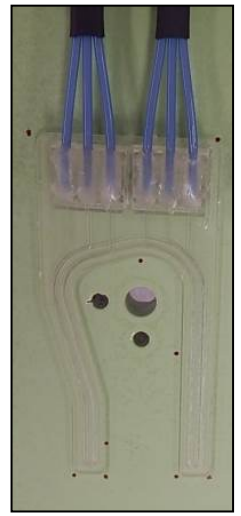
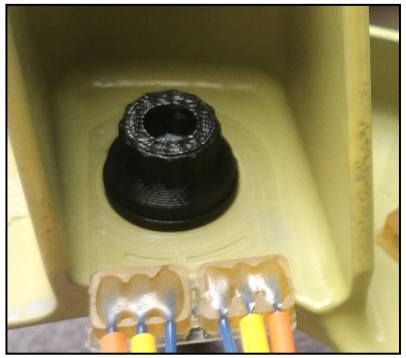
First Regulatory Approved Application of Structural Health Monitoring

2023 A4A-SAE NDT Innovation Award



DELTA ENGINEERING
A Panasonic Company

AERO
Keeping You Flying



STRUCTURAL MONITORING SYSTEMS plc

AEM ANODYNE ELECTRONICS MANUFACTURING CORP.

CVM SMART SENSOR SOLUTIONS

Team

Structural Health Monitoring Systems, PLC:
Rich Poutier

Anodyne Electronics Manufacturing Corp:
Trevor Lynch-Staunton, Brian Shaigec, Derrick Formosa, and Taylor Wylie

Delta Airlines:
David Piotrowski

FAA-AANC (Sandia); now DR Engineering, LLC:
Dennis Roach

Aero X Aviation Services:
Ron Grigsby, Billy, Yuriy and Alex

Delta Engineering
Ben Stanford, and Matthew Van Name

STRUCTURAL MONITORING SYSTEMS PLC

- Structural Monitoring Systems plc (SMS) has licensed and engaged its wholly owned subsidiary Anodyne Electronics Manufacturing Corp. (AEM) to provide all R&D, sales, manufacturing, and installation support for CVM™.
- CVM™ is the first technology to become commercially available, and FAA certified, to reduce span time and maintenance costs for commercial airline operators, by redeploying certain structural inspections from dedicated major heavy and out-of-sequence check visits to the gate environment.
- Comparative Vacuum Monitoring (CVM™) technology has been designed and developed for more than 15 years, working in partnership with several major industry airlines and OEMs.
- It's the first application available to the market for monitoring structural metal fatigue on RONs , or at the gate.

WHY CVM™?

- LESS DOWNTIME MEANS MORE FLIGHT revenue
- Comparative Vacuum Monitoring (CVM™) smart sensors minimize the time and labor maintenance crews spend inspecting aircraft surfaces for cracks. In what used to require days in the hangar now takes minutes on the RON, or at the gate.
- Significantly reduces or eliminates costs associated with inspections at heavy and out-of-sequence checks, maximizes scheduled maintenance program efficiencies, reduces span time, and restores thousands of flight hours across your entire fleet network.

REPLACES HANGAR TIME WITH AT-THE-GATE INSPECTIONS

RESTORES VALUABLE FLIGHT HOURS TO THE NETWORK

SHIFT TO CONDITION-BASED MAINTENANCE PROGRAMS

CVM™ OPTIMIZED MPD SIGNIFICANTLY REDUCES SPAN TIME

VALUE PROPOSITION

SAFETY

- Enables elevated inspection frequencies, with little to no impact on the day-to-day operations.
- Eliminates false negative readings, removing the significant rework and open-up for no crack verification and compliance.

QUALITY CONTROL

- Eliminates false negatives. It's a 'go/no-go' gauge when it comes to structures.
- No sample calibration mishaps; no tight areas for probe position.
- Virtually eliminates human error during inspections.

ENGINEERING

- Allows engineers to effectively mitigate impact of future Service Bulletins, FCDs, and new fatigue areas.

CONDITIONS-BASED MAINTENANCE

- Groundbreaking technology to broaden the maintenance program, shrink the maintenance footprint and give significant 'green time' back to the operator.

MAINTENANCE PLANNING

- Allows planning to connect to the aircraft anytime without impact to flight or maintenance operations.
- Enhances flexibility of high-frequency, low-impact inspections.
- Saves time, and reduces workload conflict, and improves the general flow of the visit.

MAINTENANCE ADAPTABILITY

- No time wasted. Work card becomes easily managed.

