Bonded Repair to MD88/90 Horizontal Stabilizer

A4A NDT Forum September 24th, 2014

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Background

- DAL plans to operate MD88/90 aircraft well into the future. Substantial investment taking place for all “T” tail fleets (MD88, MD90 B717/MD95)

- The Boeing developed Horizontal Stabilizer Bonded Repair seeks to address cracks with mandated service action that will drive removal of the horizontal stabilizer for panel replacement

- Delta has found this type of cracking in conjunction with S/B MD80-55A065 inspection at routine opportunity

- Delta has multiple MD-80/90 aircraft with Horizontal Stabilizer Upper Aft Skin Panel Crack Stop Drill or Trim outs

Background Continued

- Successful development of a Bonded Repair Doubler will allow operators to fly cracked panels beyond the 4000 cycle mandatory replacement requirement per the current AD
    - *Due to inspection limitations, bonded repair must be further limited to a maximum size whereby limit load residual strength can be demonstrated with a complete or partial failure of the bond within the repair or base structure arresting design features.* *Draft language from FAA Policy Statement* PS-AIR-20(xxx)-xx-xx
    - Since we can not take strength restoration credit for the bonded repair the primary benefit is scheduling permanent repair at a convenient maintenance opportunity.
- Repetitive inspections are required, but can be conveniently integrated into scheduled maintenance opportunity

