



Infrared Reflectance Imaging for Corrosion Inspection Through Organic Coatings (WP-0407)

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NORTHROP GRUMMAN



Report Documentation Page

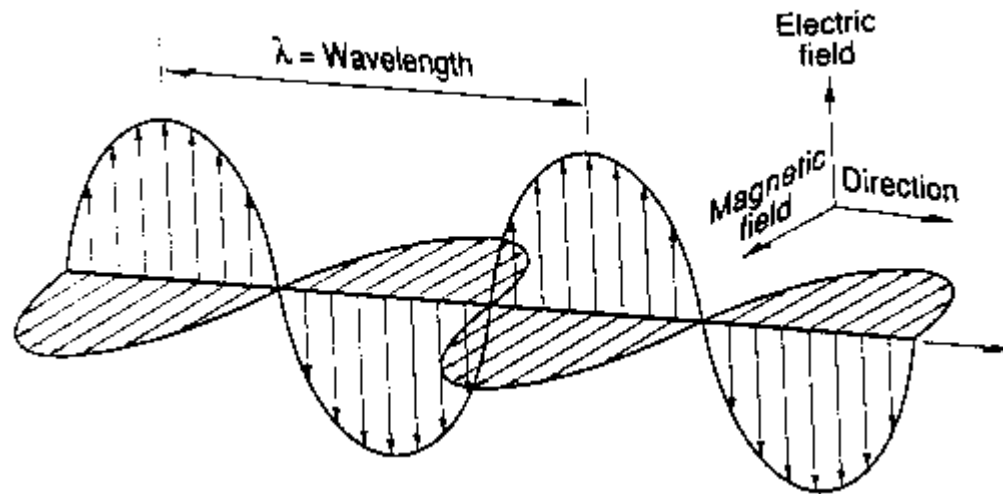
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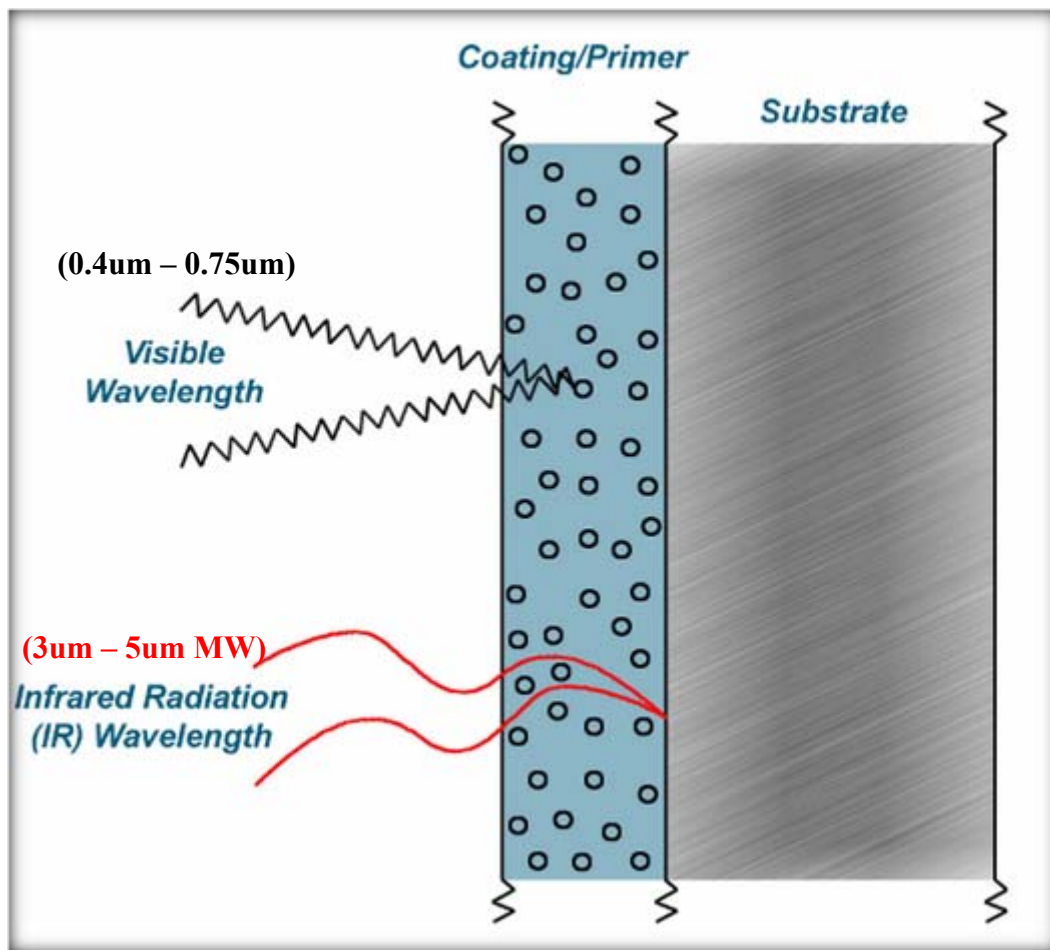
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TECHNICAL CONCEPT

THEORY



TECHNICAL CONCEPT



U.S. Patent: 7,193,215

IR cameras tuned to a transparent spectral window can image through standard paint systems.

Reflectance differences between regions appears as image contrast.

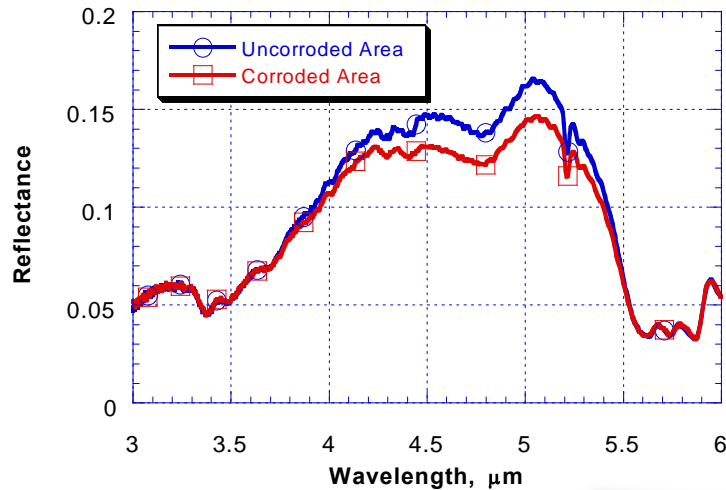
Result is real time imaging of substrate surfaces for video or digital capture.



