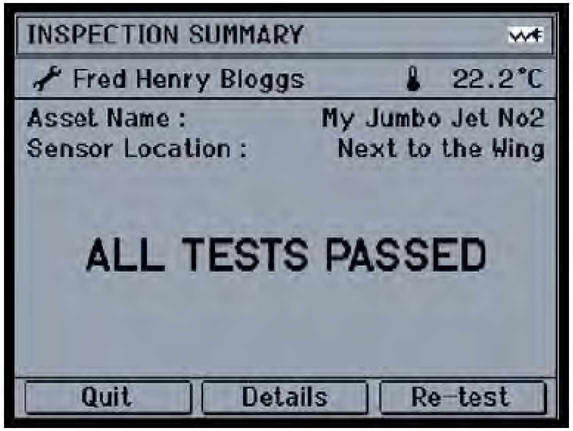
CVM Sensor Response – Crack Detection Uses a Damage Threshold





PM200 Readout – No Cracks Detected



Crack detection occurs when dCVM exceeds Damage Threshold (Green Light – Red Light)

STRUCTURAL MONITORING SYSTEMS

Historical CVM Partners for Integration into Routine Maintenance

Delta Air Lines

RYANAIR

FEDERAL AVIATION ADMINISTRATION

Sikorsky

Azul Linhas Aéreas Brasileiras

BOEING

easyJet

AIR CANADA

EMBRAER

BOMBARDIER

Sandia National Laboratories

AIRBUS

AEM ANODYNE ELECTRONICS MANUFACTURING CORP.

AIR FRANCE

Transport Canada

KLM

United Airlines

American Airlines

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JAL JAPAN AIRLINES

jetBlue

DE HAVILLAND DH CANADA AIRCRAFT OF CANADA LIMITED

SOUTHWEST AIRLINES

TESTIA AN AIRBUS GROUP COMPANY

ANAC

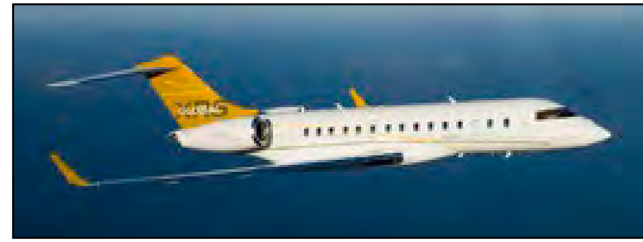
ANA All Nippon Airways

EASA European Aviation Safety Agency

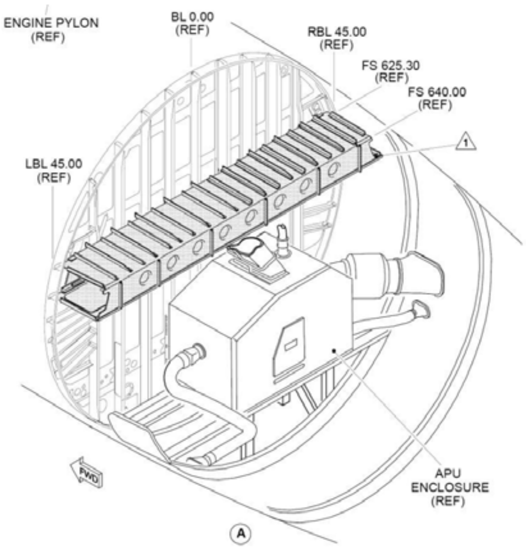
Emirates

Lufthansa

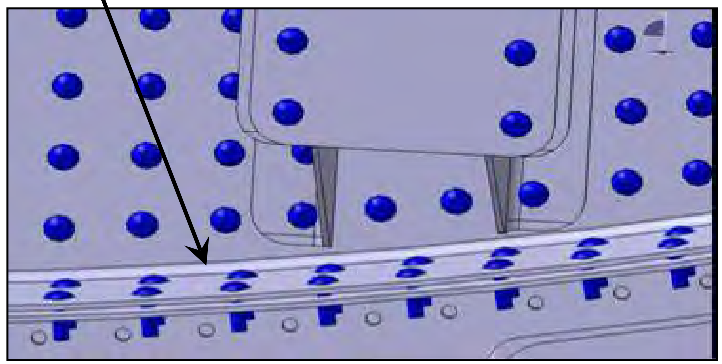
CVM Success on CRJ Aircraft



Pilot program with Bombardier and Air Canada



Inspect in the radius

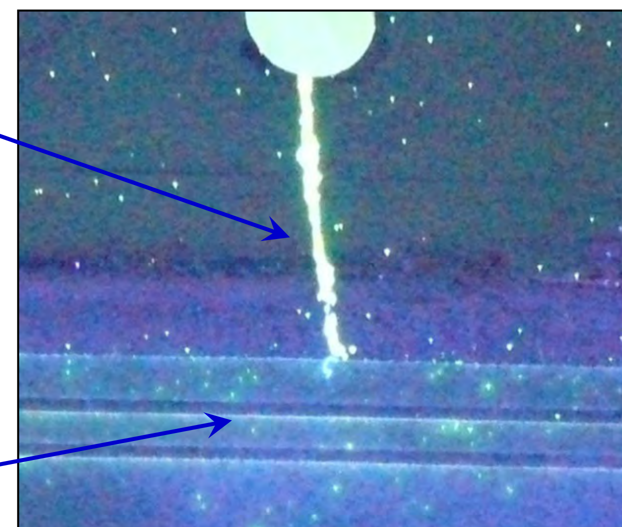


Sensor Success:

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

Aft Equipment Bay

First detection of a fatigue crack on an aircraft (confirmed by dye penetrant test)



