Microwave Nondestructive Evaluation (MNDE)

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In the beginning . . .

There was corrosion detection

- SMRC wins 1999 Phase I SBIR program to prove concept of detecting corrosion under paint on (then) conventional metallic aircraft structure

Microwave Corrosion Detector (MCD)
Circa 2003

- 10 Beta units built and field tested
- Sensitive to onset levels of corrosion

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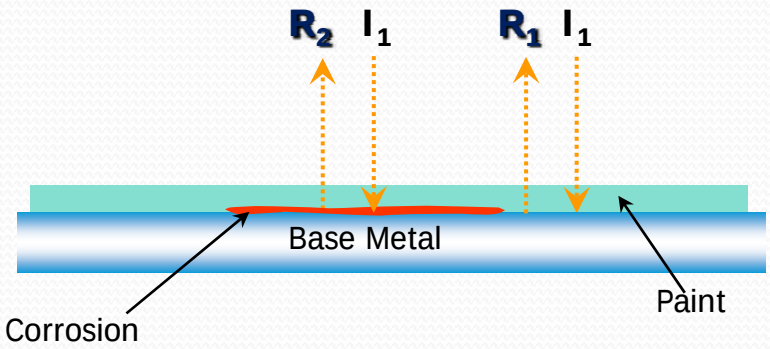
Detecting Corrosion with Microwaves

Early Onset

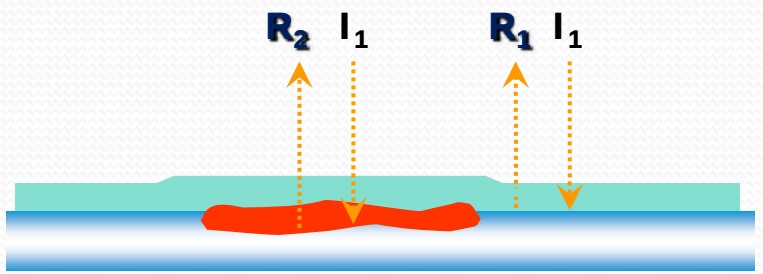
Detecting dielectric contribution from oxides



$R_2 \neq R_1$ due to change in dielectric signature

Advanced Corrosion

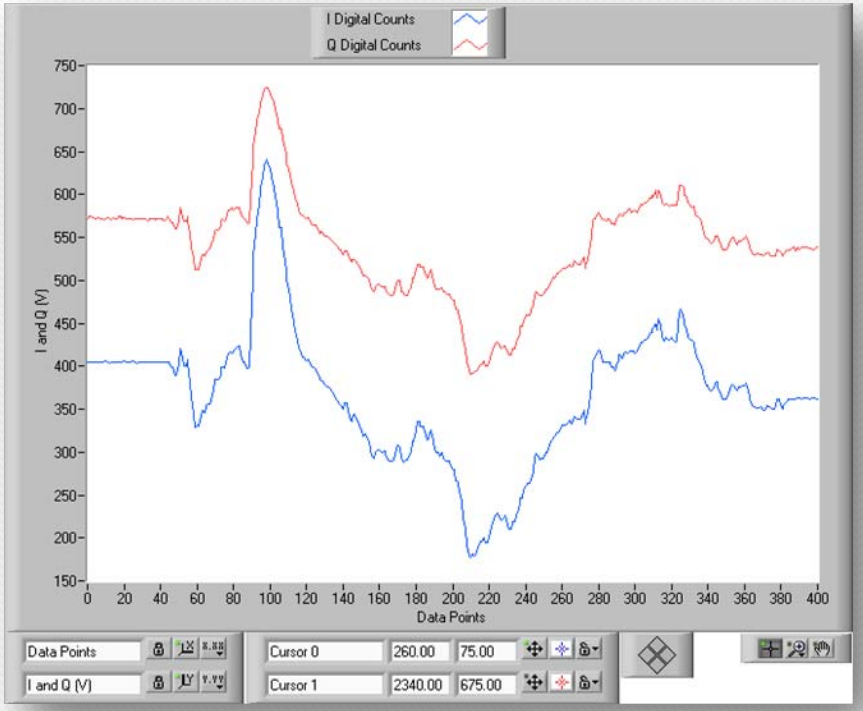
Combination: dielectric and signal path to base metal



