



**Airlines for
America[®]**

NDT
NONDESTRUCTIVE
TESTING FORUM

Microwave Coating Thickness Inspection for Aerospace Composite Structures

Airlines for America NDT Forum

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Systems and Materials Research Corporation (SMRC)

Background

Substrate Composition

Microwave Theory

MNDE Toolkit

Analysis

Summary

- Small business founded in 1998
- Based in Austin, Texas
- Heavy R&D/product development concentration
 - Outsourced manufacturing
 - Licensing
 - Strategic Partnering
- Three key manufacturing technologies developed for military aerospace platforms
 - Intelligent Sealant Application System (ISAS™)
 - QwikSeal® pre-sealed aircraft fasteners
 - Microwave Nondestructive Evaluation (MNDE) Toolkit™



Industry Need

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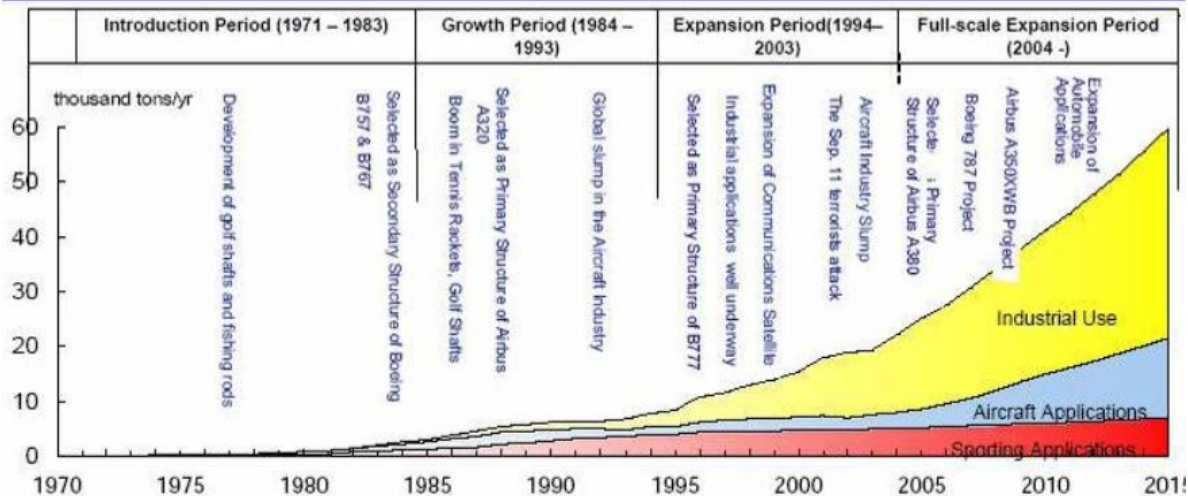
MNDE Toolkit

Analysis

Summary

- Use of composite materials has expanded rapidly in aerospace and other industries
- Many of the traditional NDI methods must be reevaluated for accuracy and some have proven to no longer function as intended
- Aerospace manufacturers and maintainers are currently seeking replacement technologies for accurate coating thickness measurement over composite structures

Trends in World's Carbon Fibers Market



* Global Carbon Fiber Market

- 80,000 – 90,000 metric tonnes per year expected by 2015
- Aerospace segment comprises 10-20% of global market

Coating Thickness Inspection

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- Nondestructive inspection (NDI) technologies used to monitor coating thickness to detect:
 - undercoated substrates, can lead to early substrate failure
 - overcoated substrates, which contribute to aircraft weight
 - effect the efficacy of lightning strike protection mechanisms, especially expanded copper foil (ecf) mesh