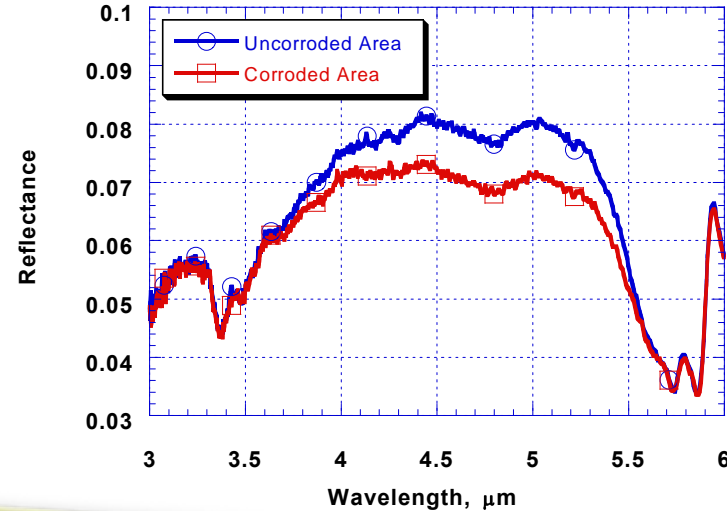
IMAGE CONTRAST

Reflectance of Corroded and Uncorroded Regions of Painted Aluminum Coupons

Gloss White Topcoat/PRC 23377 Primer
Alodined



Gloss Gray Topcoat/Korflex Sealer/PRC 23377 Primer
Alodined

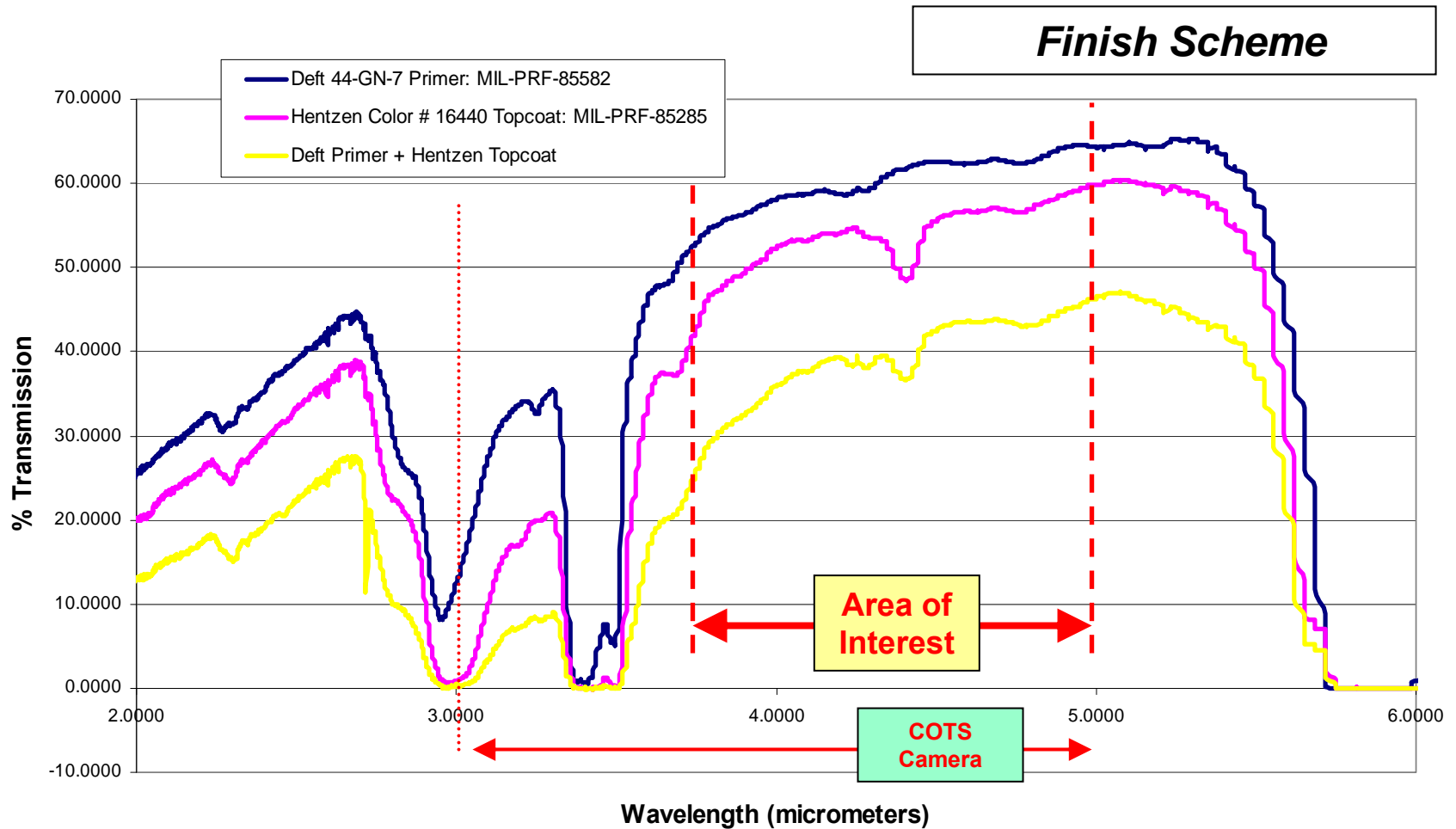


U.S. Patent: 7,193,215

Modern IR cameras tuned to this spectral window can see through the paint, and reflectance differences between regions appears as image contrast



OPTIMAL TRANSMISSION BAND



Note: Coatings are standard mil-spec thicknesses.

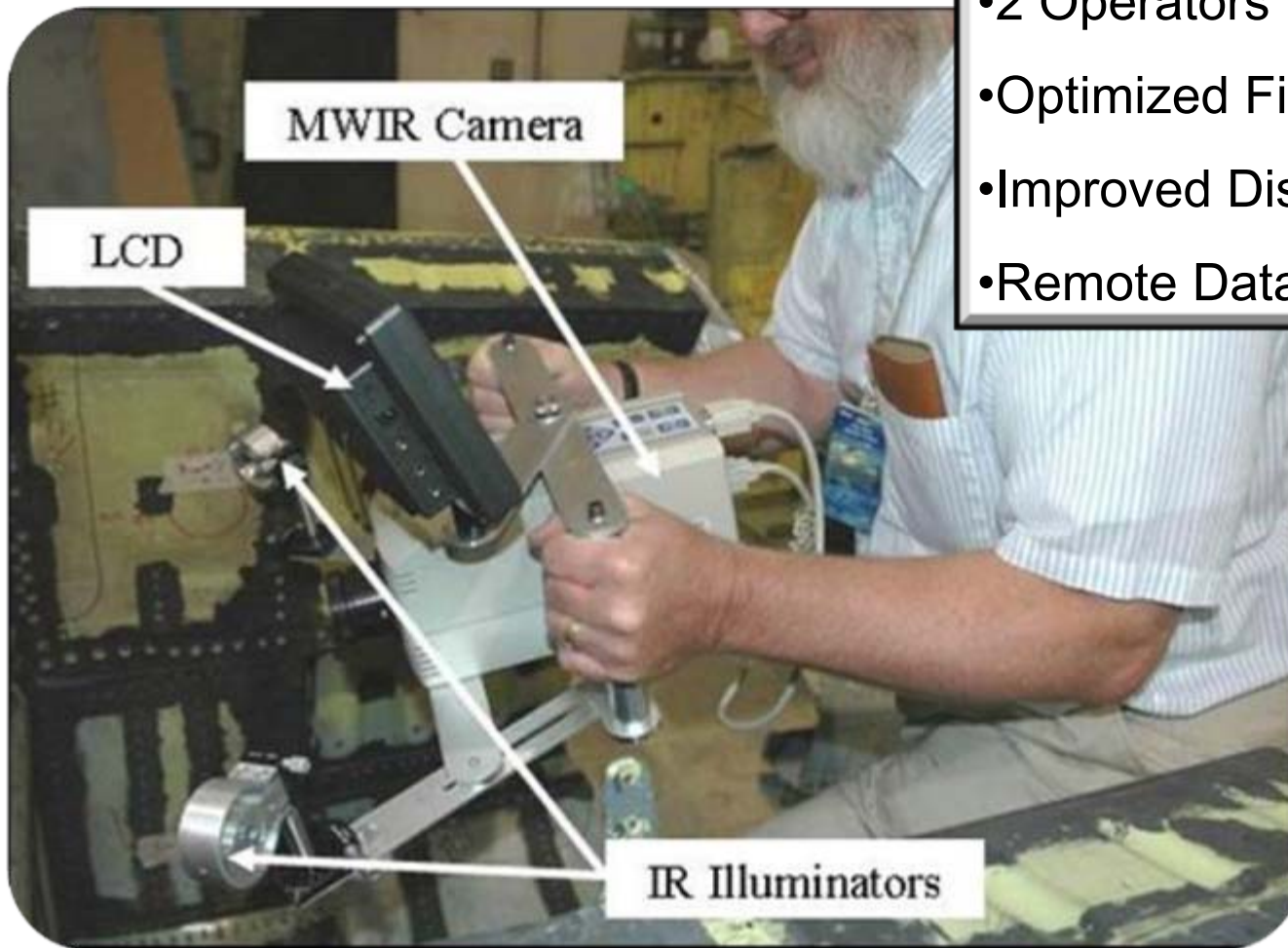


TECHNICAL CONCEPT

DEVELOPMENT



2ND GENERATION PROTOTYPE SYSTEM



- 2 Operators
- Optimized Filter
- Improved Display
- Remote Data Capture

IR Illuminators



TARGET STANDARD ANALYSIS

Visible Image



Visible Painted Image



IR Painted Image



Laboratory validation standard in support of image optimization.

Field operational check standard to verify camera functionality.