$R_2 \neq R_1$ due to change in dielectric signature and distance to base metal

From Door Openers to Corrosion Detectors

- Microwave transceiver operating in near field of target
  - COTS Doppler radar for automatic door opener sensors
- Schottky diodes sense reflected μwave energy components
- I and Q components digitized
- “Fingerprint” of reflected signal analyzed
- Corrosion/No-Corrosion decision



A Funny Thing Happened on the Way to Corrosion Detection . . .

2001:

We make some bone-headed rookie assumptions that led us down a blind alley.

- **The BAD news**:
  - We can't tell the difference between extra coats of paint and corrosion
- **The GOOD news**:
  - Microwaves are very sensitive to differences in coating thickness
  - With math and motion we can eliminate the masking effects of variable coating thickness

Voila!

Microwave corrosion detection works!

(Sound of one hand clapping)

"So what did you do with the coating thickness info?"

The F-35 Microwave NDE Era Begins

Jan 2003:

- Microwave Corrosion Detector introduced at LMA Ft. Worth
  - Stacey Luker, Robert Trice, Scott Fetter et al in attendance
- JSF team cool to corrosion detection, but . . .
- ***We discover that (near field) microwave radiation penetrates specialty coatings***
  - On both metallic and composite substrates
- That opens the door to investigating numerous candidate applications for MNDE

Mid-2004:

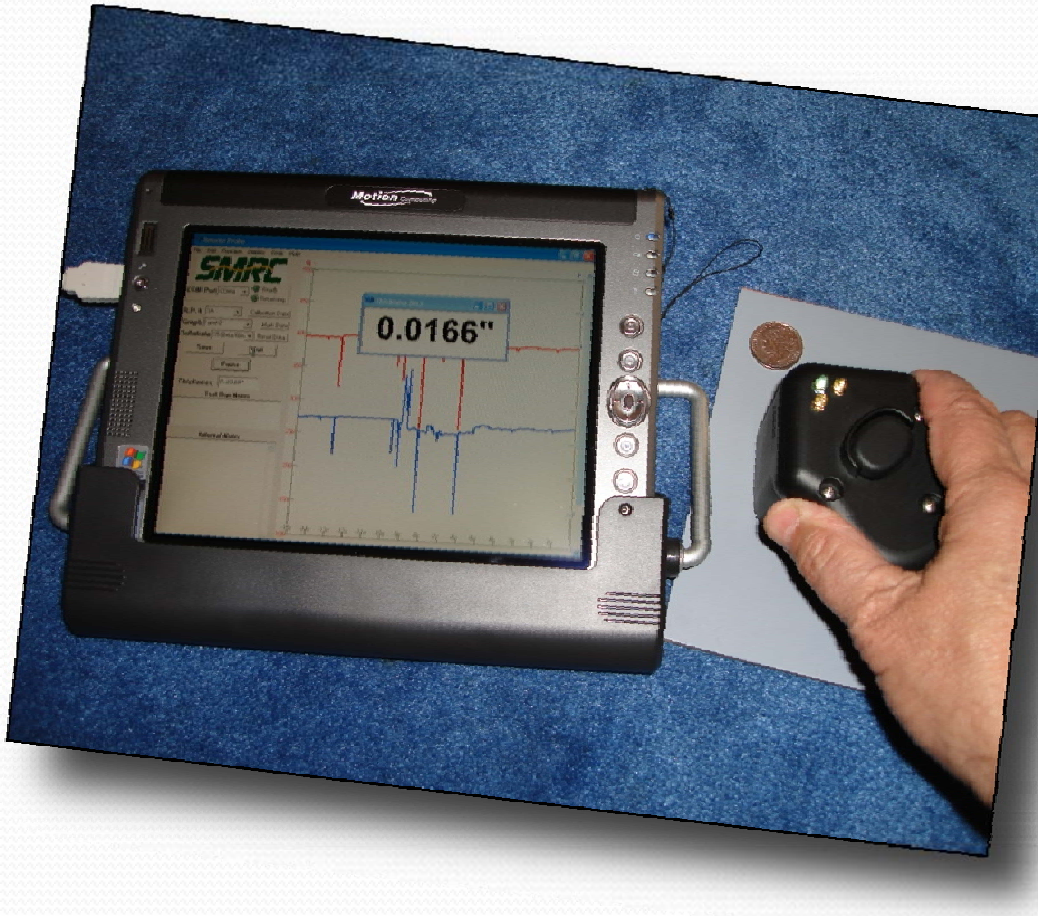
- JPO lets first Phase III DO for SMRC

Initial F-35 MNDE Applications

- Measure thicknesses of specialty coatings
  - Over metal
  - Over composites
    - With and without lightning strike
- Detect important features through coatings
  - Fasteners
  - Seams
  - Leaks
  - Corrosion

The MNDE Toolkit™ is Born

A ***software-defined*** microwave NDE system capable of multiple inspection applications in a single handheld package



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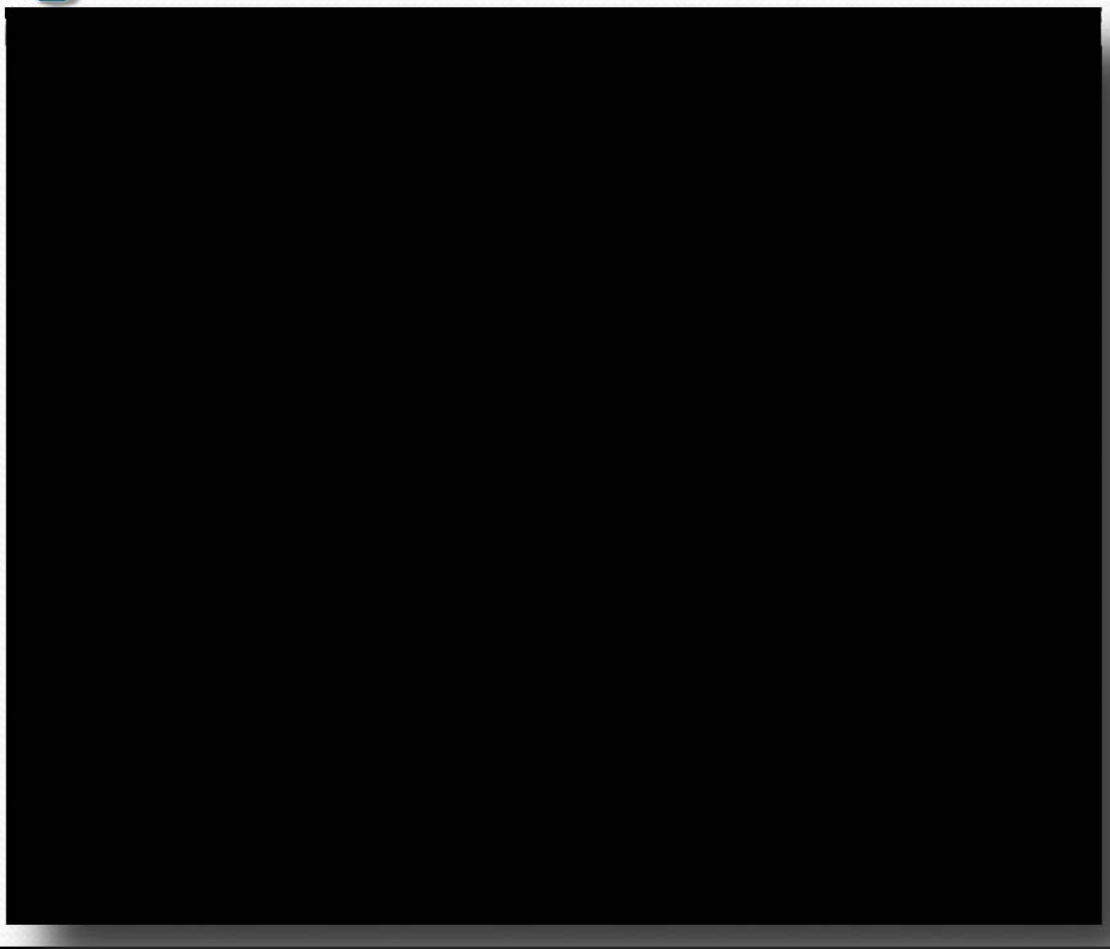
Coating Thicknesses Measurement