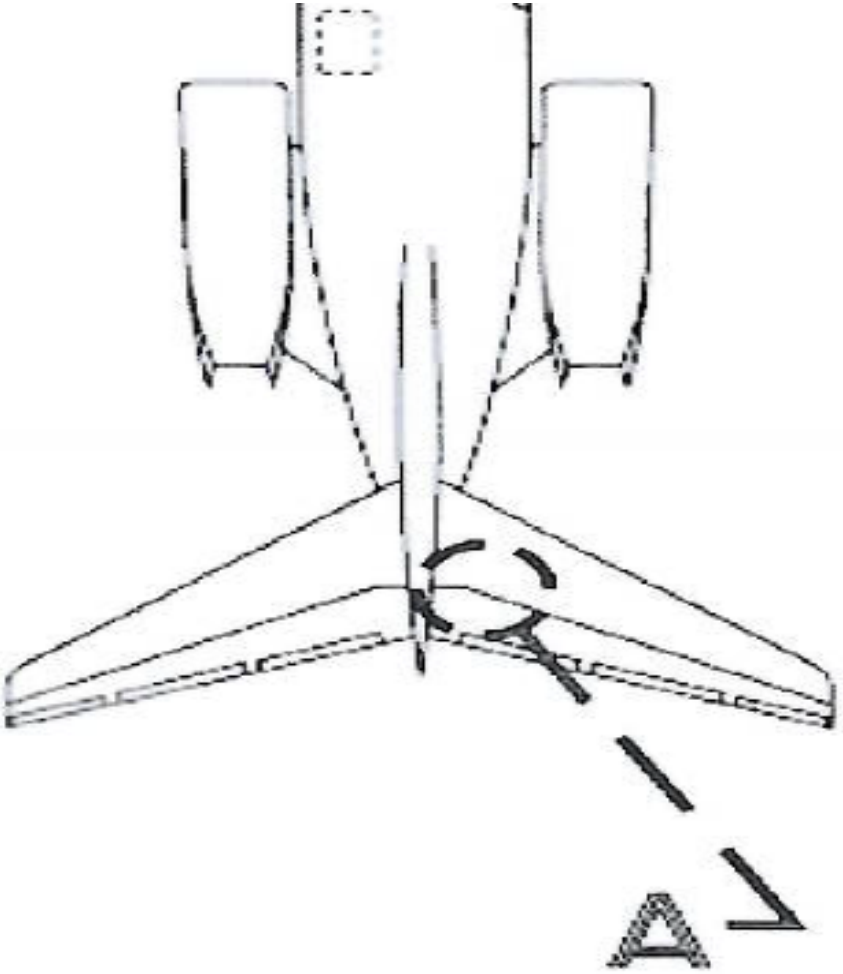
Background continued

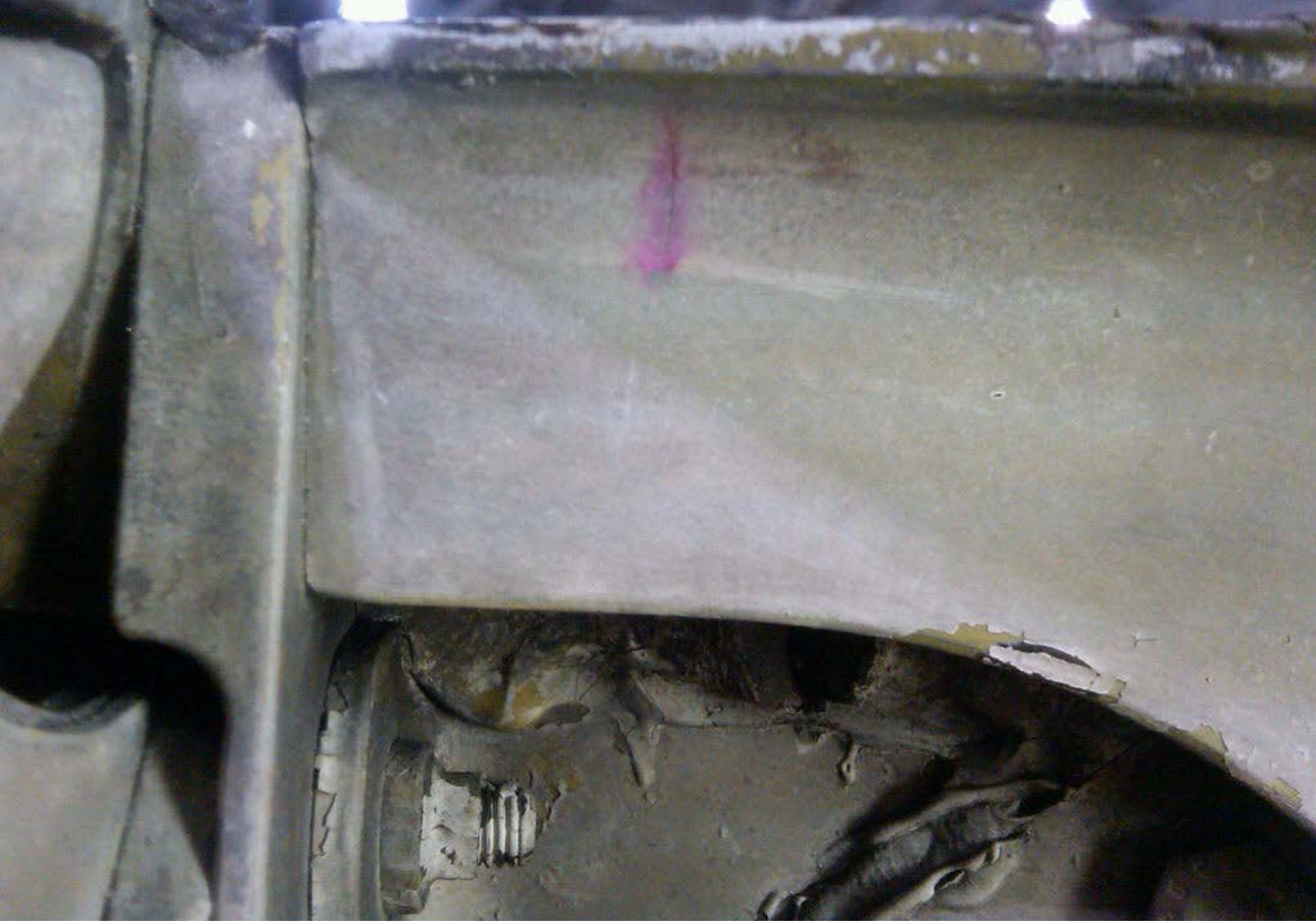
- S/B MD80-55A065 inspects aft skin panels and rear spar upper cap
- Barrel Nut Crack (Rear Spar Cap) is located about two inches inboard of crack addressed in S/B MD80-55A065
- Lab analysis revealed rear spar cap failed in fatigue
- Boeing safety assessment concluded that this issue is a safety concern
- An undetected crack in the spar cap may grow until it severs, which may result in failure of the upper center or upper aft skin panel before existing service bulletin inspections detect a crack in the skin panel(s)
- Issue affects both the MD-80 and MD-90
- Horizontal Stabilizer Bonded repairs offer unique possibilities

Bonded Repair

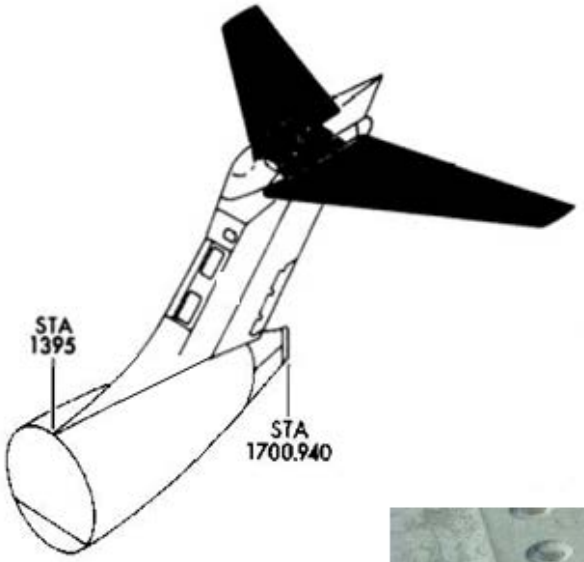
- The Bonded repair's on DAL MD88 & MD90 were installed installed per an approved SR Drawing
- AMOC obtained for both MD88 & MD90 repairs
  - AMOC issued on a tail number specific case-by-case basis
- Bonded Doubler can be installed in 3-4 days without removing the horizontal stabilizer
  - As additional installations take place we believe installation time can be cut to 1-2 day's
- Aircraft downtime could potentially be reduced by an average of 10 days versus wholesale panel / spar cap replacement
- Kit and man hour costs offer savings potential
- Repair kits made available by Boeing