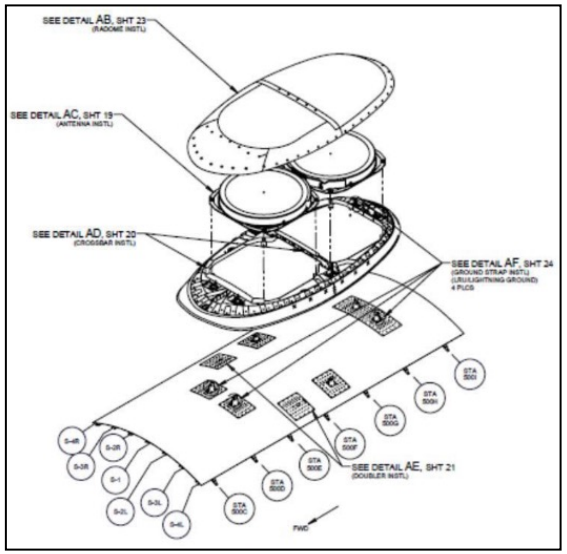
Delta Engineering Corporation Overview

DELTA ENGINEERING
A Panasonic Company

- In business for over 30 years offering Aviation Certification, Engineering and Manufacturing capabilities.
- We support projects on small, single engine Part 23 aircraft up thru large cabin and large radome installations on A340 and B777 commercial aircraft and everything in between.
- Completed over 1,500 FAA STC's and amendments for a range of avionics related projects including Digital Autopilots, ADS-B, Electronic Flight Instrumentation, EGPWS, Flight Data Acquisition, Comm/Nav suites, In-Flight Entertainment Systems, cabin interiors, large antenna's (including radomes) along with many other systems.
- Besides the FAA in the US, Delta has also obtained many foreign approvals and validations from Japan (JCAB), Singapore (CAAS), Europe Union (EASA), Hong Kong (HKCAD), Canada (TCCA), among many others.
- We are specialists in solving aviation engineering problems with interiors and avionics. We pride ourselves on finding several workable options for solving any problem our clients bring to us.

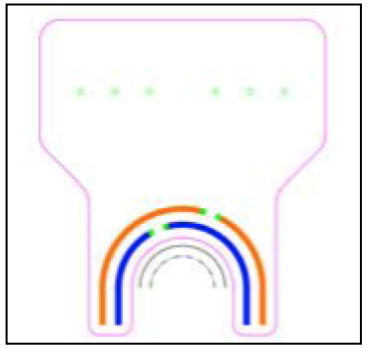
CVM™ Application – WiFi Antenna Installation Structure

Multiple aircraft types, multiple airlines

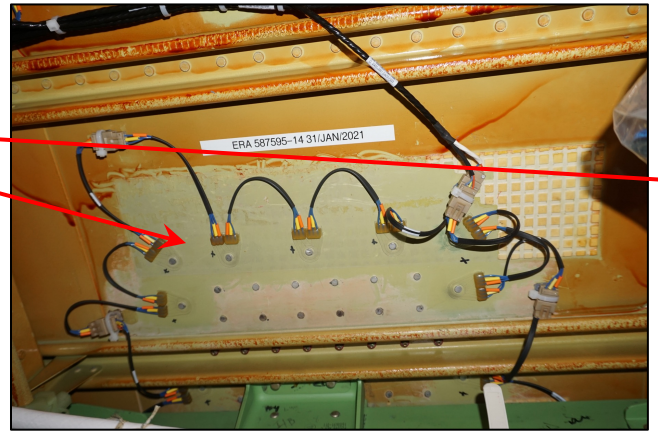


B737 WiFi Antenna Support

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



CVM™ Sensor Design



FAA Issue Paper – WiFi Specific and Generic (Nov. 2019, 2021)

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
NATIONAL POLICY REF:	AC 25.571-1D	**ISSUE STATUS: OPEN**
SUBJECT:	Comparative Vacuum Monitoring (CVM) for Damage Detection in Structure of Antenna Installations	**BRANCH ACTION: AIR-7H1, AIR-7H2, AIR-675, AEG** **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)