Remember the story of Goldilocks and the Three Bears?

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Finding (and Marking) Fasteners with MNDE

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MNDE Toolkit Next Steps

- Mechanical/Electronic Design
  - Harden the Remote Probe for field (SE) use
    - Environmental
    - Explosion-proofing (Div2)
  - Improve marking mechanics
  - *Consider* redesigning into standalone system (connected to PC only for calibration)
- Software
  - Improve existing capabilities and add new ones
    - Improve fastener detection algorithms
    - Eliminate orientation effects in selected composites
    - Detect intrinsic heat damage in composites

New MNDE Developments

- F-35 Final Finish Coating Thickness Measurement
  - Replace spray head with Microwave NDE/laser sensor suite
  - Check coating thicknesses at many points quickly using paint robot
  - NAVAIR (JSF) Phase II SBIR
    - In cooperation with NGC
- V-22 Erosion Coating Thickness Measurement
  - Leading edges of rotor blades (highly curved surfaces)
  - NAVAIR (V-22) Phase II SBIR
    - In cooperation with Bell Helicopter and Hontek

MNDE Developments (Cont'd)

- F-35 Gap & Step Mismatch Measurement
  - Combination microwave/laser sensor suite
  - Measures through coatings and boots
  - Multiple gap types
    - With and without coatings
    - With and without boots
    - With and without lightning strike
- G-S measurements would allow significant workflow improvements in F-35 assembly
  - Lockheed ManTech Program

Measuring Coatings in F-35 Final Finish

Phase II SBIR work in progress in cooperation with NGC

End effector-mounted microwave/laser sensor head interchangeable with spray head

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Measuring F-35Gap and Step Mismatch

Early work in progress in cooperation with LMA

MNDE gap-step measurement would allow significant efficiencies in F-35 production.

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Since this is an ESTCP Workshop . . .

It's worth noting that corrosion detection isn't entirely passé.

- Even new advanced fighter aircraft corrode
  - And with specialty coatings it's even harder to detect . . .

But not with microwave.