CVM Sensor

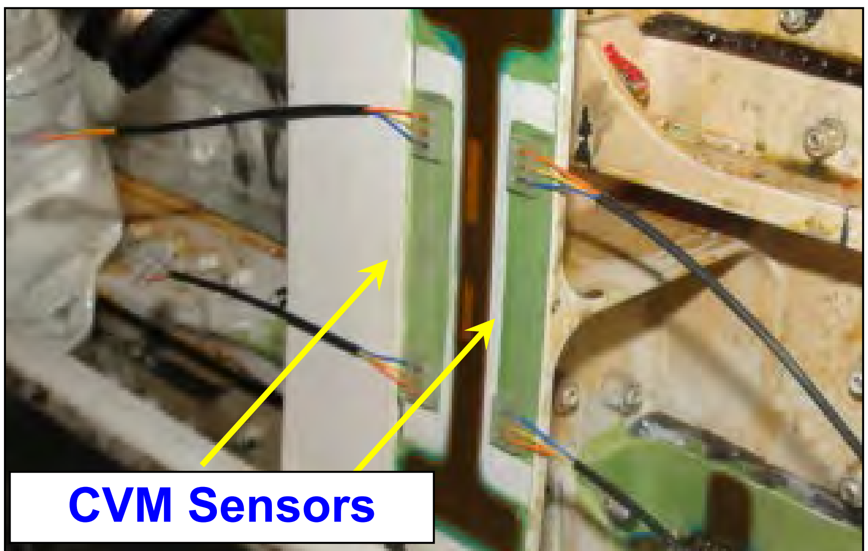
STRUCTURAL MONITORING SYSTEMS

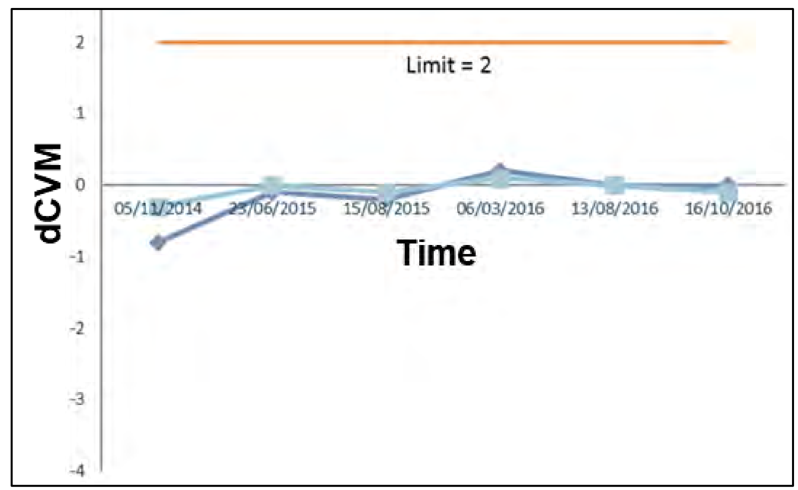
Embraer CVM & PZT Flight Tests – Azul Aircraft PR-AYW

EMBRAER

Installation Summary

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



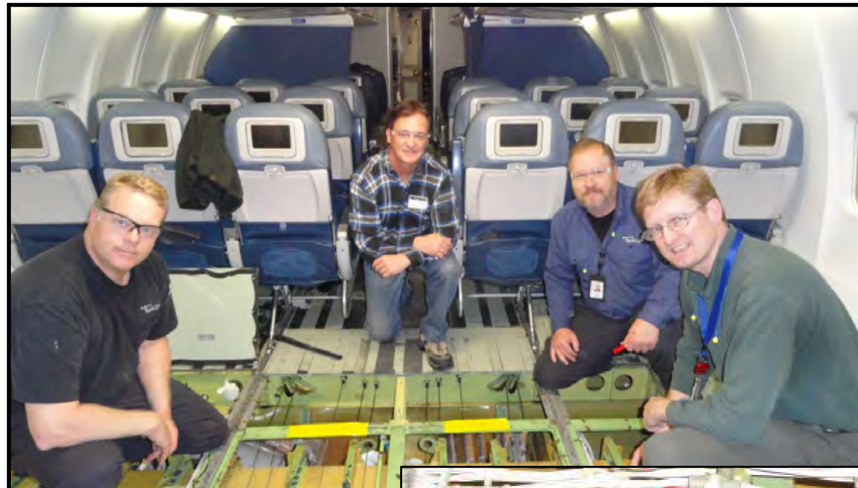


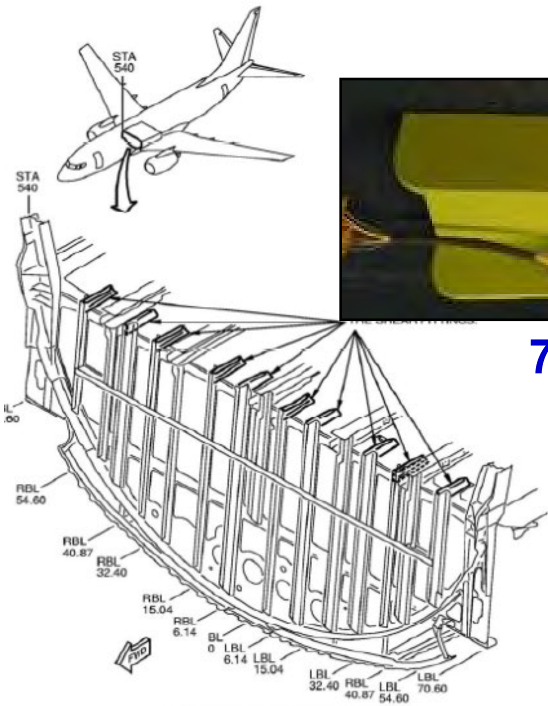
Consistent CVM Data Over Two Years of Flights - dCVM Well Below Damage Detection Threshold

STRUCTURAL MONITORING SYSTEMS

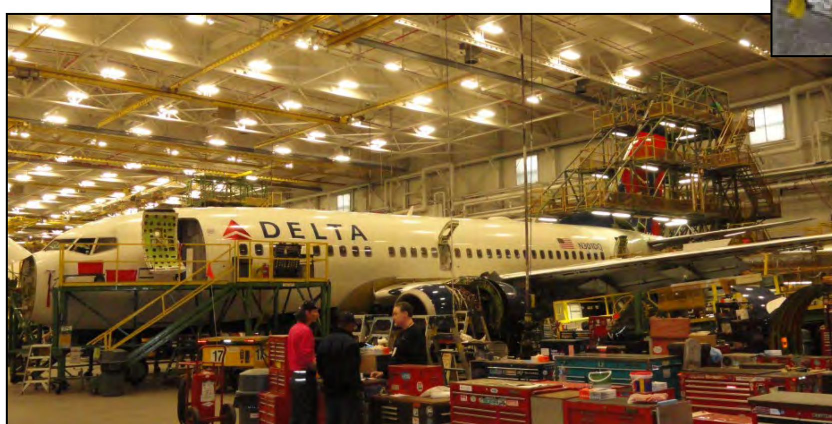
CVM Sensor Network Applied to 737 Wing Box Fittings

- **Comprehensive performance assessments completed: sensitivity, reliability, durability**
- **Flight testing: successful operation on flying aircraft**
- **Formal approval from aircraft manufacturers and aviation regulators**