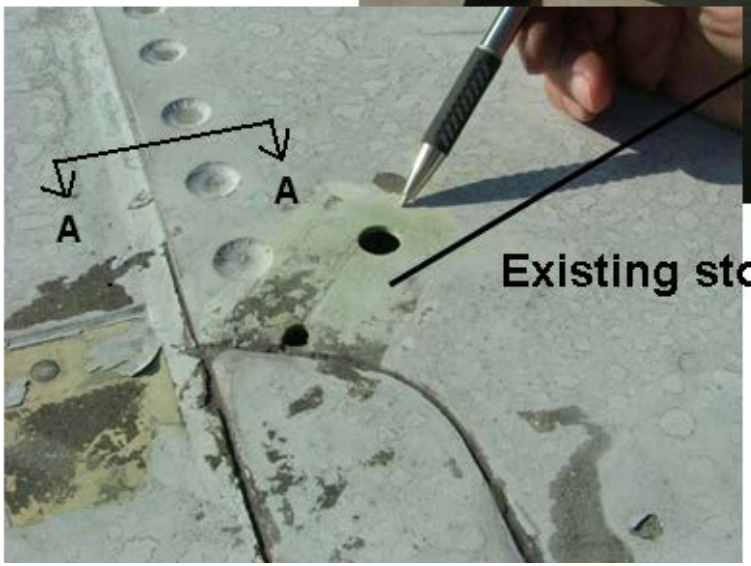
Area of Interest Example





Location





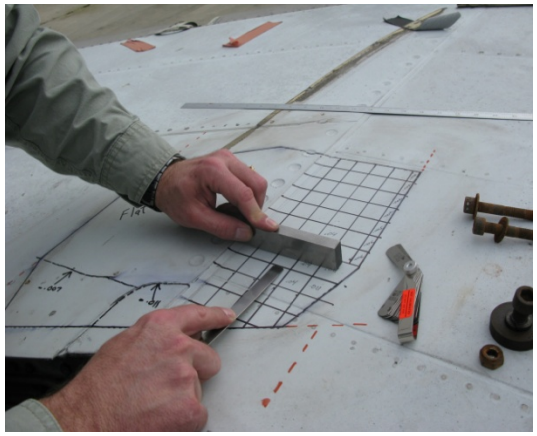
Existing stop-drilled Crack

R/H Side Shown
(L/H Opposite)

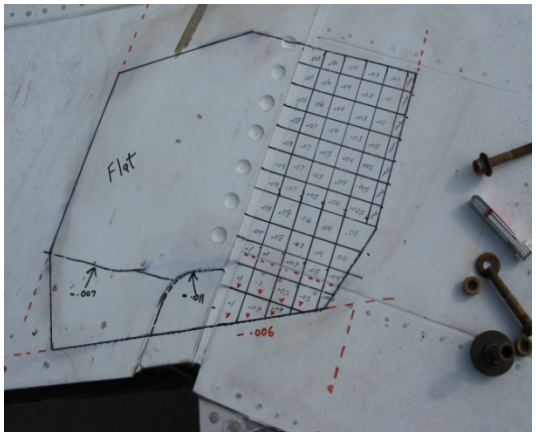
Image Credit: 2011Boeing Bonded Repair Summary Presentation

Surface Preparation & Gap Checks

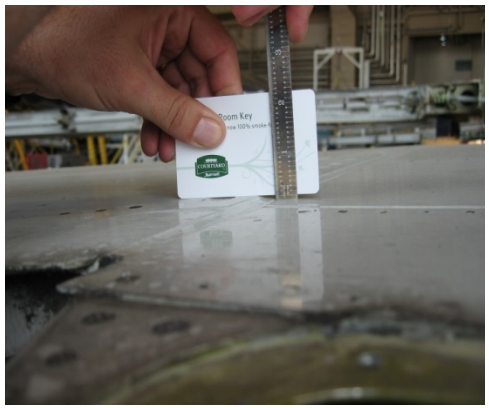
Step 1: Grid out doubler profile using 1 inch x 1 inch squares.



Step 2: Use a straight edge and feeler gage to measure the gaps between the outer aft panel and center panel. Ensure straight edge sits flat on the outer aft panel in the ‘flat area’



Step 3: Record gap measurements for each grid location. Gap measurements to be taken at the center of each grid. Submit gap measurements with airplane information (Model, fuselage number, serial number and registry).



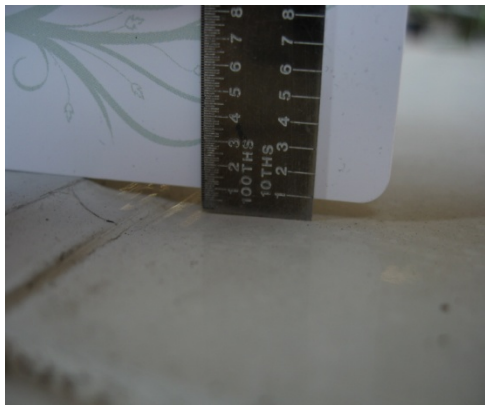
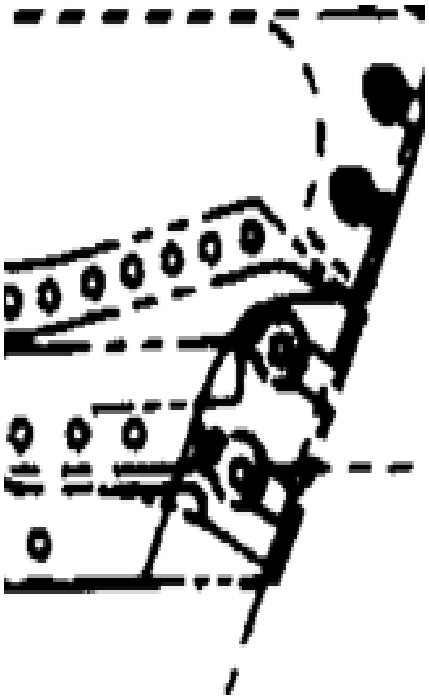