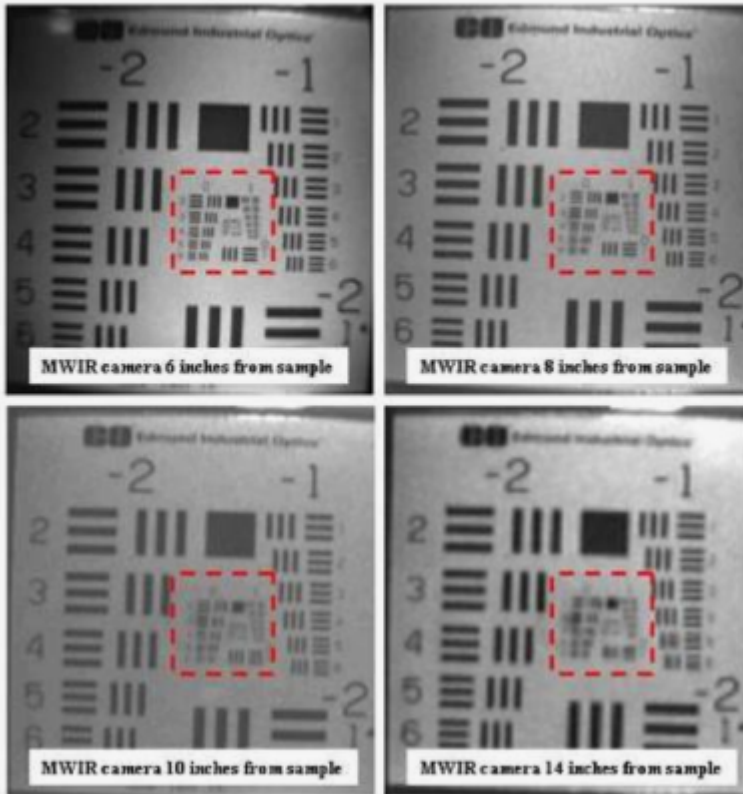
Note: This standard is painted MIL-PRF-85582 epoxy primer and MIL-PRF-85285 polyurethane topcoat.

(NAVAIR Standard Paint Scheme).



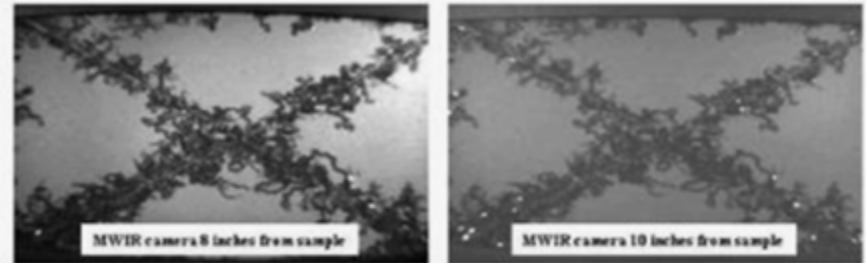
IR IMAGING OPTIMIZATION

USAF Target – Resolution/Distance Test

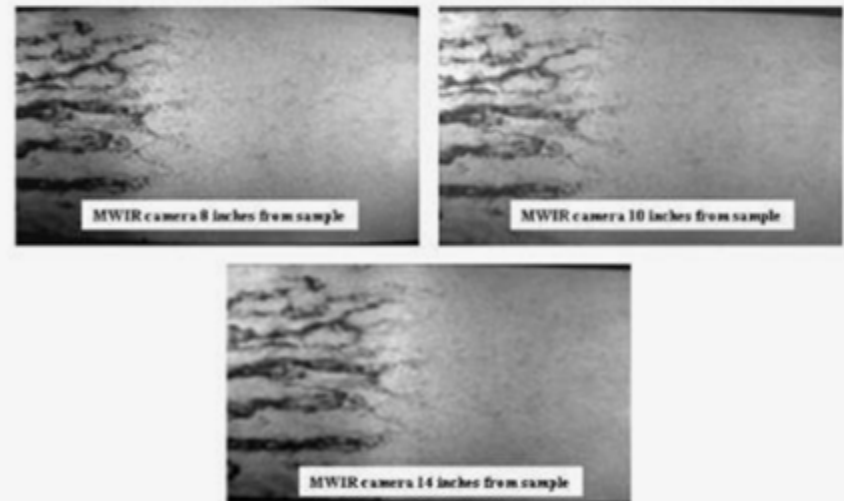


USAF Target Coated with P-3 Aircraft Paint Scheme (Primer + Topcoat).

Filiform Sample – Resolution/Distance Test



Corrosion Sample – Resolution/Distance Test

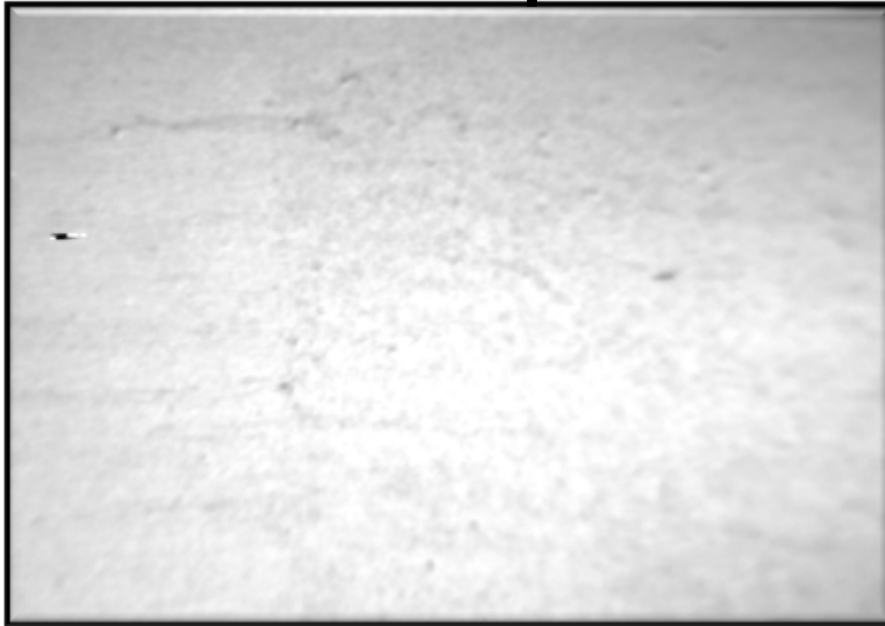


Corrosion Sample Coated with P-3 Aircraft Paint Scheme (Primer + Topcoat).

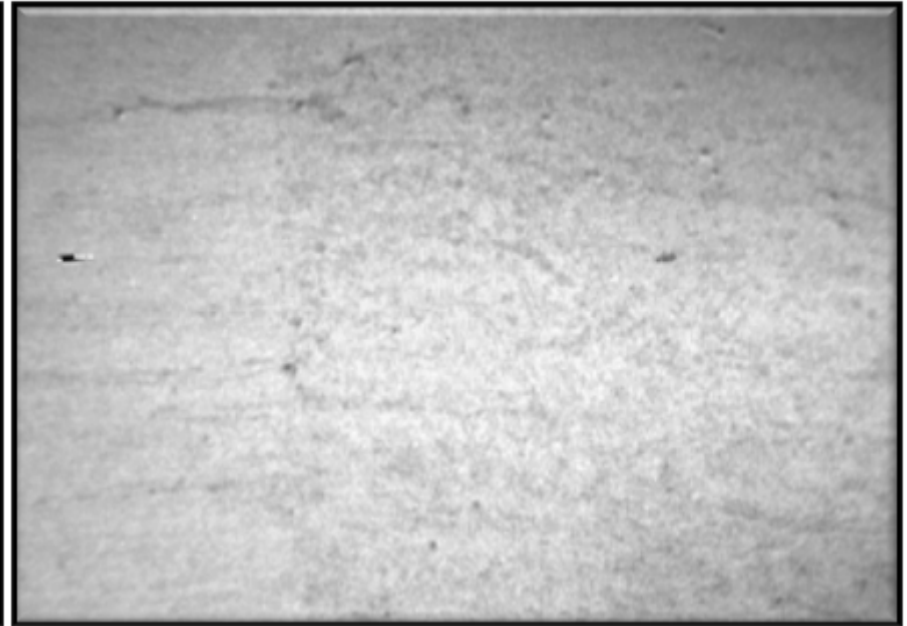


FILTER EVALUATION

Optimized Filter Results



3-5 μm : STANDARD FILTER



3.75-5 μm : OPTIMIZED FILTER

*****Received new Merlin IR camera with internal 3.75-5 micron filter.***

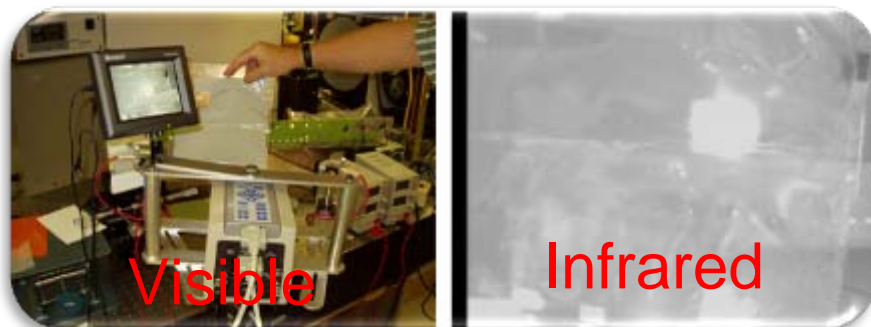
(US 2006/0289766 Patent Application)