737 Wing Box Fittings



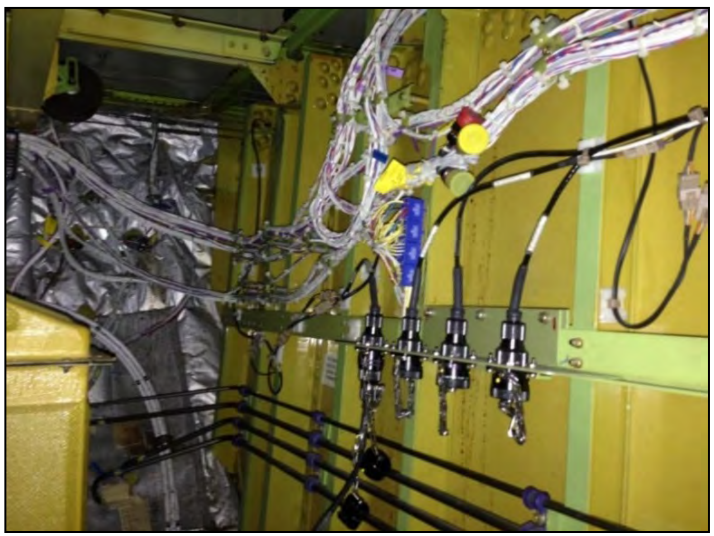
~ 1.5 M hours of successful flight history

STRUCTURAL MONITORING SYSTEMS

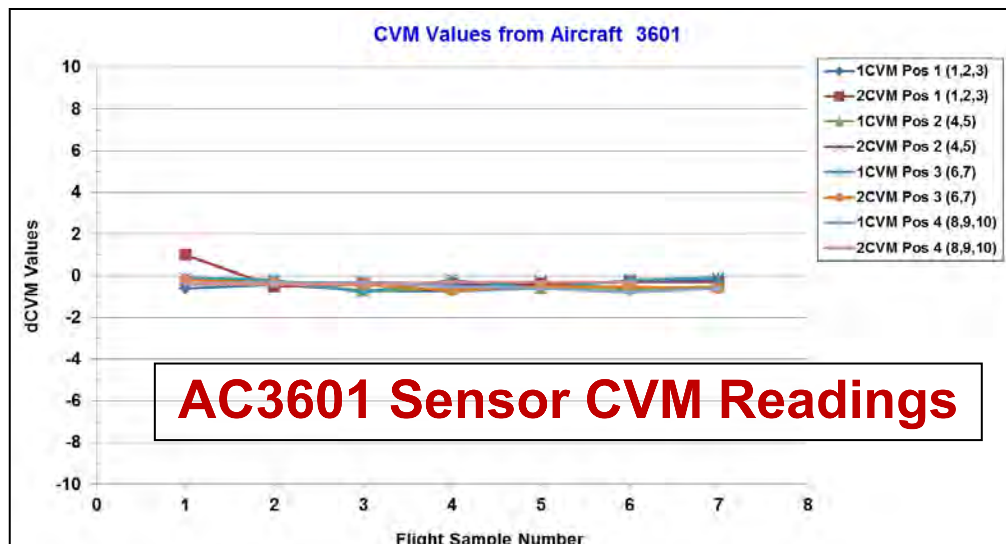
737NG Center Wing Box – Accumulating Successful Flight History

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



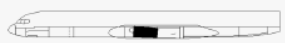
STRUCTURAL MONITORING SYSTEMS

Adoption of SHM at Airlines - Job Cards Produced to Guide All Aspects of CVM Deployment

CVM SENSORS AT WING CENTER SECTION SHEAR FITTINGS (STA 540), 737 - INSTALL; SECTION 01 -3

A/C **3602** Card **5711-01044-01-3** Crew **12**

Zone: 130 - Subzone - Body STA 540 to STA 727



7066542

WBS No.

DELTA	**B737**	A.A. Workcard	**Page 2 of 4**

Scan Pages 2 of 4
Job # **059-0003**

INFORMATION:

For AA details, access the AA via the AA Management System. AA Management System and tutorial are located on TOHP under "Maintenance Links".

1. Ensure disposition of each of the 10 shear fittings from 5711-01044-01-2.

   A. If four (4) or more shear fittings contain cracks, then all 10 shear fittings will be replaced; contact Planning and proceed to 5711-1044-04 (N/A this card).

   B. If only one, two or three fittings are cracked, then only those fittings will be replaced (contact Planning and proceed to 5711-01044-04 for replacement of those fittings; N/A the steps corresponding to sensor installs for those affected fitting zones on this card).

      (1) The remainder of the fittings (in a non-cracked zone) will undergo sensor installation; proceed to next step.

Disposition
Inspector

2. Locate center wing box front spar shear fittings at Left Buttock Line (LBL) 54.60, 40.87, and 32.40 at Body Station (STA) 540. Install CVM sensors on all three fittings per Delta Technique Sheet SHM 100-57: B737-800 CVM Installation at Wing Center Section - Front Spar Shear Fittings (STA 540).

NOTE: If one or more of these fittings were found cracked in 5711-01044-01-2, then N/A the step for that fitting and replace only the cracked fitting or fittings via 5711-01044-4. Installation of CVM sensors will not occur on the affected fitting(s). Refer to Delta Technique Sheet SHM 100-57: B737-800 CVM Installation at Wing Center Section - Front Spar Shear Fittings (STA 540), for details about 'capping' the tubing to bypass the intended sensor location on the affected fitting(s).

NOTE: If the surface needs primer touch-up, accomplish via BSOPM 20-44-04 prior to installing sensors. Ensure surface meets requirements of Delta Technique Sheet SHM 100-57: B737-800 CVM Installation at Wing Center Section - Front Spar Shear Fittings (STA 540).