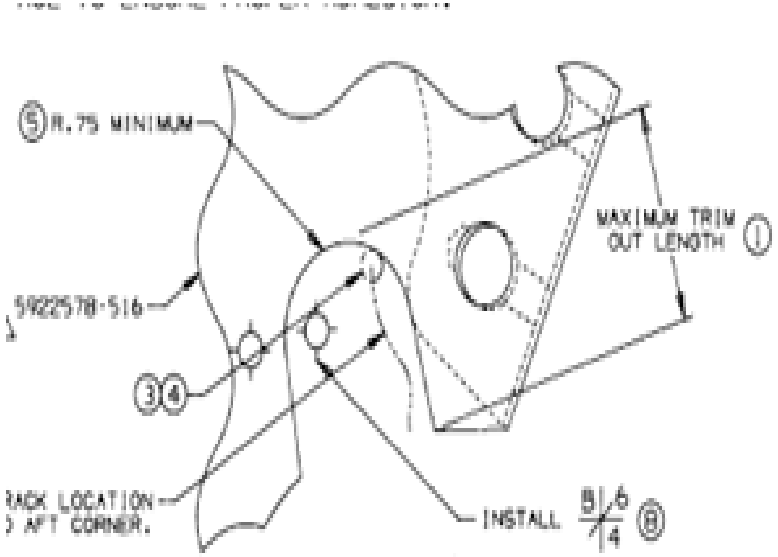
Image Credit: 2011Boeing Bonded Repair Summary Presentation

Damage Containment

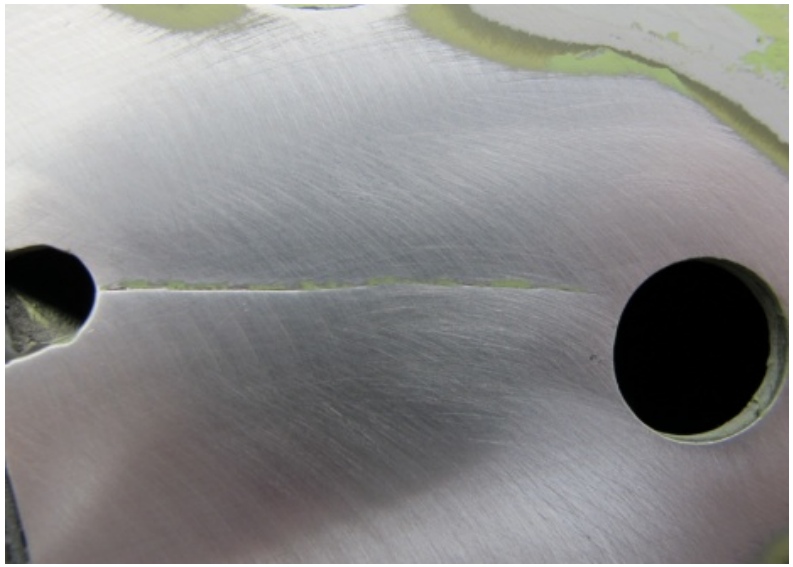
Measure length of stop-drilled crack or trim-out