(02 5000105021 00 5 9800 98000000)



CHEMICAL AGENT RESISTANT COATINGS

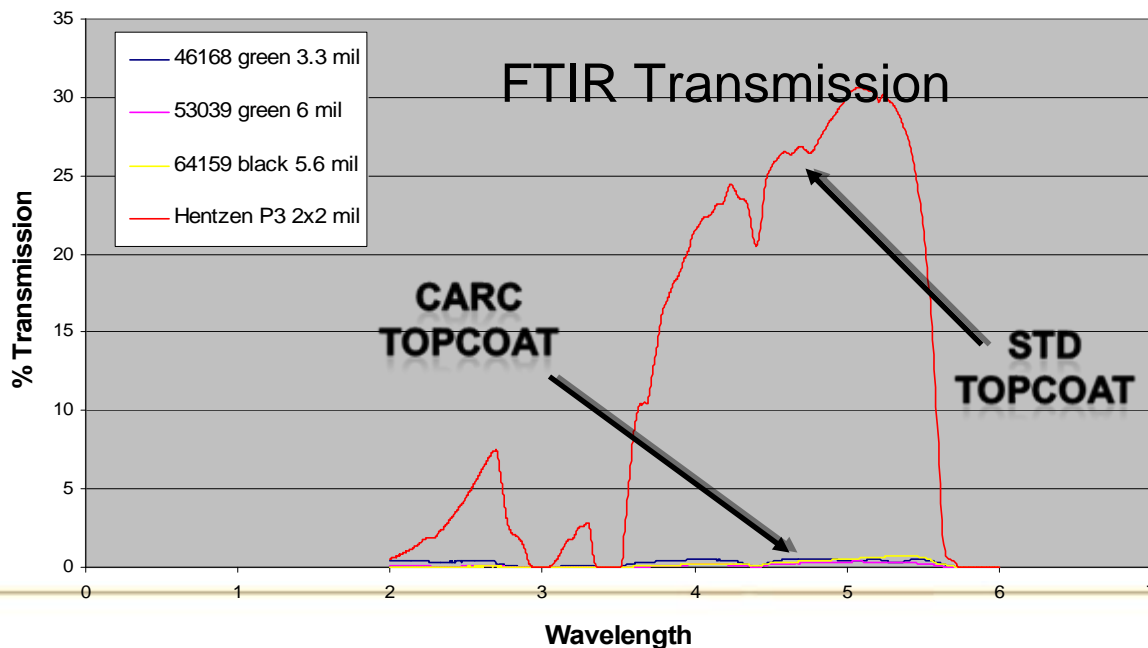
STD TOPCOAT



CARC TOPCOAT



Paint films on plastic substrate introduced between the heat source and the IR camera.



Polysulfide & Ty II primers exhibit poor IR transmission similar to CARC coatings.



TECHNICAL CONCEPT

Demonstration



TECHNICAL APPROACH – Dem/Val

NADEP Jacksonville, FL

IRRIT Results (Painted) vs. Visible Results (Stripped)

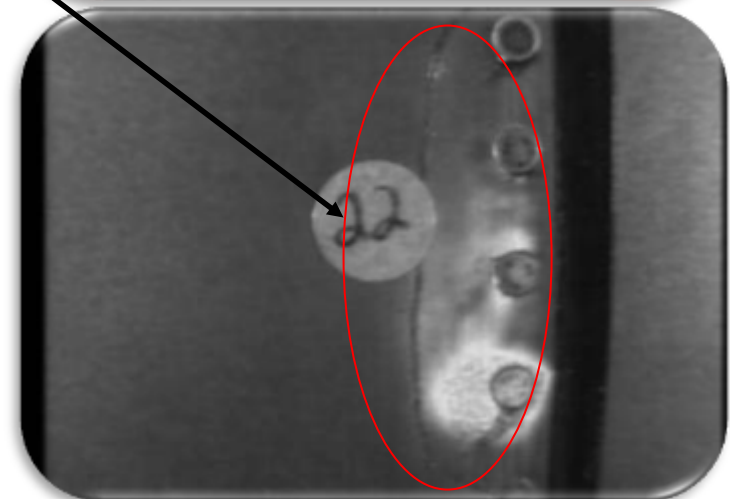
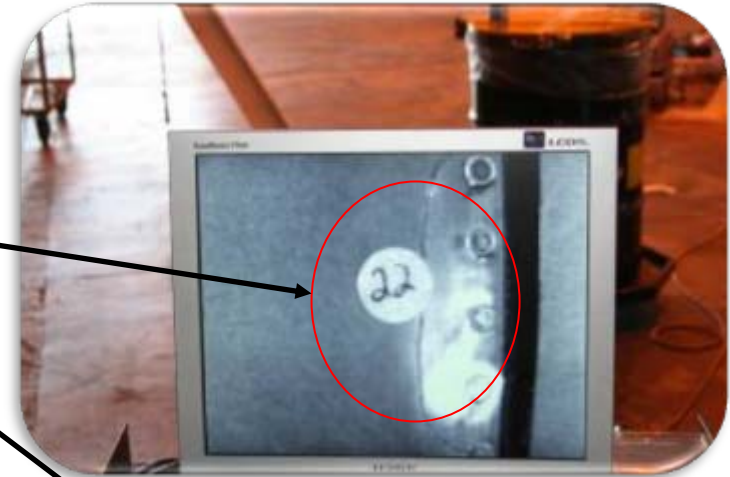
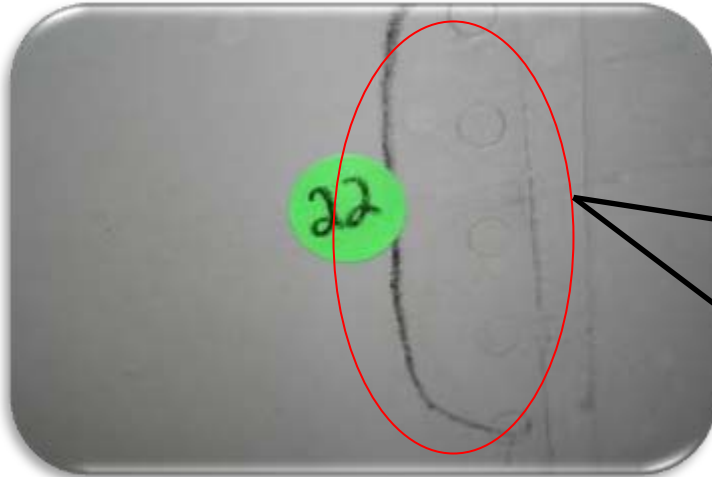


Comparing the IRRIT results of the painted aircraft versus the visible results of the chemically stripped aircraft will demonstrate and validate that the IRRIT is a viable inspection method to reduce pollution products.