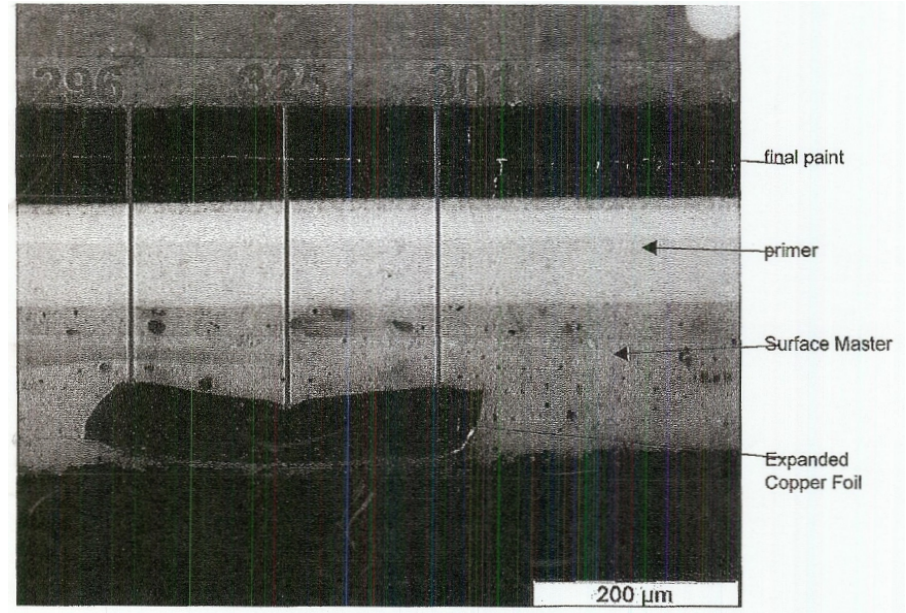


Figure 1 – Example of a composite coating matrix from a cross-sectional micrograph of coating over an aerospace composite panel with expanded copper foil.

Microwave Non-Destructive Evaluation

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MNDE Toolkit™



Remote Probe™

Software defined coating thickness measurement system with sub-coating feature/fastener and corrosion detection.

RoboChek™

Robotic end-effector mounted for real-time thickness monitoring.



BladeChek™

Erosion coatings wear monitoring for high radius-of-curvature applications.

ChekMate™

Laser- and microwave-based panel alignment measurement (gap and flush)



- Simple microwave and electronic components
- Well-founded, innovative calibration software
- Highly accurate coating thickness measurements
- Ability to see surface characteristics through coatings
- Robust software-defined functionality
- Ideal technology for composite coating thickness measurement

Using this foundation we can build standalone and custom integrated solutions using our MNDE technologies.

MNDE Toolkit™

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- Software-defined, multi-function portable NDE system
 - Coating thickness
 - Hidden fastener detection
 - Corrosion under specialty coatings



*Hardware built and tested at Lockheed, Northrop, and JAX.
Hardening required before fleet-ready. Many enhancements under discussion.*

MNDE Toolkit™

Background

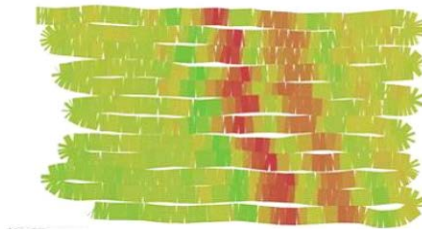
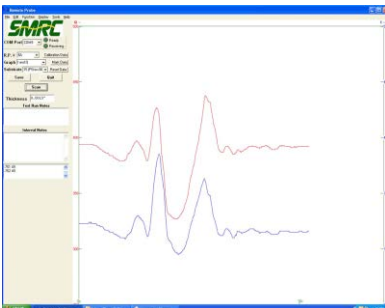
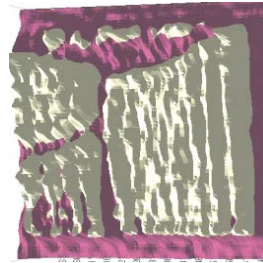
Substrate Composition

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The MNDE Toolkit Remote Probe can be adapted to provide wireless x/y scanning capabilities in a handheld, easy-to-use system. Coating thickness accuracies are approximately $\pm 1\%$ for composite and metallic substrates. Imaging capabilities can provide corrosion and flaw detection as well as identification of sub-surface elements such as fasteners for repair

BladeChek™

Background

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Summary

- Designed to measure erosion coating thickness on highly curved surfaces
- Proprietary laser pitch/catch system measures only when microwave is normal to surface



Self-contained coating measurement solution for high radius of curvature and flat applications. Calibration requires computer. Commercially available.