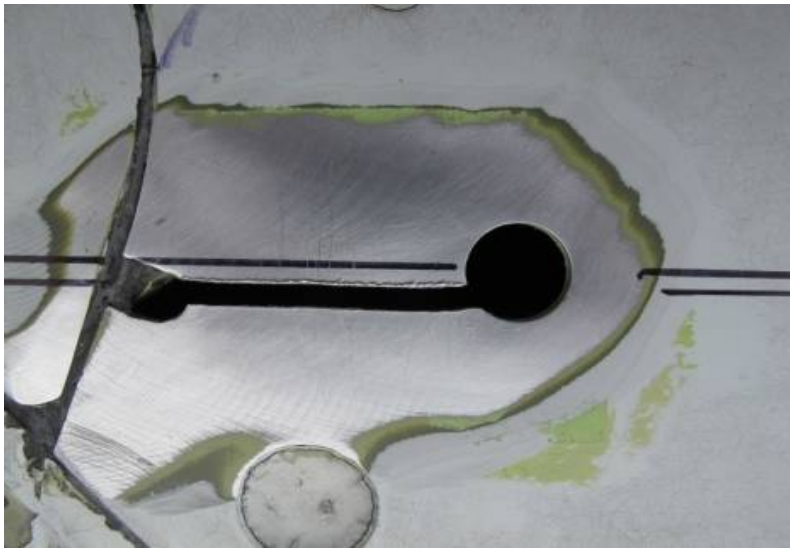
- Stop drill vs. trim out

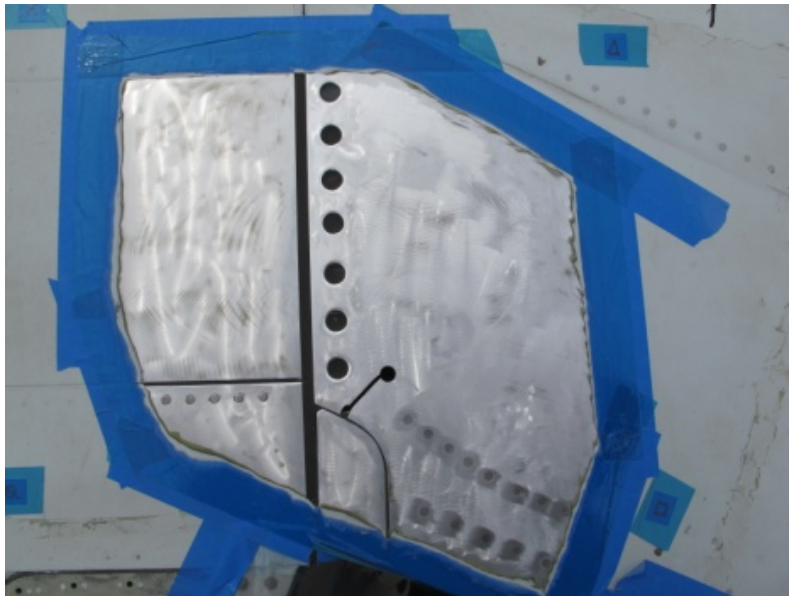




Damage Containment continued







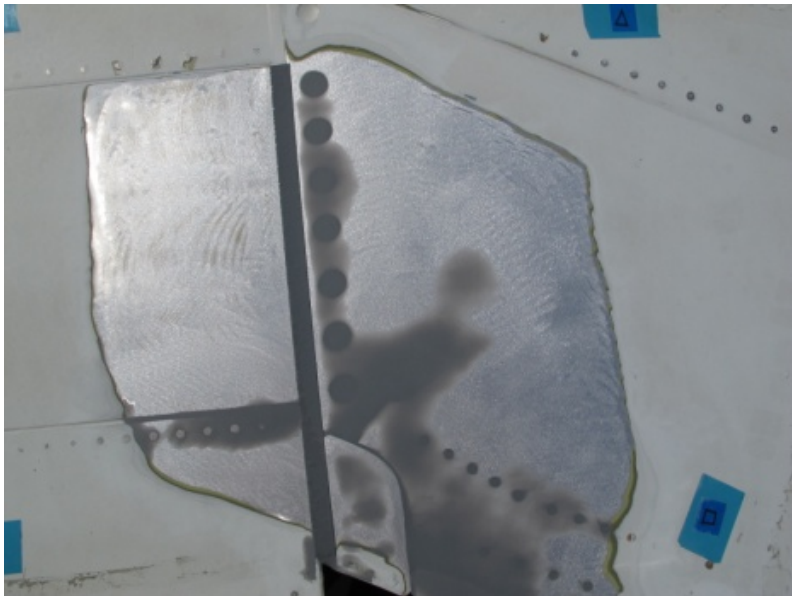


Image Credit: 2011Boeing Bonded Repair Summary Presentation