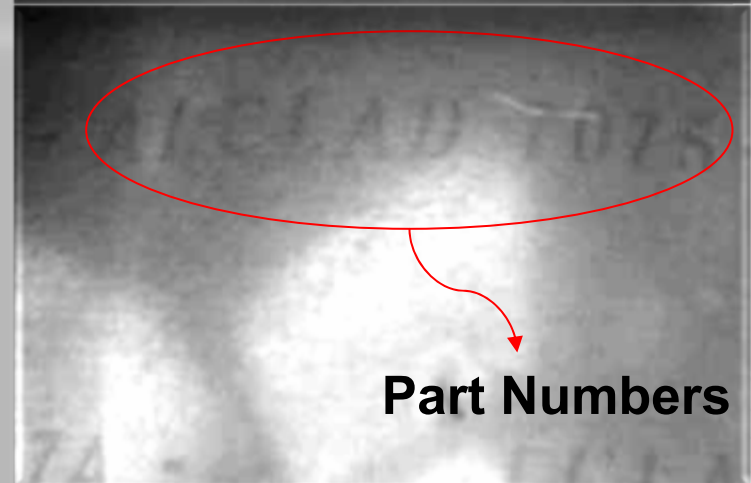
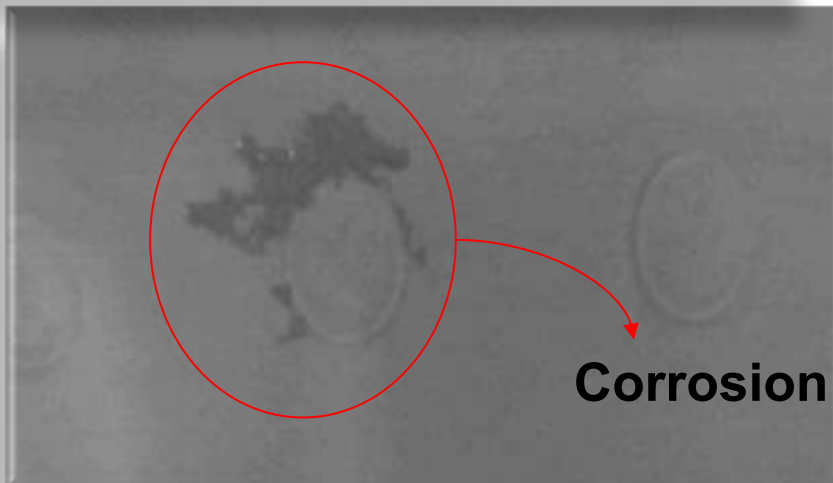
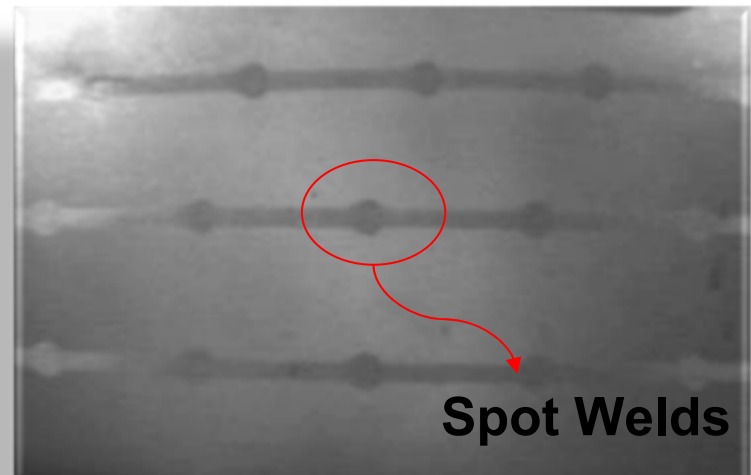
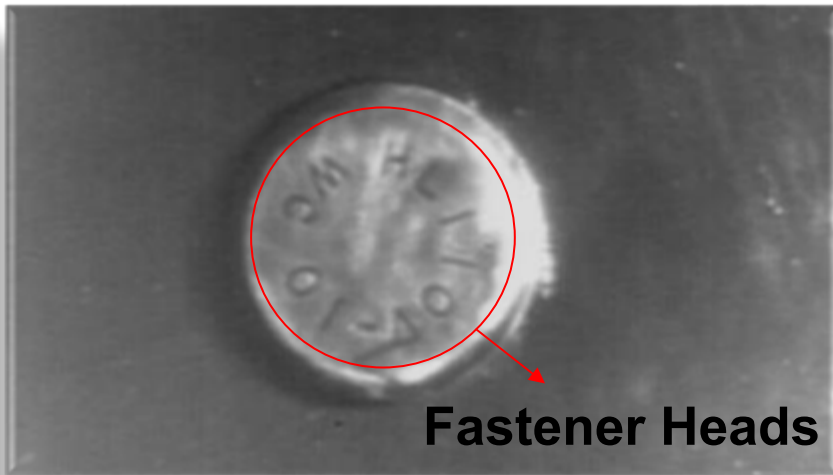


NADEP JACKSONVILLE – Dem/Val

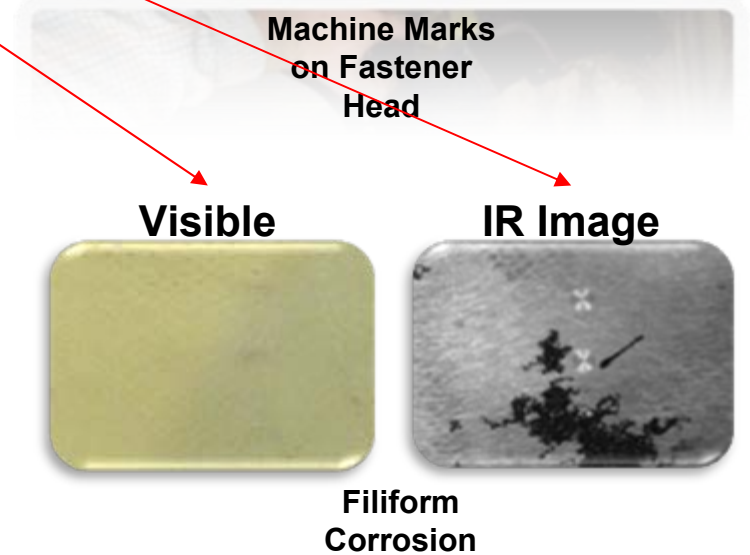
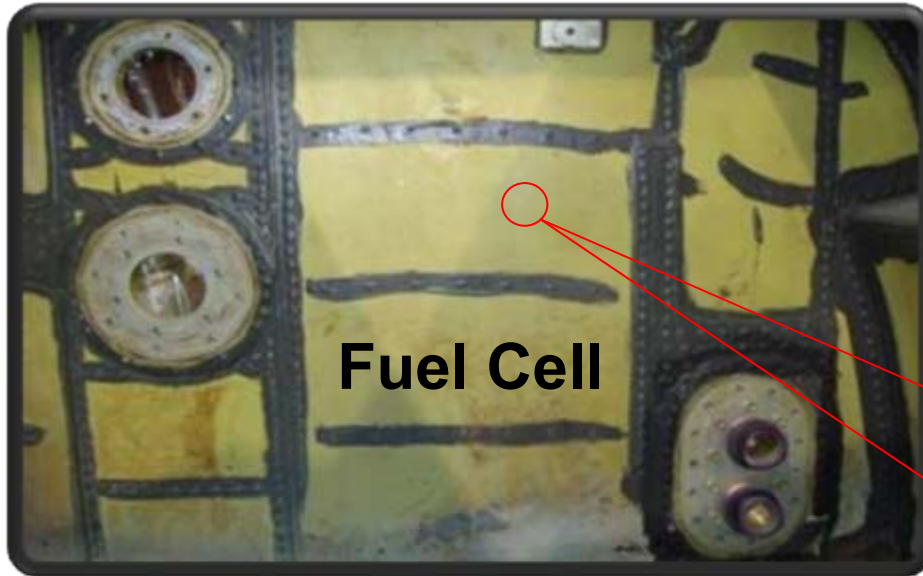
Started Official Dem/Val (2of 3) – P-3 BU# 162772, SEQ 311