LBL 54.60	LBL 40.87	LBL 32.40
Mechanic	Mechanic	Mechanic

- **Job Cards point to 'Technique Sheet'**
- **Delta Technique Sheet used for CVM Installation**
  - **Date/revision controlled by Level III**
- **Second Delta Technique Sheet used for CVM Monitoring/Inspection**
- **Correct sign-offs needed (I/M)**
- **"What if" scenarios were covered**

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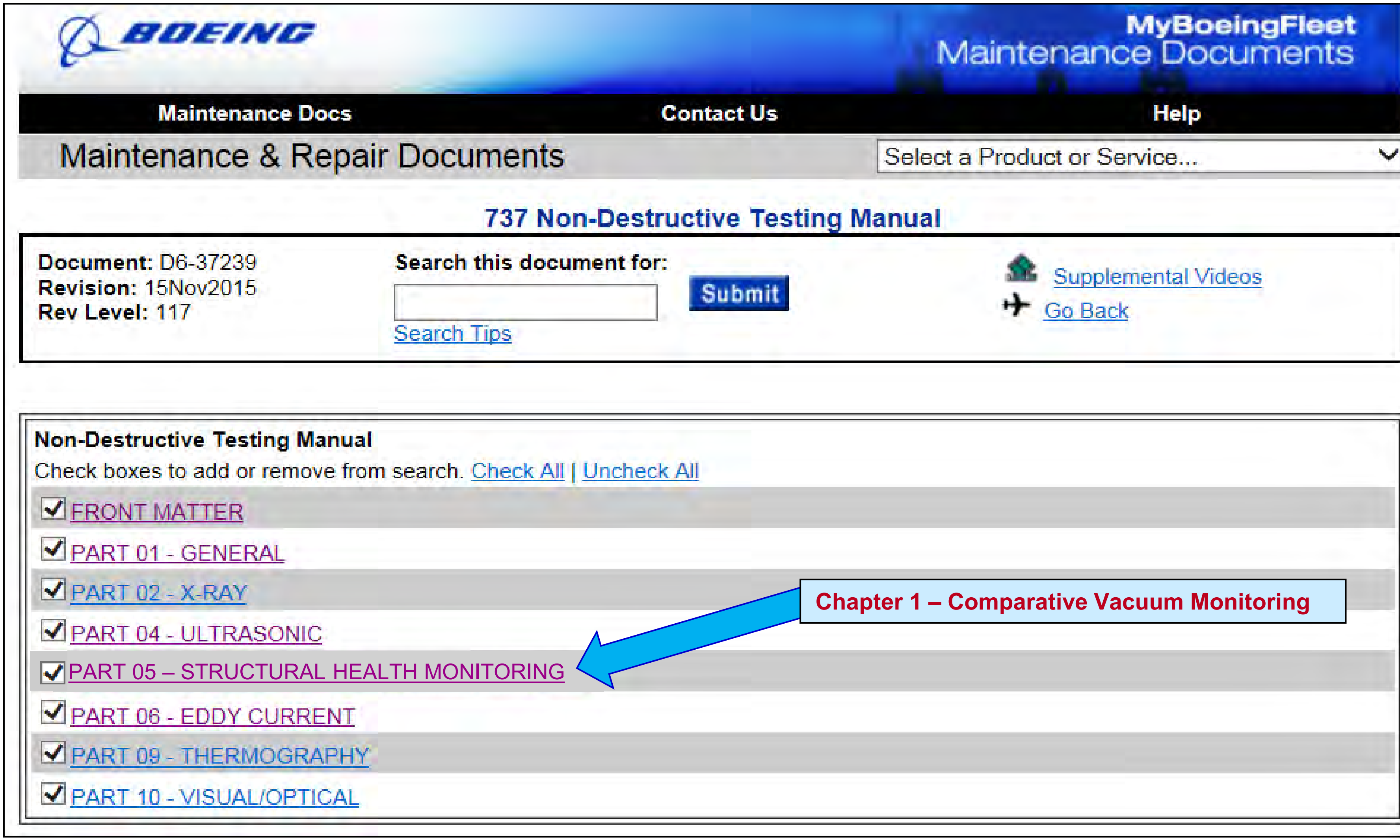
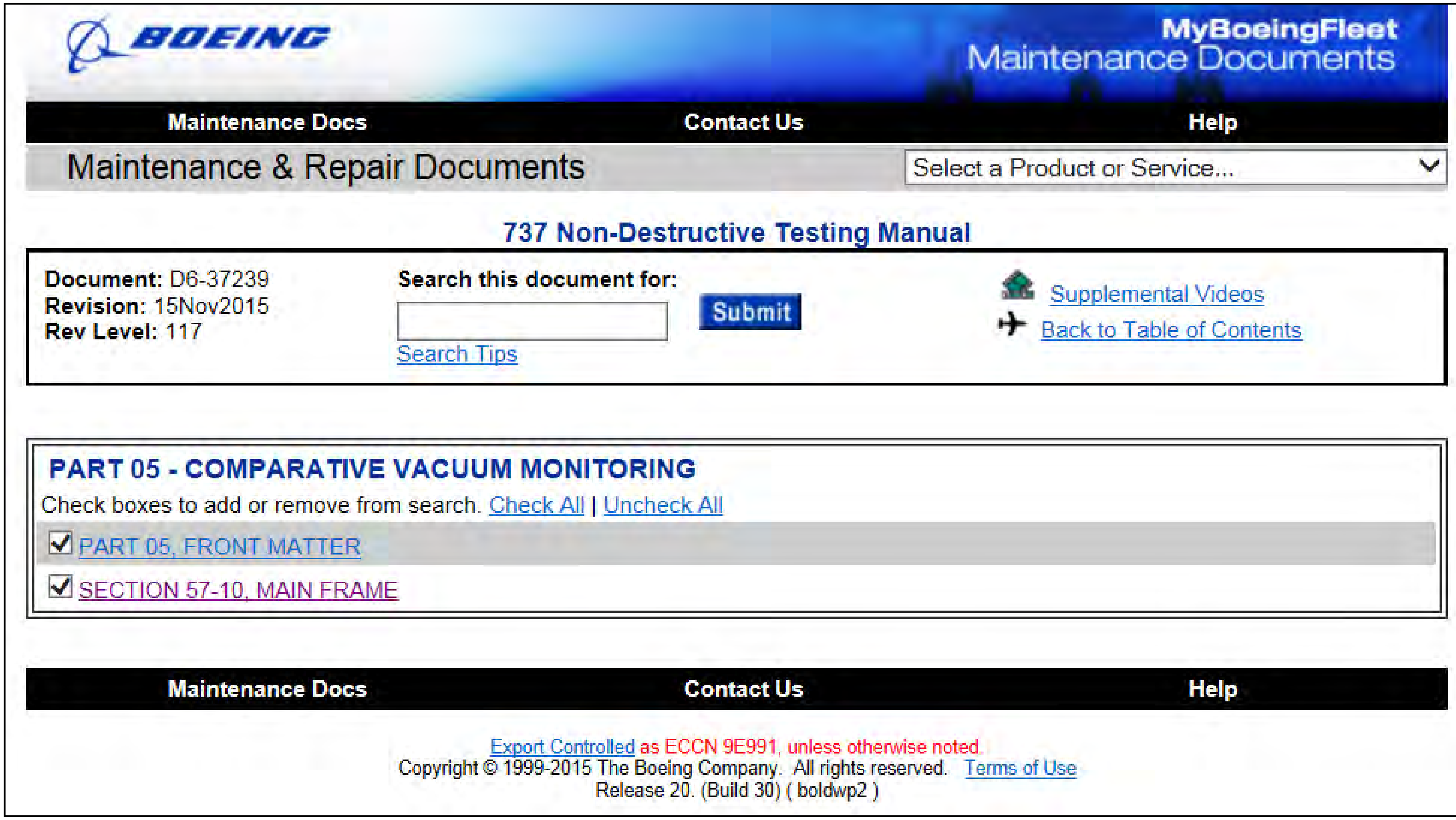
737 NDT Manual - New SHM Chapter Published (Nov 2015)