Installed Repair

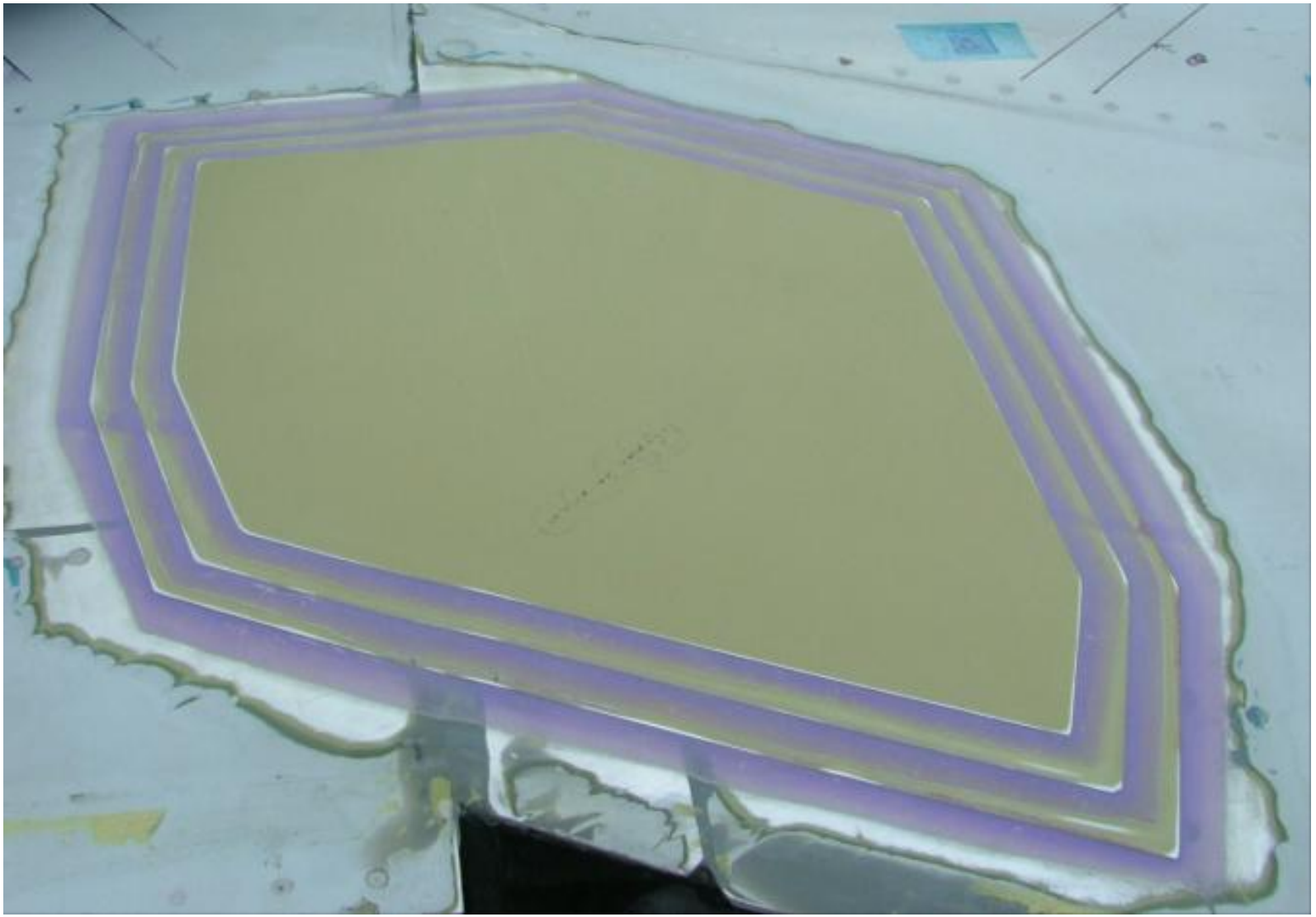
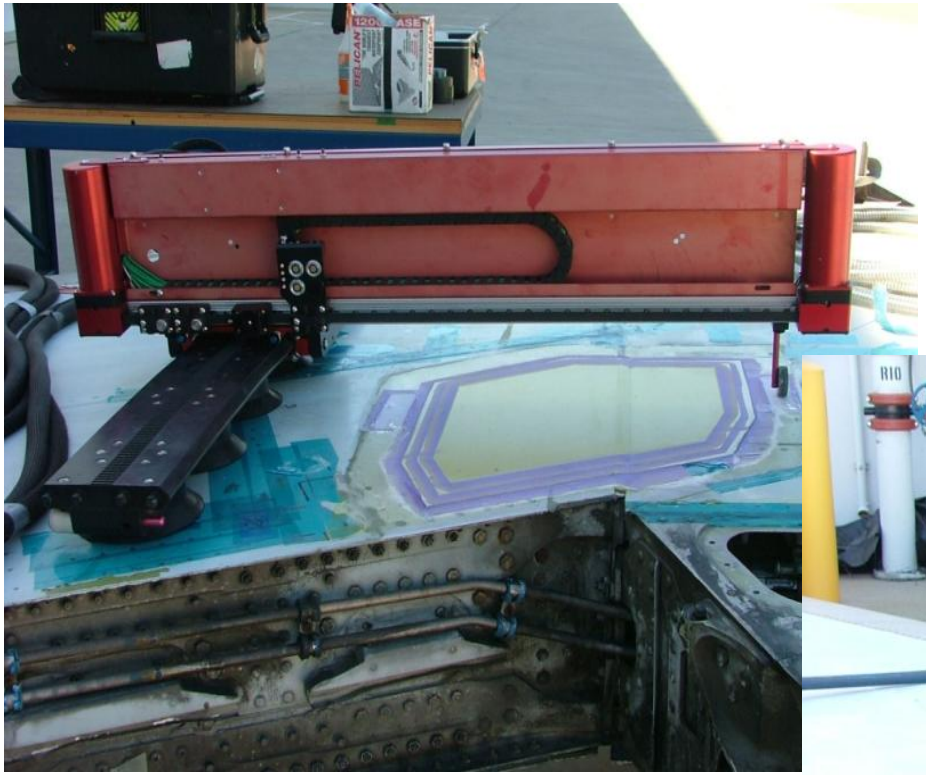


Image Credit: 2011Boeing Bonded Repair Summary Presentation

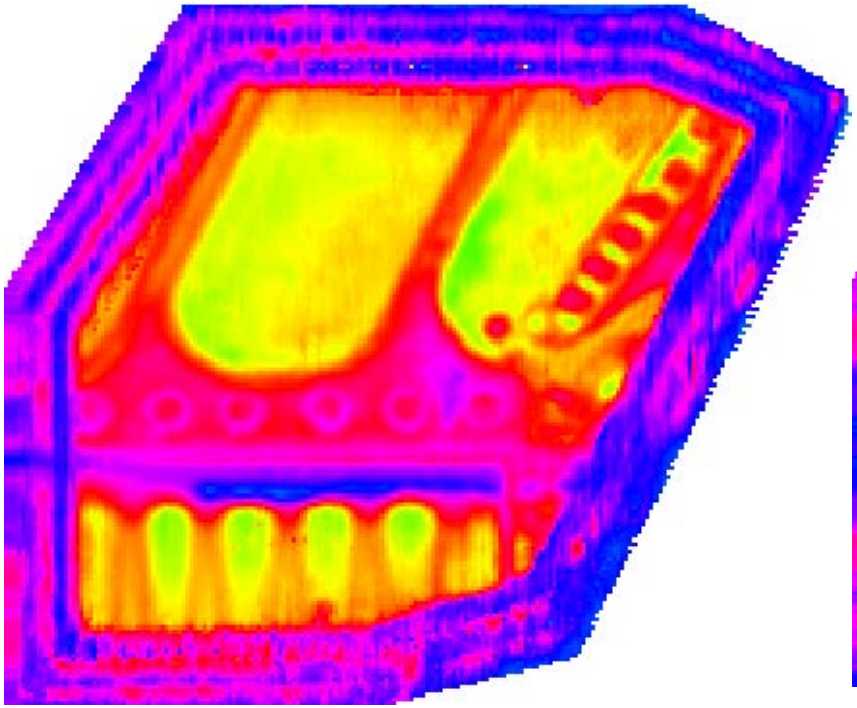
Nondestructive Evaluation of Repair Using MAUS V