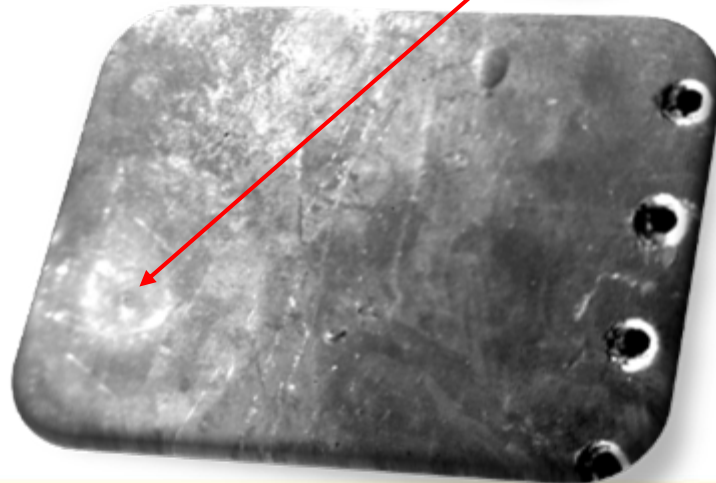
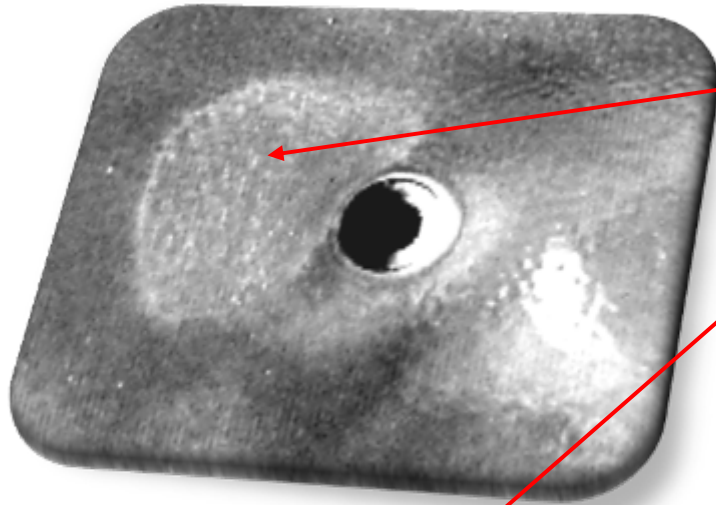
IR Inspection of Painted A/C



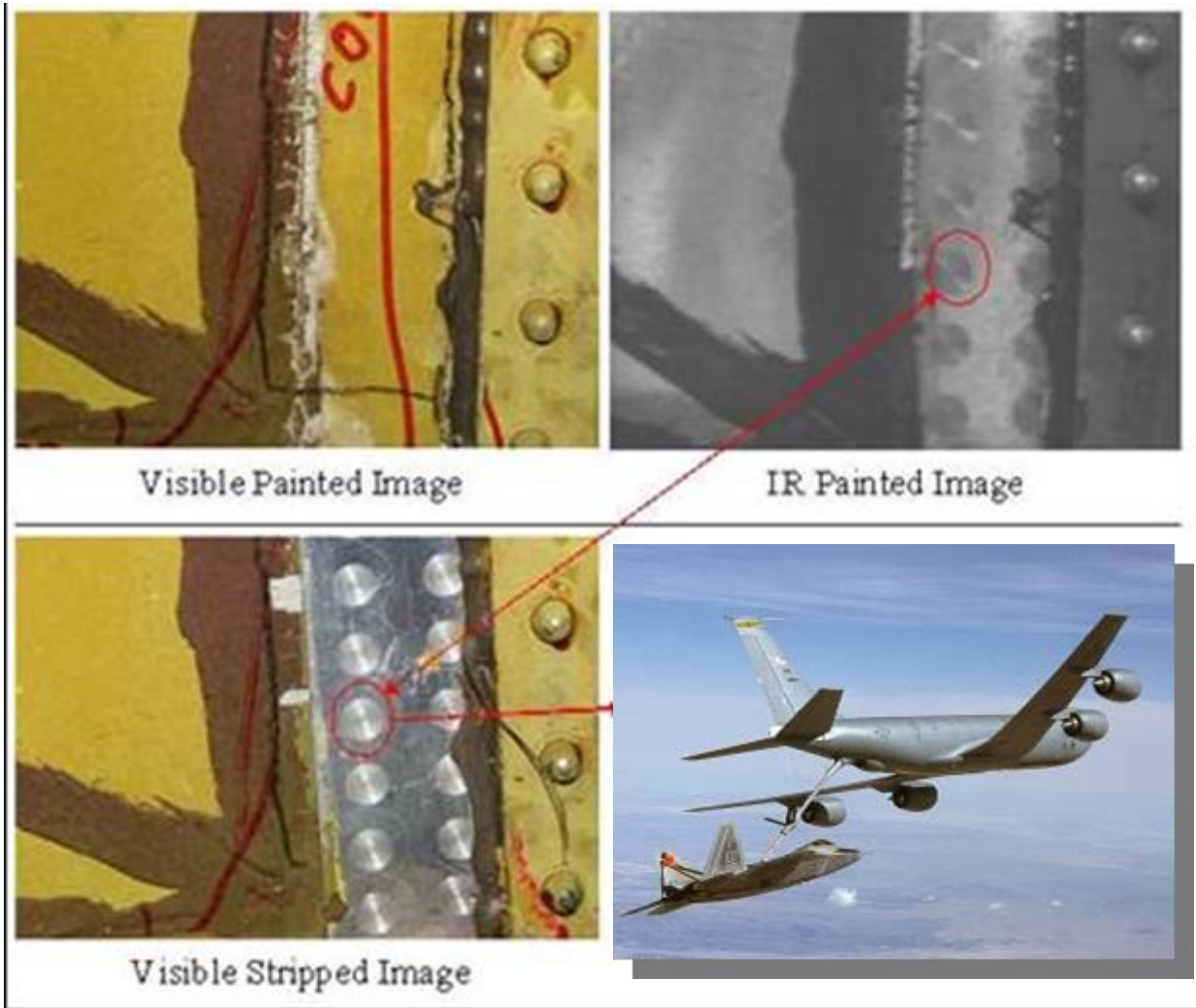
HILL AFB: A-10 CORROSION SURVEY



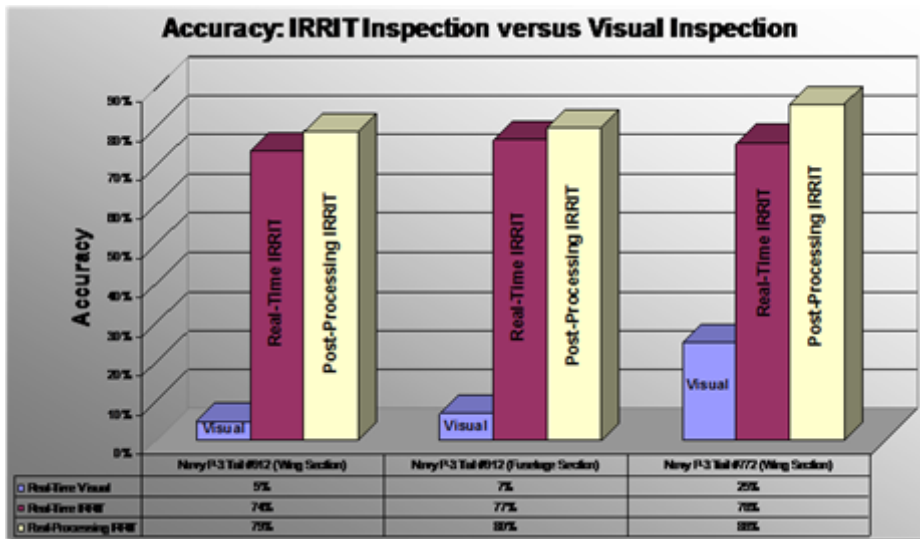
DETAIL OF E2-C HAWKEYE PANELS



KC-135 OC-ALC – Dem/Val



Results



Why?

1. The IR method directly images corrosion by-product through the paint system due to reflectance contrast differences of the substrate.
2. The visual method relies upon the identification of paint surface irregularities/blistering (i.e., paint degradation) as a result of substrate volume changes associated with corrosion formation.



DEPLOYMENT - PRODUCTION MAINTENANCE & OVERHAUL

- Wing Spar Inspection – Engineering evaluation of incoming material condition following visual ID of Corrosion.