Building Block to Approval for Routine Use of SHM



STRUCTURAL MONITORING SYSTEMS

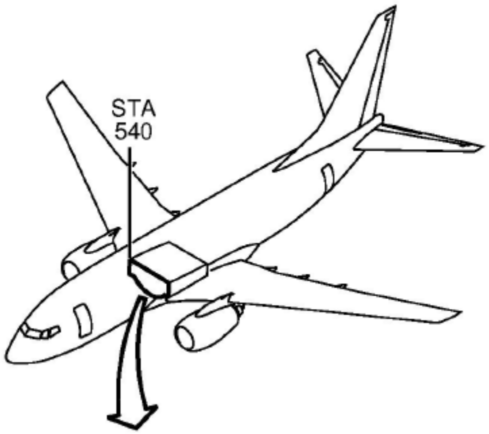
737 NDT Manual – CVM Installation Instructions Added (Jan 2016)



Installation Instructions

STRUCTURAL MONITORING SYSTEMS

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

Revision Transmittal Sheet

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

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.

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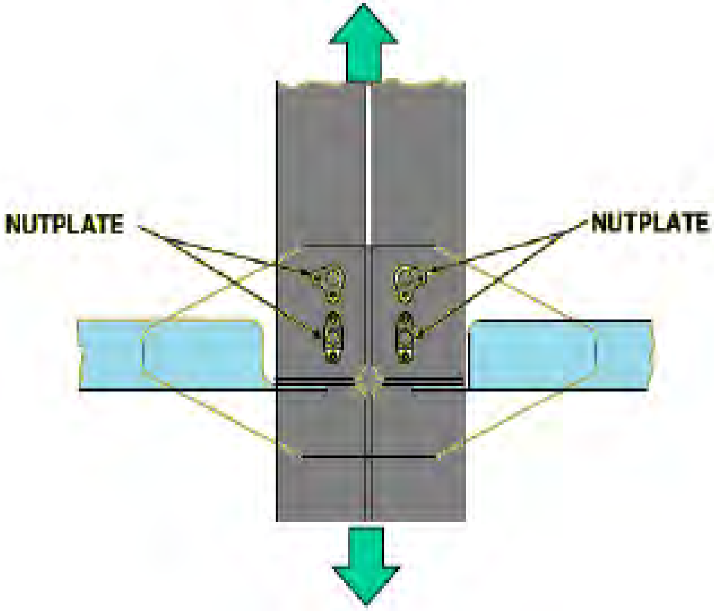
CVM for Rotorcraft - SHM of Cracks Emanating from Fastener and Nutplate Holes

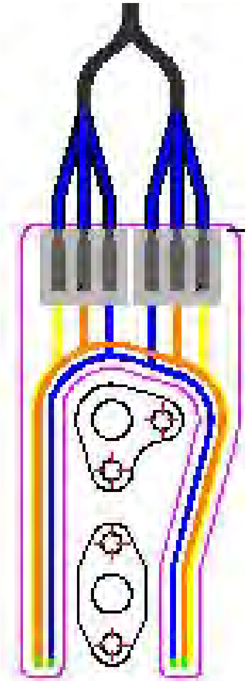
Local (Hot Spot) Monitoring Application: S-92 Frame Gusset

- **Failure History - cracking begins at nutplate holes on inner cap; grow outward to edge of frame**
- **Thickness/materials are common for frame/beam caps – good extrapolation to other high-interest locations for rotorcraft SHM**

Frame Gusset



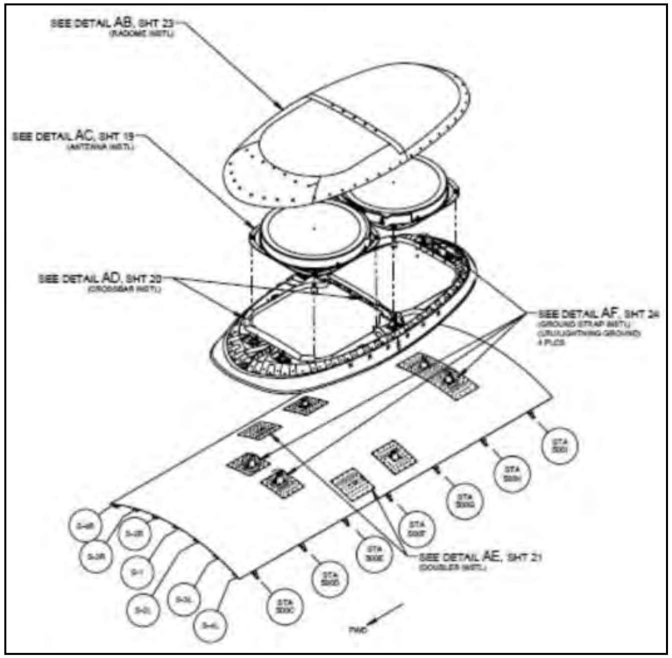
Sensor Performance Validation Test Set-Up