Test Case – Aerospace CFRP

Background

Substrate Composition

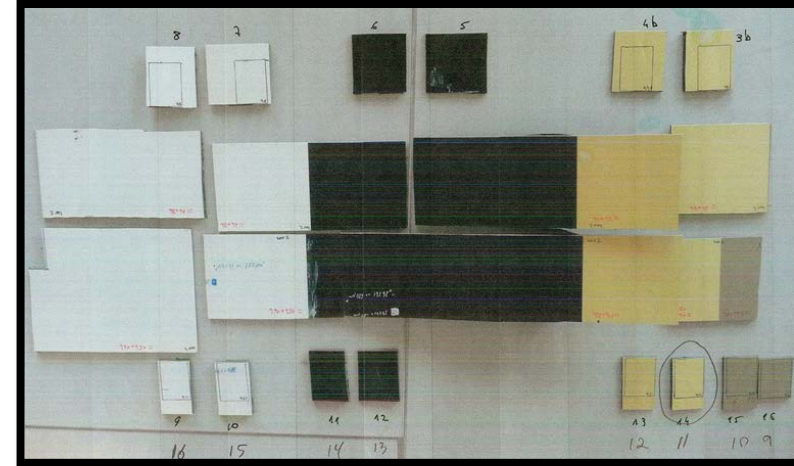
Microwave Theory

MNDE Toolkit

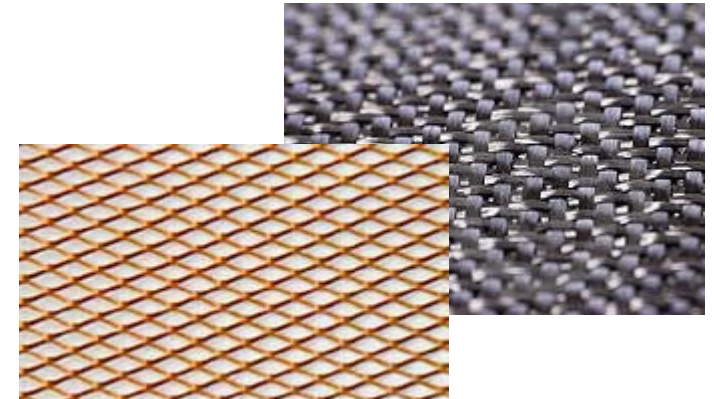
Analysis

Summary

- Provided sample panel sets from aerospace manufacturer
- SMRC performed calibration, sampling and analysis of capabilities over samples
- Improvements made to microwave system to increase accuracy to customer desired 15 micron accuracy



The Remote Probe detects the “peaks and valleys” of the ecf and carbon fiber with rotation of the tool, causing changes in the signal and prediction capability.



Test Case – Aerospace CFRP

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Summary

Further experiments yielded increased accuracy from improvements to Remote Probe

Changes to microwave configuration resulted in accuracy improvement to +/- 15 microns

- *Antennae changes to reduce surface irregularity effects*
- *Selective standoff and calibration*
- *Signal conditioning using increased gain*

Sample Set	Mean	Standard Deviation	Number of Samples	Specification for 95% Confidence Interval	Predicted Yield for +/- 15 microns
Nor-1 Initial	121	113	1250	161	11.16
Nor-2 Initial	4	86	4500	121	32.66
Nor-1 Slot Antenna	-3	23	3500	64	63.18
Nor-2 Slot Antenna	14	29	3000	24	75.7
Nor-1 Adjusted Standoff	-7	31	3000	85	31.29
Nor-2 Adjusted Standoff	-6	24	9000	61	60.87
Nor-1 with Gain and Adjust Standoff	-9	17	3500	23	49.03
Nor-2 with Gain	6	23	4500	53	56.71
Nor-2 with Gain and Adjust Standoff	-4	4	3000	4	100