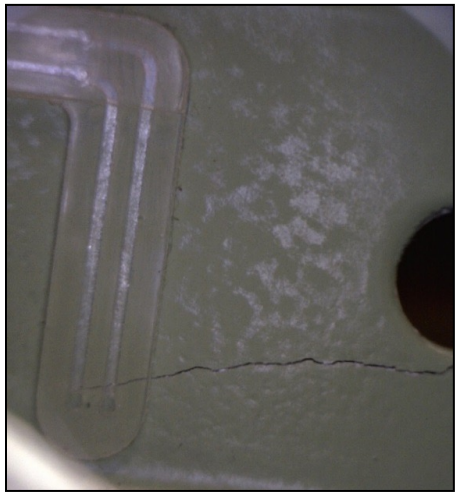
Purpose

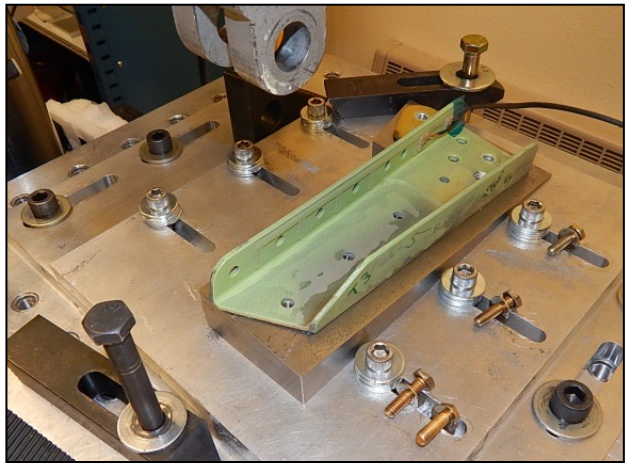
- Address type certification and type validation processes - issues of particular interest to the FAA, including aspects of the design or proposed methods of compliance (MoC)
- Uniform certification approach between applicants - valuable reference for future type certification programs & for development 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

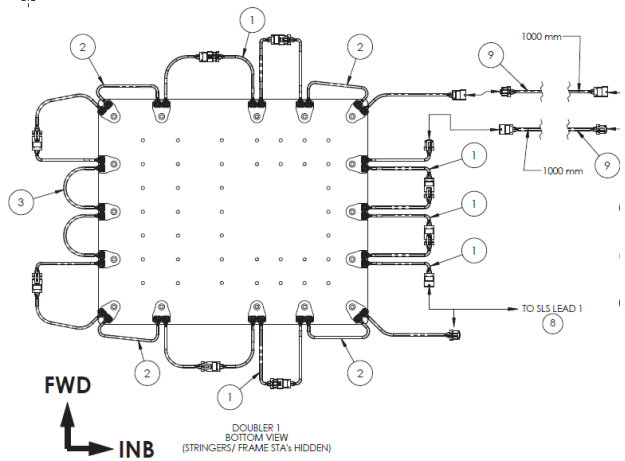
CVM™ Performance Test – Sensitivity, Durability, Reliability