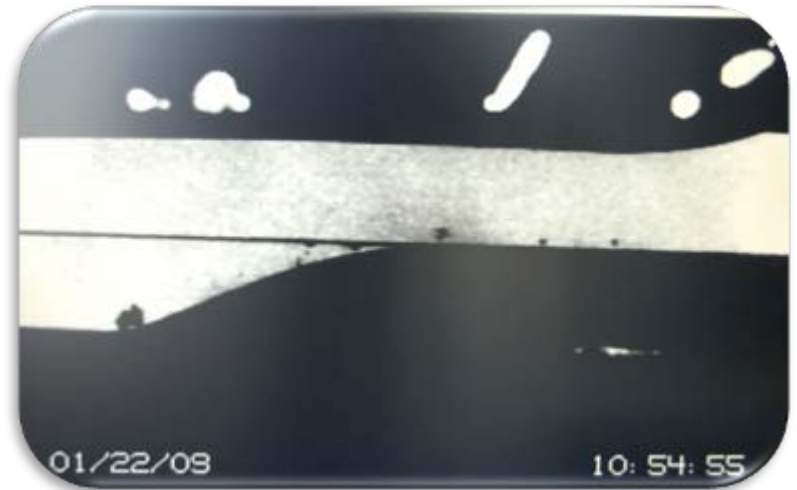
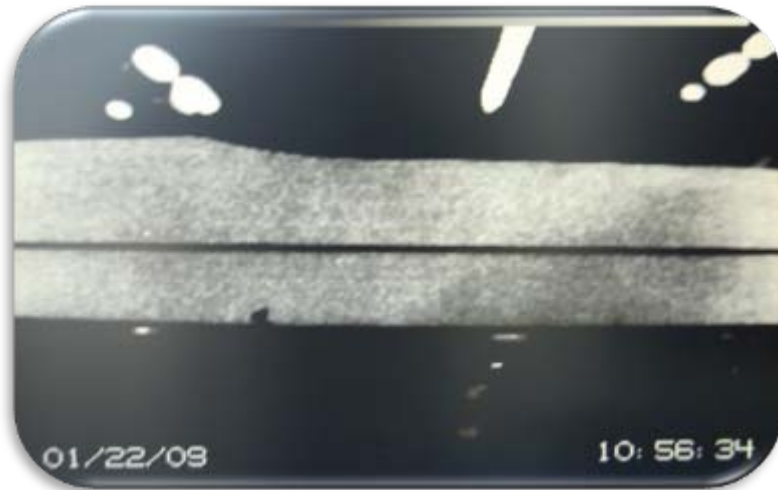
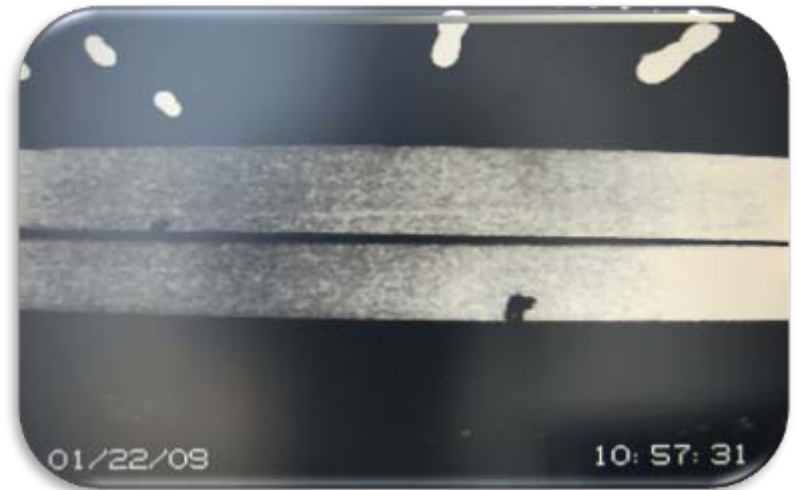
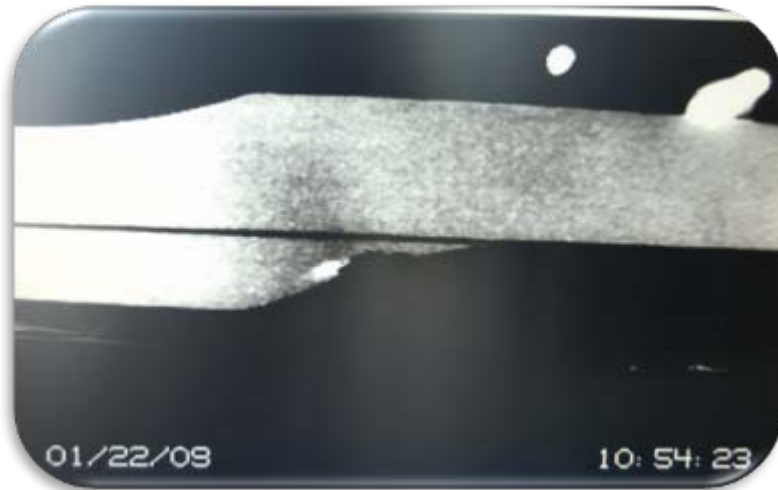


Mid-IR Inspection

Exfoliation Corrosion



DEPLOYMENT -IR PHOTOS



DEPLOYMENT – RESEARCH & DEVELOPMENT

- Outdoor Exposure Testing – Evaluation of NAVAIR exposure coupons located at Cape Canaveral, FL



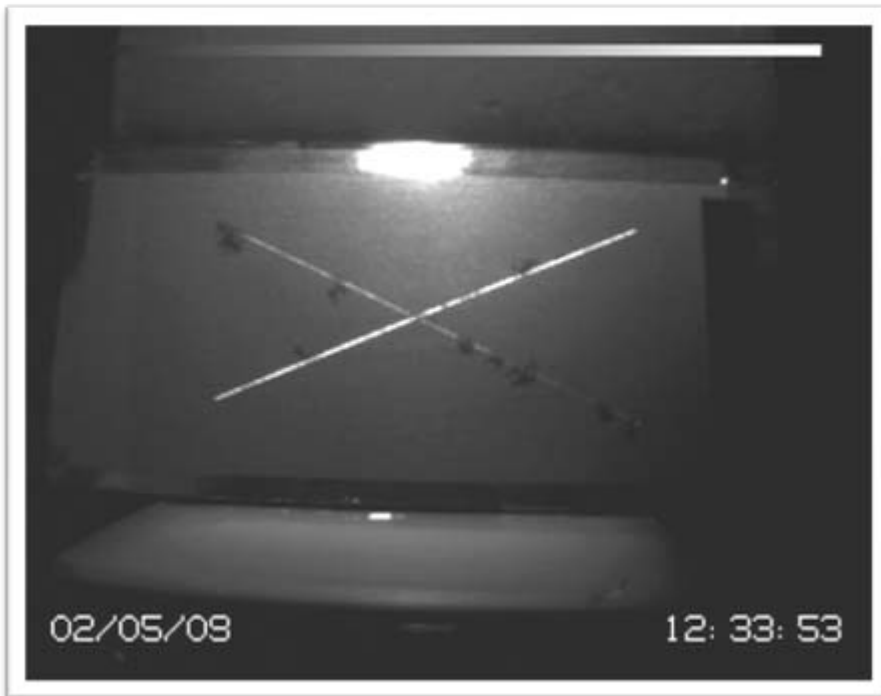
Exposure Test Facility

Exposure Coupons

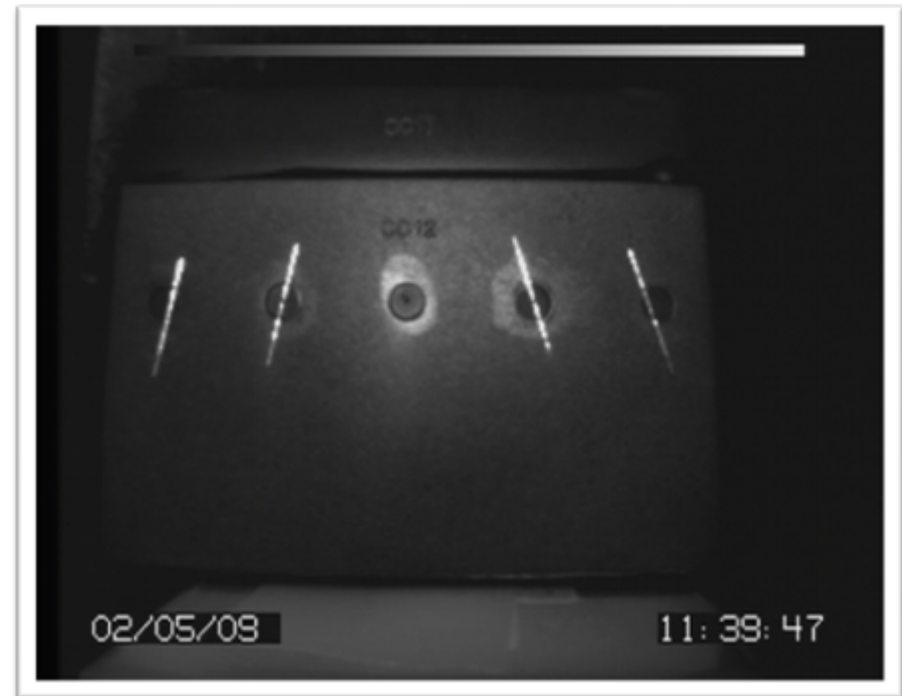


DEPLOYMENT – IR PHOTOS

- Outdoor Exposure Testing – Evaluation of NAVAIR exposure coupons located at Cape Canaveral, FL