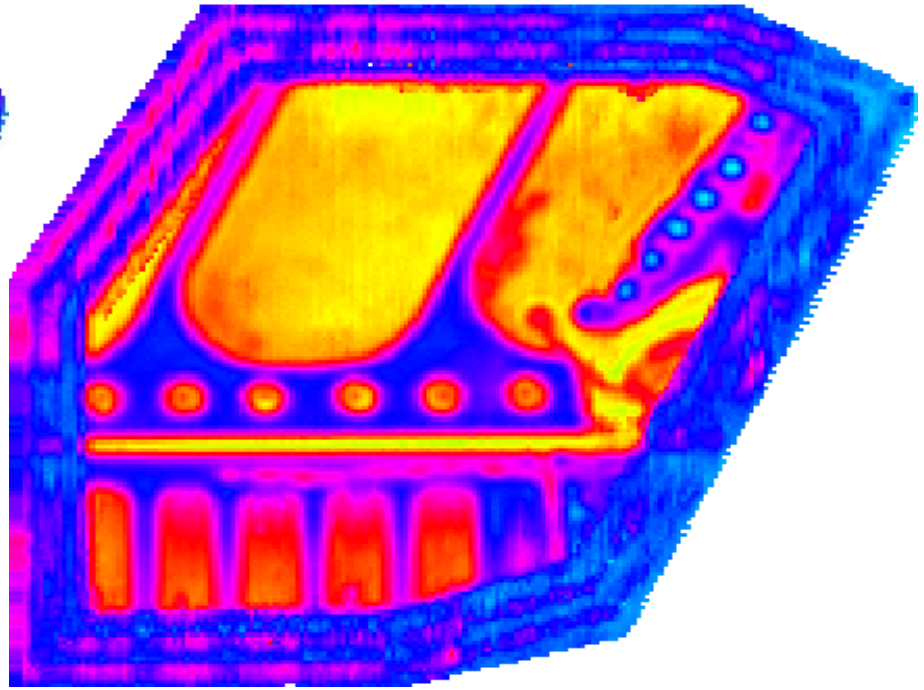


MAUS V system shown. Resonance C-scan for unbond detection and Low Frequency Eddy Current C-Scan for crack detection.