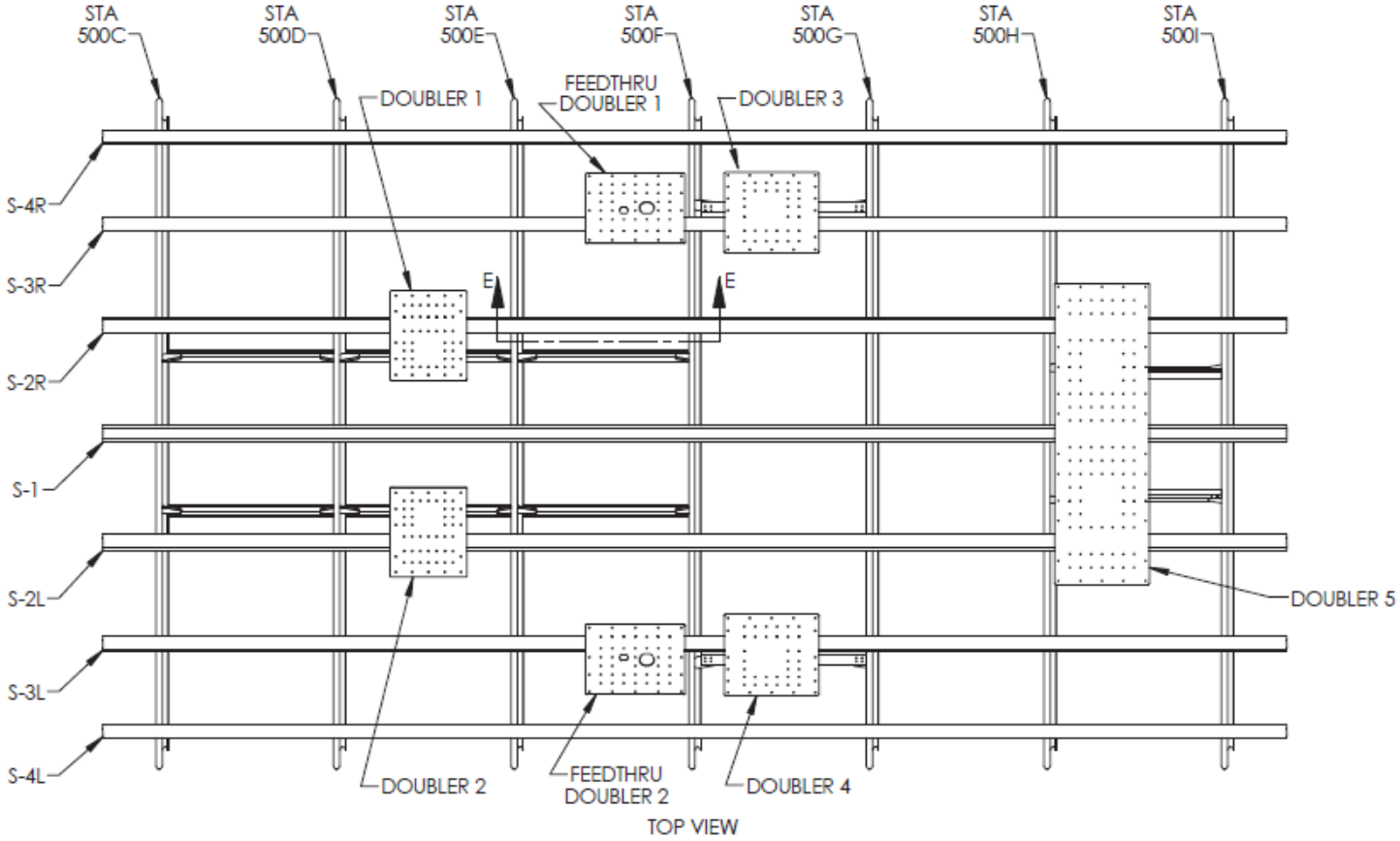




CVM™ Application – WiFi Antenna Kit

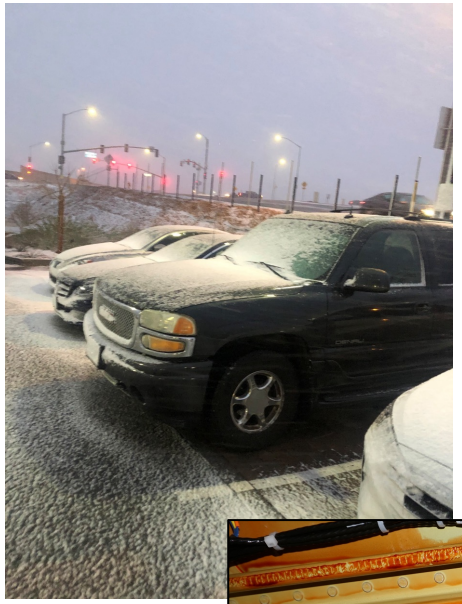
158 Sensing Locations
7 Sensor Networks

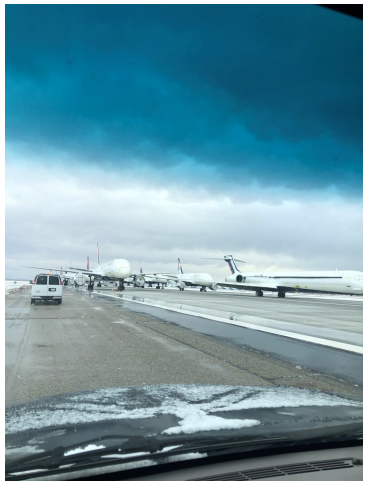


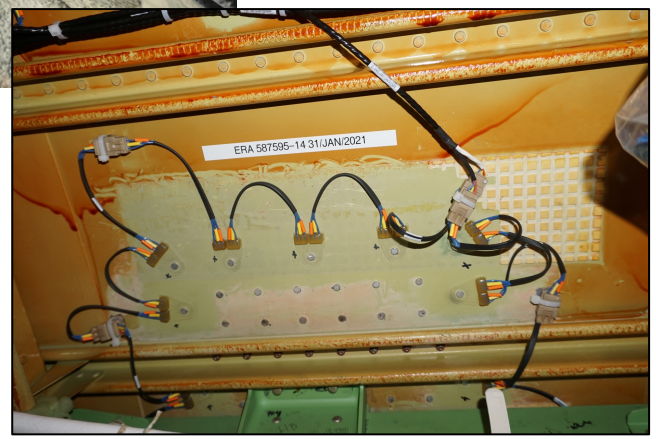


CVM™ Application – WiFi Antenna Installation at VCV (Jan. 2021)

First Installation Victorville, CA







Mid-pandemic, and recent snow in California, first installation for STC completed on tarmac

- **Remotely supported from Canada**
- **Installation crew was inexperienced with CVM and hadn't received standard training prior to install**
- **Snow, generator, largest most challenging installation ever completed**

Certification Status – FAA Approved (STC granted March 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 is the basis for obtaining additional approvals in the near future.

Developments to Facilitate Routine Use of SHM on Commercial Aircraft

[Q&A]

Benjamin Stanford
Trevor Lynch-Staunton