Other Aerospace Samples

Background

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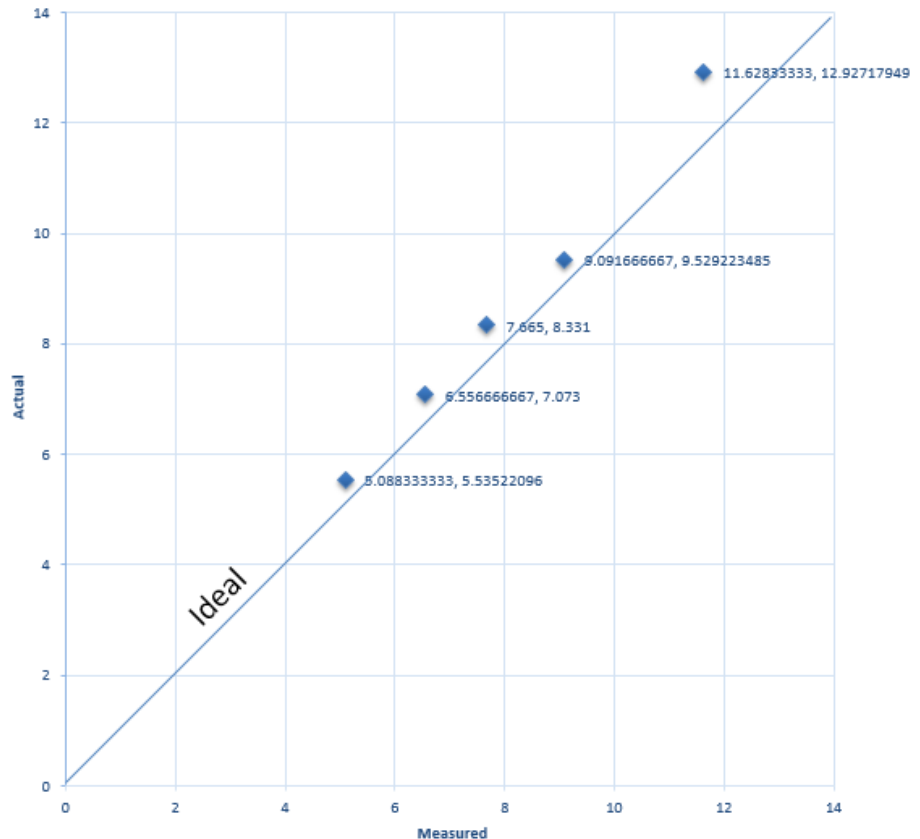
Microwave Theory

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Analysis

Summary

- Measured vs actual comparison using cross-section/optical measurement
- Range of coatings from 2-14 mils thick on cfrp with ecf
- MNDE Toolkit shows accurate, precise, and repeatable results
- Down-selected as best tool for coating thickness for large-scale platform repair



Future Work

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Analysis

Summary

- Currently the MNDE Toolkit Remote Probe is a software-defined system
 - *Requires tether to computer*
 - *Provides extra capabilities such as fastener and corrosion detection*
- SMRC will bring a single, self-contained unit to the marketplace in the next generation Remote Probe
 - *No computer tether required*
 - *Provides coating thickness measurements only*
- R&D focused on eliminating rotational uncertainty over expanded copper foil composite substrates



Commercial Status

MNDE Toolkit

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Summary

- Current system is commercially available for purchase with a production lead time
- Interested in licensing technology dependent upon customer commitments and market size
- Incorporation of feature/requirements above and beyond the current system will be evaluated based on customer commitments/requirements