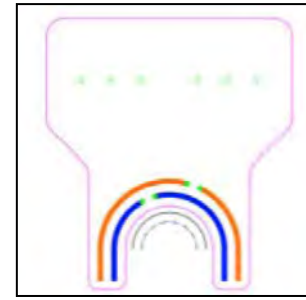


CVM Sensor Design

CVM Application – WiFi Antenna Installation Structure

Multiple aircraft types, multiple airlines

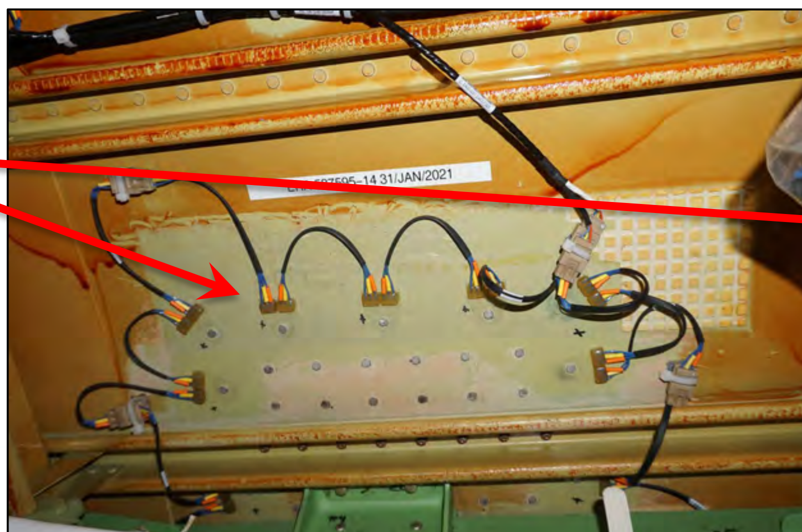




CVM Sensor Design

CVM sensors used to rapidly complete frequent, repeat HFEC/LFEC inspections required on internal structure hidden behind interior panels.

B737 Wi-Fi Antenna Support



STRUCTURAL MONITORING SYSTEMS

FAA Issue Paper – WiFi Specific and Generic (Nov 2019, 21)

WiFi Specific IP

For use in conjunction with Memo No. AIR600-18-AIR-6C0-DM119
Electronic means of capturing the below data can be used in lieu of this grid.
Remove Grid Before Transmitting Externally

ISSUE PAPER

PROJECT:	Delta Engineering ODA Boeing 737-600/-700/-700C/-800/-900/-900ER Project No. ODA-2499-01	**ITEM:** A-1 **STAGE: 2**
REG. REF.:	§ 21.50, § 25.571, §25.1529, Appendix H,	**DATE:** 11/21/19 **ISSUE STATUS: OPEN**
NATIONAL POLICY REF:	AC 25.571-1D	**BRANCH ACTION: AIR-7H1, AIR-7H2, AIR-675, AEG**
SUBJECT:	Comparative Vacuum Monitoring (CVM) for Damage Detection in Structure of Antenna Installations	**COMPLIANCE TARGET:** Pre-STC

Method of Compliance

STATEMENT OF ISSUE:

Delta Engineering seeks a supplemental type certificate (STC) to install a Structural Health Monitoring (SHM) system—Comparative Vacuum Monitoring (CVM)—on a Boeing 737 model airplane. An SHM system such as CVM, evaluates the integrity of certain structure by acquiring data from on-board sensors that interface with handheld carry on electronic device. This approach for detecting structural damage (e.g., fatigue cracking) eliminates the need for an inspector to physically access and assess structure. Over the past 35 years, industry has used nondestructive inspection (NDI) techniques, such as visual and eddy current inspections, to detect structural damage and ensure the continued airworthiness of transport category airplanes. Industry incorporates procedures and timing for implementing NDI techniques & in the Instructions for Continued Airworthiness (ICA) manuals as part of their data for showing compliance with Title 14, Code of Federal Regulations (14 CFR) 25.571 and 25.1529.

Physical accessibility of structure has been an important aspect of inspection programs used to ensure the continued operational safety of transport airplanes. The FAA has not previously approved an SHM system as an inspection technique for compliance with §§ 25.571 and 25.1529. The current industry practice and guidance used to validate conventional NDI techniques may not be adequate for an SHM system. The purpose of this issue paper is to ensure the proposed SHM system can adequately & reliably detect damage for compliance with §§ 25.571 and 25.1529.

Project:	Delta Engineering ODA Boeing 737-600/-700/-700C/-800/-900/-900ER Project No. ODA-2499-01	**Item:** A-1 **Stage: 2** **Date: 11/21/19**

This issue paper specifies key elements and criteria the applicant must address to demonstrate that their proposed SHM system adequately replaces existing ICA that are necessary for compliance with §§ 25.1529 and 25.571. The primary intent of §§ 25.1529 and 25.571 is to ensure an airplane's structural maintenance program will prevent catastrophic failure due to fatigue damage over the operational life of the airplane. The elements and criteria identified in this IP (FAA Position) will guide the applicant's comprehensive assessment of the functionality, reliability, durability, and maintainability of the proposed SHM system.

Generic SHM Certification IP

ISSUE PAPER

PROJECT:	*[Applicant]* Model *[make & model]* Project No. *[project number]*	**ITEM:** A-# **STAGE:**
REG. REF.:	14 CFR § 21.50, § 25.571, §25.1529, Appendix H	**DATE:**
NATIONAL POLICY REF:	AC 25.571-1D	**ISSUE STATUS:** Open
SUBJECT:	Qualification of a Structural Health Monitoring System for Detection of Damage in Structure	**OFFICE ACTION:** AIR-621, AED **COMPLIANCE TARGET:**

Method of Compliance

STATEMENT OF ISSUE:

The applicant proposes to install a Structural Health Monitoring (SHM) system on a model <Enter TCDS Model(s)> airplane. An SHM system evaluates the integrity of structure by acquiring and analyzing data from on-board sensors that interface with an electronic device (either on-board or off-board) that processes the data and provides an indication of the health of structure in terms of the existence of damage (e.g., fatigue damage). A SHM technology capable of reliably detecting damage of a specific nature and size over a specific line, area or volume is a candidate alternative to conventional non-destructive inspections (NDI) such as visual, eddy current, ultrasonic and X-ray inspections methods. This approach for detecting structural damage may supplement or eliminate the need for an inspector to physically access and assess structure. Over the past 30 plus years, industry has relied on accessing structure to assess its overall integrity and, as part of that assessment, perform NDI such as visual and eddy current inspections, to detect structural damage. The current industry practice and guidance used to validate conventional NDI techniques may not be adequate as a method of compliance with title 14, Code of Federal Regulations (14 CFR) 25.571 and 25.1529 for an SHM system. Therefore, this issue paper is necessary to establish an acceptable method of compliance.