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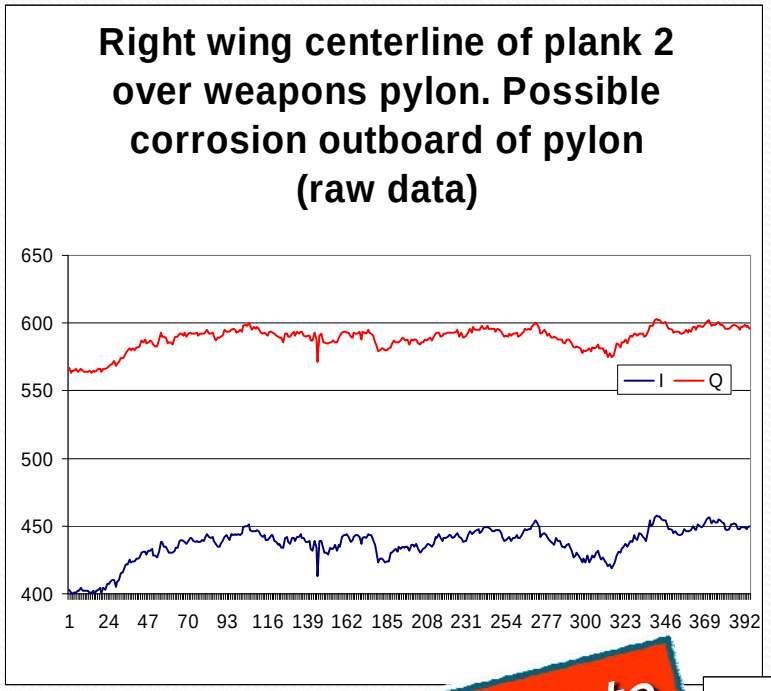
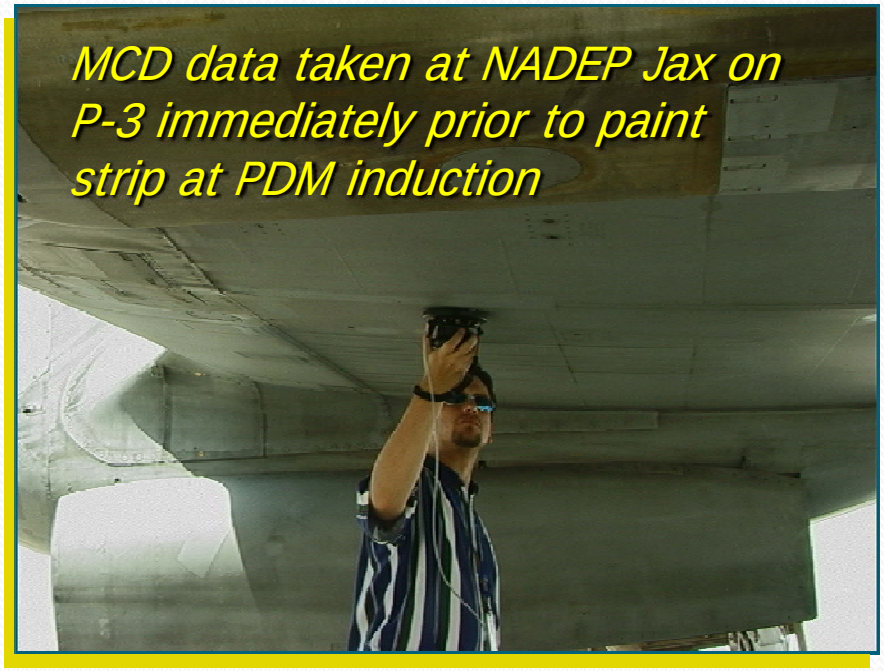
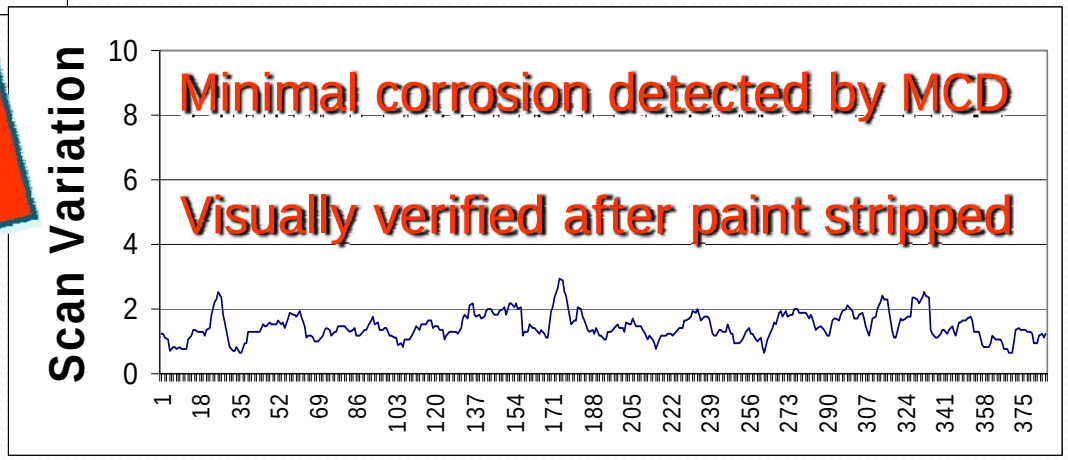
An Early Lesson from the Field





Was it necessary to strip and repaint this P-3?



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Thank you for your attention!

Questions?

For more info

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