Scribe Line Corrosion



Fastener Panel Anomalies

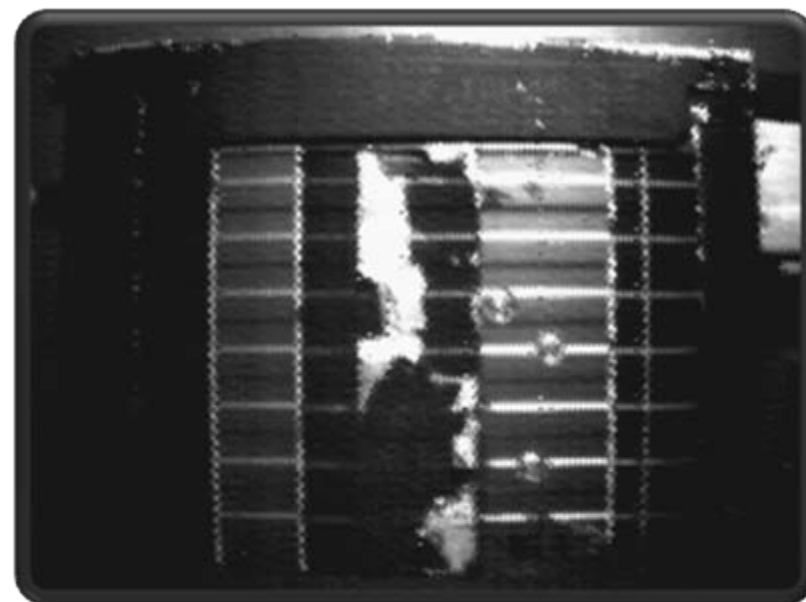


DEPLOYMENT – ENGINEERING INVESTIGATION

- Avionics Receiver/Transmitter – Evaluation of corrosion damage for root cause assessment.



Visual Photograph



IR Photograph

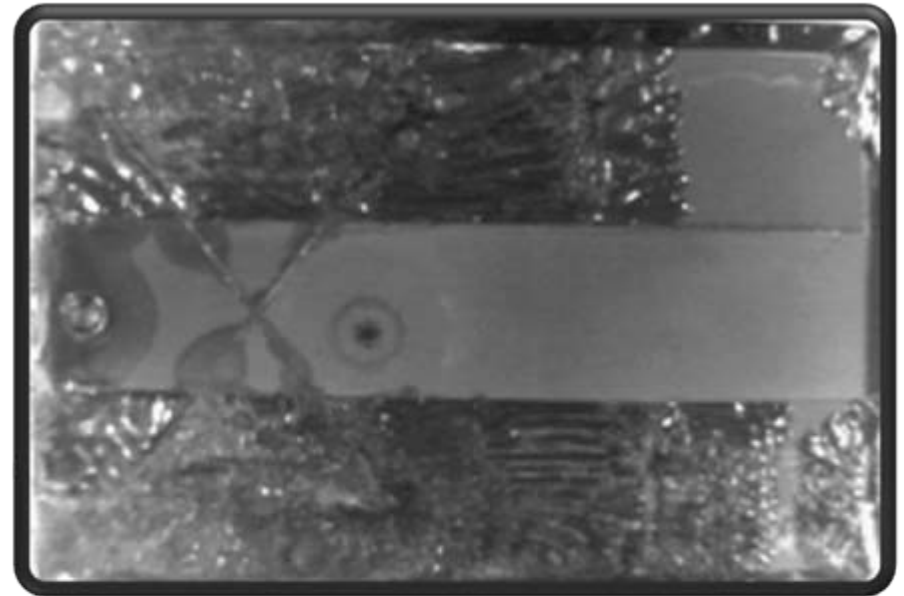


DEPLOYMENT – RESEARCH & DEVELOPMENT

- ASTM B117 corrosion investigation in support of cadmium alternative brush electroplating repair of AISI 4130 substrate.



Visual Photograph



IR Photograph



TECHNOLOGY IMPROVEMENT

- MWIR cameras are required to be smaller, lighter and more portable than prototype system.
- Require integrated data capture and storage.
- 3.75 - 5.0 μm band pass filter.
- Detector Resolution: (320 x 240 min).
- Auto focus, zoom with interchangeable lenses.



TECHNOLOGY IMPROVEMENT – FLIR GF309

- 3.9 um narrow bandpass cold filter specifically designed for imaging through flames.
- FLIR is replacing the current cold filter with a broadband 3 – 5 um filter and offering it as a standard MWIR camera.



FY10 NPRE Funded



QUESTIONS



FINAL REPORT: (ESTCP WP-0407)

(Approved for public release)

<http://www.estcp.org/viewfile.cfm?Doc=WP%2D0407%2DFR%2Epdf>



USCG HU-25 INSPECTION

Paint Thickness in this Zone = ~6.5 mils

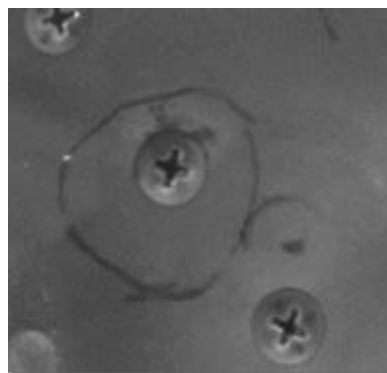


USCG NDI Program Manager – Mr. Rusty Waldrop

Visible Image - Painted



IR Image - Painted



Note: Several corroded areas were found while checking the scan rate on this region, all corroded areas found via the IRRIT were confirmed by chemically stripping.



B-52 Demonstration

Results

- *Surveyed Bomb Bay Longerons of (2) B-52 Aircraft at OC-ALC. Right and left sides inspected, each 15-16 feet in length.*
- *8 corrosion sites located via IR Inspection that were not identified through visible or eddy current inspection.*
- *All corrosion sites were confirmed following chemical spot stripping. 100% correlation achieved.*



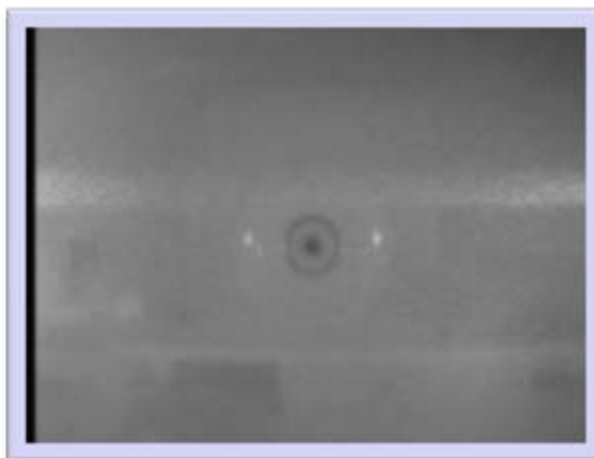
IR IMAGES – Blackbody Effect

US Patent 7,164,146



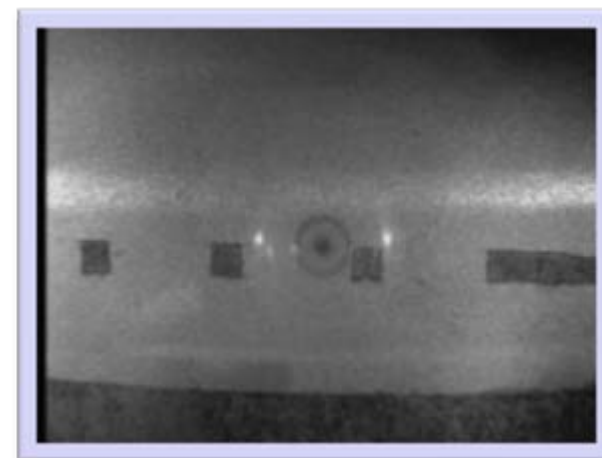
Emissive
Surface T = 95.7°F
IR source = 0W

**Corrosion Product
White**



Equilibrium
Surface T = 95.6°F
IR source = 4.35W

**No Corrosion Product
Observed**



Reflective
Surface T = 95.0°F
IR source = 7.70W

**Corrosion
Product Black**