FAA Issue Paper- Qualification of a SHM System for Detection of Damage in Structure (Nov 2021)

Purpose

- **Address type certification and type validation processes - issues of particular interest to the FAA, including aspects of the design or proposed methods of compliance (MoC)**
- **Uniform certification approach between applicants - valuable reference for future type certification programs & for development of regulatory changes; precedent-setting technical decisions & the rationales employed**

Content

- **Key elements to be addressed - compliance demonstration with §§ 25.571 and 25.1529 to assess the functionality & performance of the proposed SHM system**
  - **Sensor installation and durability/repeatability and reliability**
  - **Means for determining damage detection capability in all operating environments**
  - **In-service experience**
  - **Maintenance and continued airworthiness needs**

STRUCTURAL MONITORING SYSTEMS

Certification Status- FAA Approved (STC granted Mar 2022)

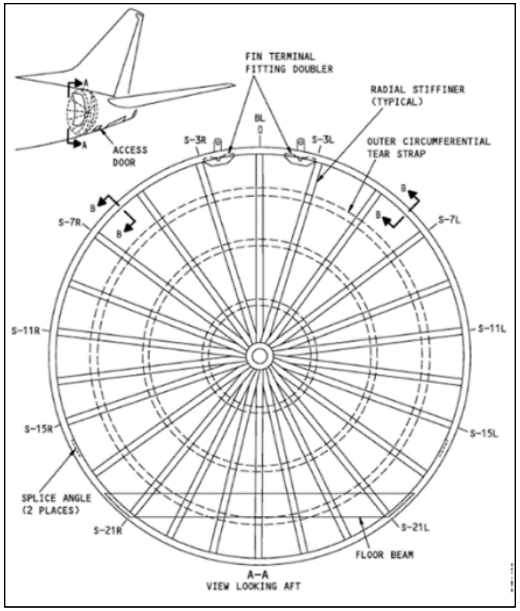
United States of America
Department of Transportation
Federal Aviation Administration
Supplemental Type Certificate
Number: ST04103NY

Description of Type Design Change:
Installation of Structural Monitoring Systems Comparative Vacuum Monitor (CVM) Sensors in accordance with Delta Engineering Master Data List 0106-10998-2499 Revision A dated Mar. 2, 2022 or later FAA approved revisions to Delta Engineering Master Data List previously listed. The Instructions for Continued Airworthiness as listed on the Master Data List is required with this installation.

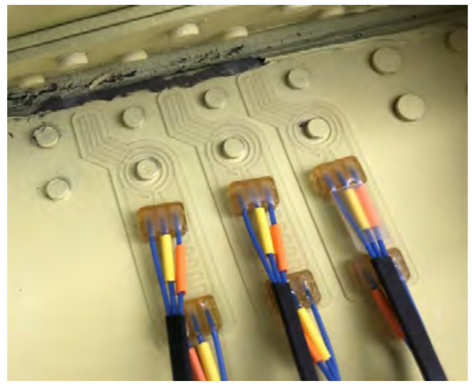
Generic FAA Issue Paper (IP) on SHM represents the first formal set of guidelines from the FAA for certification of Structural Health Monitoring (SHM) systems in routine maintenance activities. The IP guides production of SHM performance data to ensure that the proposed SHM system can adequately and reliably detect damage for compliance.

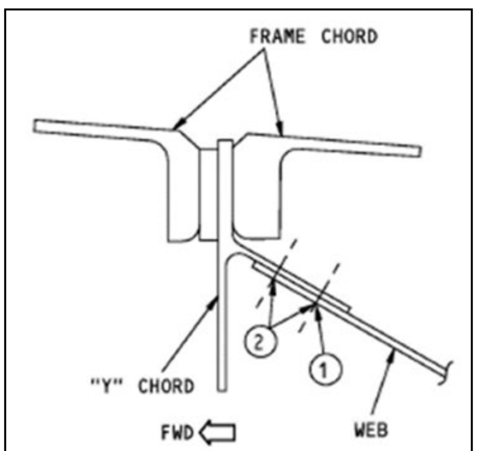
March 3, 2022- FAA Issued first ever STC for SHM, to Delta Engineering (licensed to SMS) for use on Go-Go (Intelsat) Wi-Fi antenna inspection requirements, for the B737 aircraft. The generic Issue Paper and the STC approval are the basis for obtaining additional approvals in the near future.

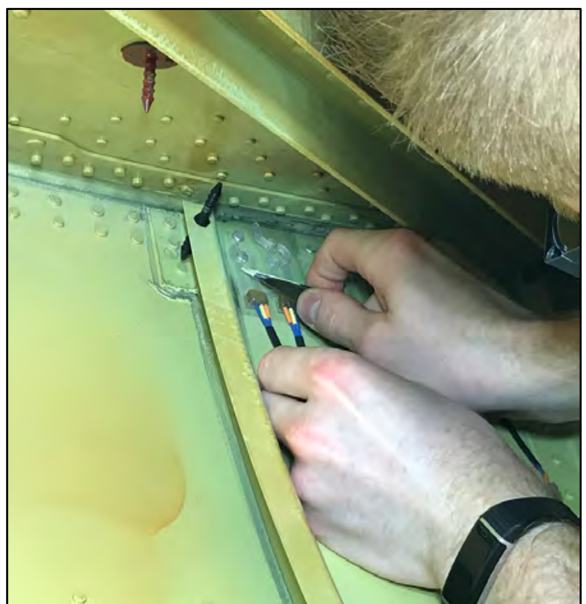
CVM Application – Aft Pressure Bulkhead Fitting



CVM Sensors on B737 Aft Pressure Bulkhead







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CVM Performance Tests – Sensitivity, Durability, Reliability

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CVM Applications – Focused Assessment of Single Platform (737NG)

- Frame Fitting and Fail-Safe Strap at STA 663.75 - Airworthiness Directive 2021-09-06
- Bearstrap at Forward Galley Door Cutout - Service Bulletin 737-53A1407 (also 737 MAX)
- Inner Chord at BS727/S-18A - Service Bulletin 737-53A1402
- Crown Skin Chem-Mill Step Cracking - Airworthiness Directive 2017-19-26 (SB 737-53A1232)
- Stringer Repairs and Post-Repair Inspections - Service Bulletin 737-53A1397
- Aft Pressure Bulkhead - Service Bulletins 737-53A1251 & 737-53A1403
- Fuselage Skin Cracking at S-14R - Service Bulletins 737-53-1399

Aerospace Industry Steering Committee on Structural Health Monitoring (AISC SHM)

First meeting of AISC-SHM
Stanford University
Palo Alto, CA
October 2006

Recognized need for guidance and standardization

20th meeting of AISC-SHM
OGMA MRO
Lisbon, Portugal
April 2016

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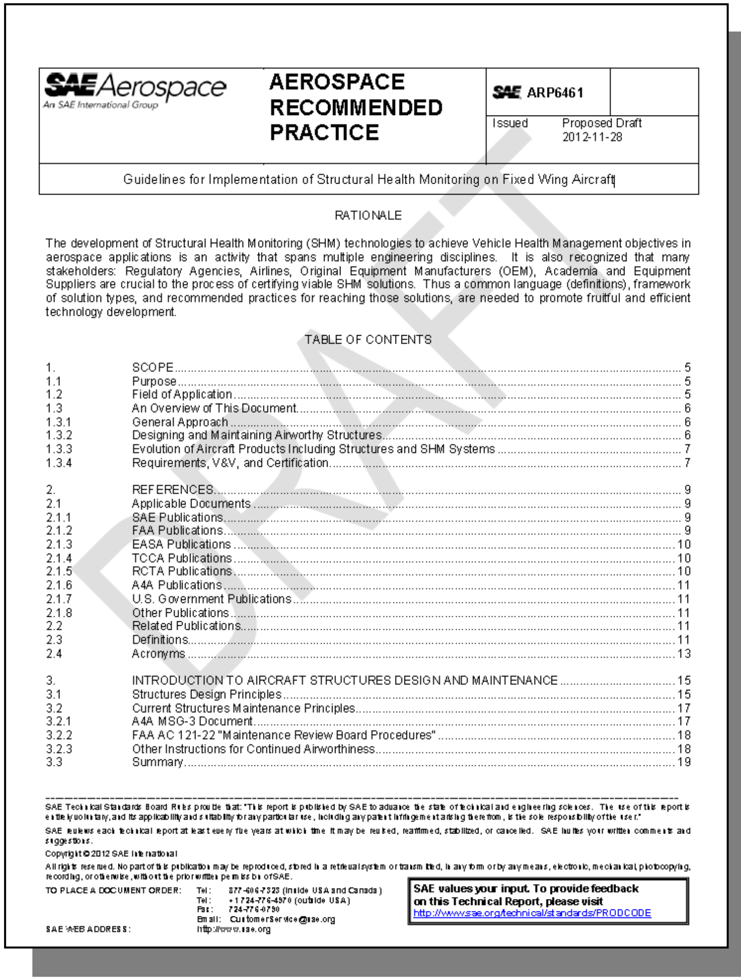
ARP – Guidelines for SHM Implementation

- The mission of the AISC-SHM is to provide an approach for standardizing integration and certification requirements for SHM of aerospace structures, which will include system maturation, maintenance, validation and introduction into accepted maintenance practices.

- The focus is the development of cross-industry guidebooks describing approaches to safely deploy SHM systems on fixed wing aircraft and rotorcraft and guidelines for the proper validation and certification of SHM solutions.

- SAE International Aerospace Recommended Practices document: ARP6461 "Guidelines on the Implementation of Structural Health Monitoring on Fixed Wing Aircraft" (Sept 2013)

- SAE International Aerospace Recommended Practices document: ARP6821 "Guidance for Assessing the Damage Detection Capability of SHM Systems" (in process)



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 of solution types, and recommended practices for reaching those solutions, are needed to promote fruitful and efficient technology development.

TABLE OF CONTENTS

STRUCTURAL MONITORING SYSTEMS

Other Developments to Aid SHM Utilization

- Multiple education initiatives completed as part of SHM application programs
- Inclusion of SHM in MSG3
- Discussions & coordination within other key industry groups:
  - Maint Programs Industry Group (MPIG)
  - Int'l Maint Review Board Policy Board (IMRBPB)
  - IATA Engineering and Maint Group (EMG)
- Maturation of SHM is supported as part of a larger effort in overall Aircraft Health Monitoring (AHM) activities
- SHM training initiatives underway (EASA & FAA)
- Quantitative performance analysis methods evolved (POD)
  - Statistics analysis software established by Boeing (Basu) and Iowa State Univ (Meeker)
- Multiple OEMS & airlines are carefully stepping through SHM application efforts

STRUCTURAL MONITORING SYSTEMS

Conclusions on Routine Use of SHM Solutions

- Overall, there is a strong interest in SHM – multitude of applications covering all aircraft structural, engine, and systems areas
- Recent advances in health monitoring have produced viable SHM systems for on-board aircraft inspections
- Sensors must be low-profile, easily mountable, durable, reliable & fail-safe
- General lab performance (sensitivity/POD) & flight test data is accumulating
- Reliability/POD assessments will depend on sensor system, flaw type/orientation and application – consider all variables that affect performance
- Performance Database – testing levels expected to be higher until sufficient database is obtained
- AMOC for SBs and ADs or STCs – safety driven use is achieved in concert with OEMS & regulatory agencies; certification & regulatory framework has evolved to streamline applications for use

Developments to Facilitate Routine Use of SHM on Commercial Aircraft

Questions ??

STRUCTURAL MONITORING SYSTEMS

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Developments to Facilitate Routine Use of SHM on Commercial Aircraft

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Reliable Structural Health Monitoring (SHM) systems can automatically process data, assess structural condition and signal the need for human intervention. The use of in-situ sensors, coupled with remote interrogation, can be employed to overcome a myriad of inspection impediments stemming from accessibility limitations, complex geometries, and the location and depth of hidden damage. While ad-hoc efforts to introduce SHM into routine aircraft maintenance practices are valuable in leading the way for more widespread SHM use, recent airline requests to deploy SHM indicated a significant need for formal SHM technology validation and certification processes to support the adoption of SHM solutions.

This paper presents recent efforts by regulators, OEMs, airlines and SHM developers to move SHM into routine use for aircraft maintenance. An array of SHM integration programs have addressed formal SHM technology validation and certification issues so that the full spectrum of concerns, including design, performance, deployment, and continued airworthiness were appropriately considered. The activities conducted in these programs demonstrated the feasibility of SHM usage and supported the development of industry guidelines and advisory materials to facilitate widespread adoption of SHM across the commercial aviation industry. The FAA has directed a number of SHM validation programs that have produced quantitative assessments for sensitivity, durability, and repeatability. Several aircraft manufacturers (OEMs) have embraced SHM with some even incorporating it into their NDT Manuals and issuing Service Bulletins that allow for SHM use. In addition, the FAA recently published an Issue Paper that provides essential guidelines for SHM system designers and procedures for assessing the performance of SHM systems. Finally, the demands by industry for standardized procedures and implementation of SHM technologies prompted the establishment of the Aerospace Industry Steering Committee for SHM (AISC-SHM). The AISC-SHM has evolved a number of documents to standardize approaches for integrating and certifying SHM use on aerospace structures. All of these efforts are allowing SHM solutions to quickly and properly support maintenance activities while establishing policies and guidance to ensure the safe, uniform and comprehensive certification of SHM systems.

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