Image Credit: 2011Boeing Bonded Repair Summary Presentation

Resonance Example



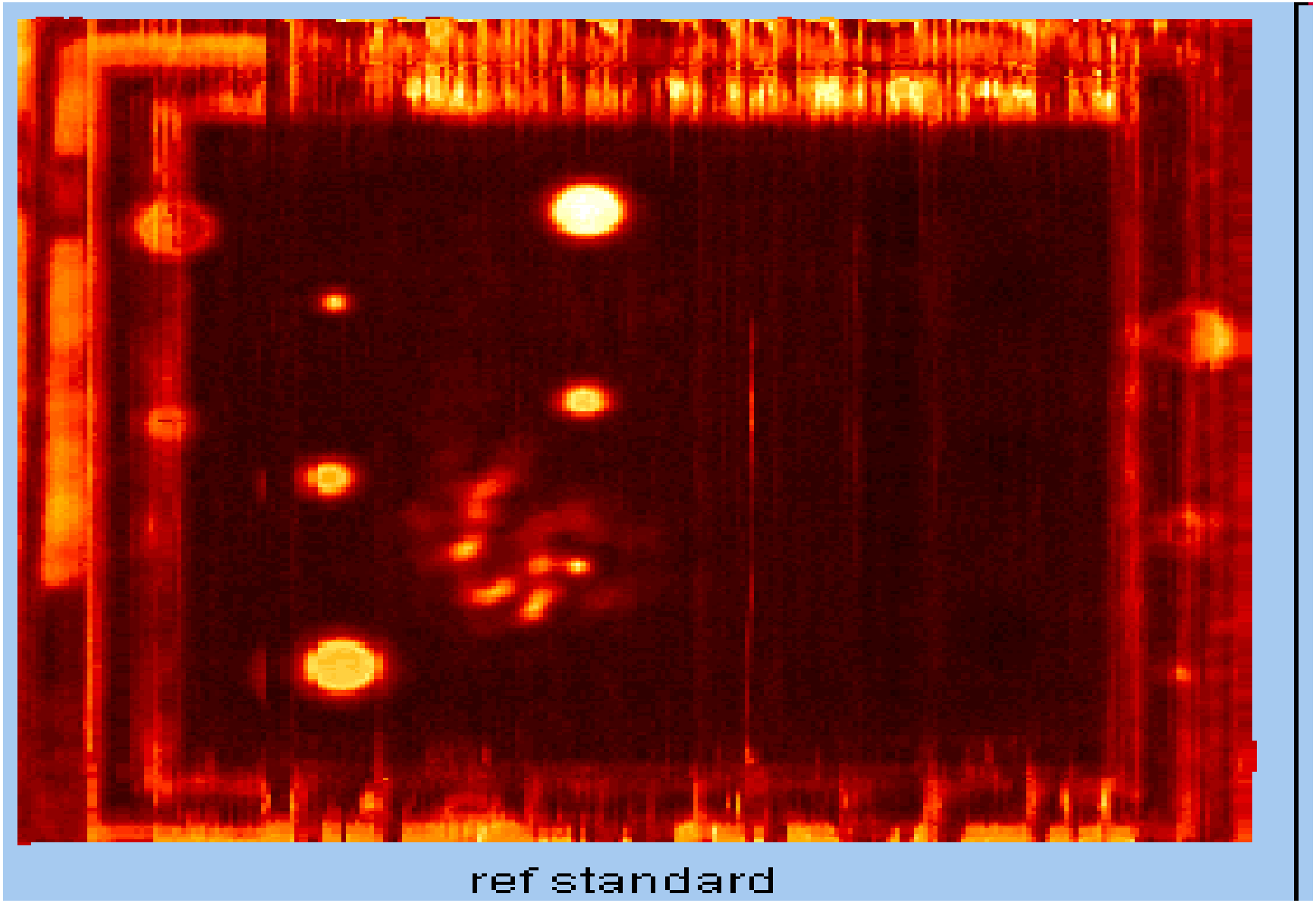


MAUS Resonance C-Scan Data
Right Side Repair – 110 KHz
X Data

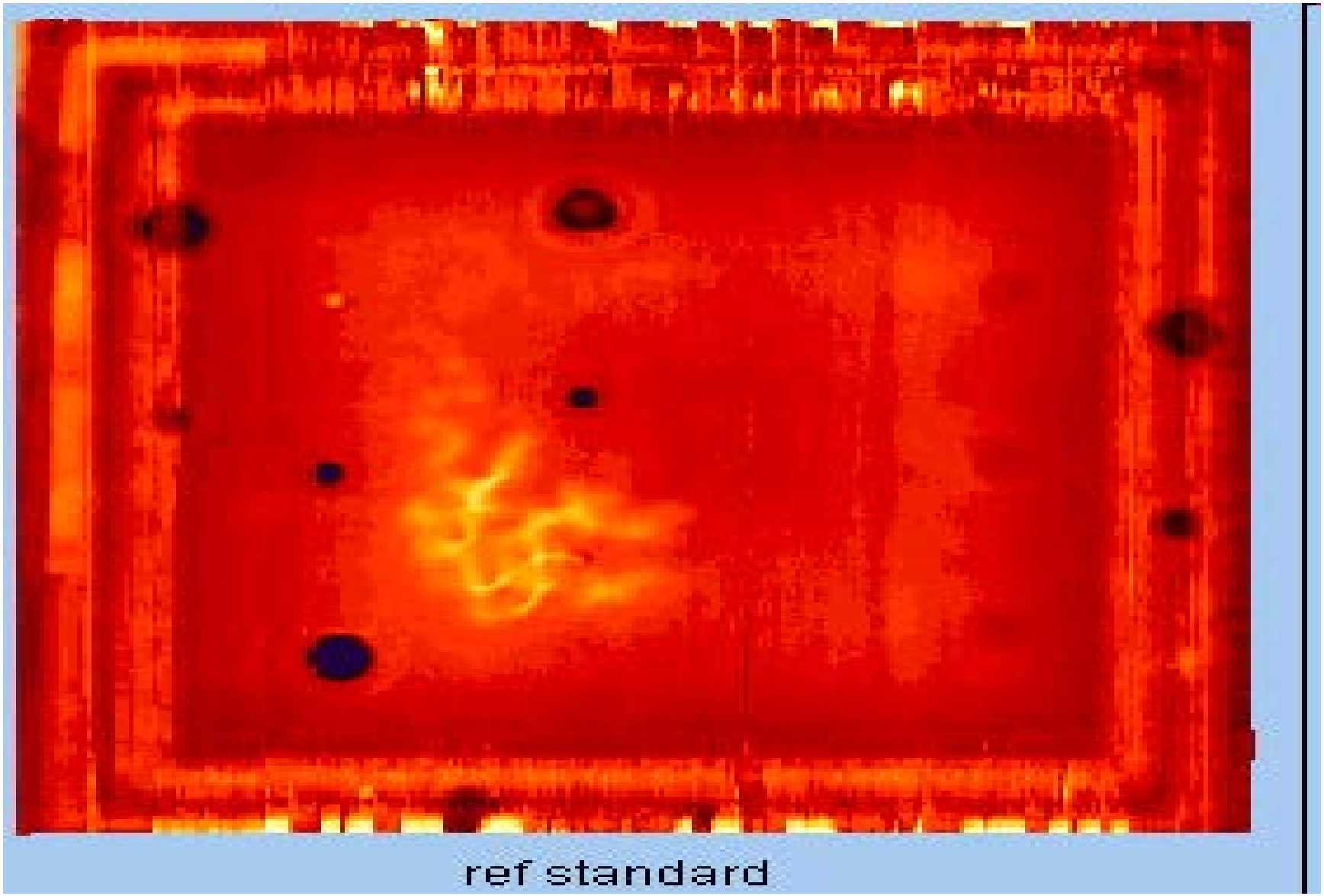
MAUS Resonance C-Scan Data
Right Side Repair – 110 KHz
Y Data

Image Credit: 2011Boeing Bonded Repair Summary Presentation

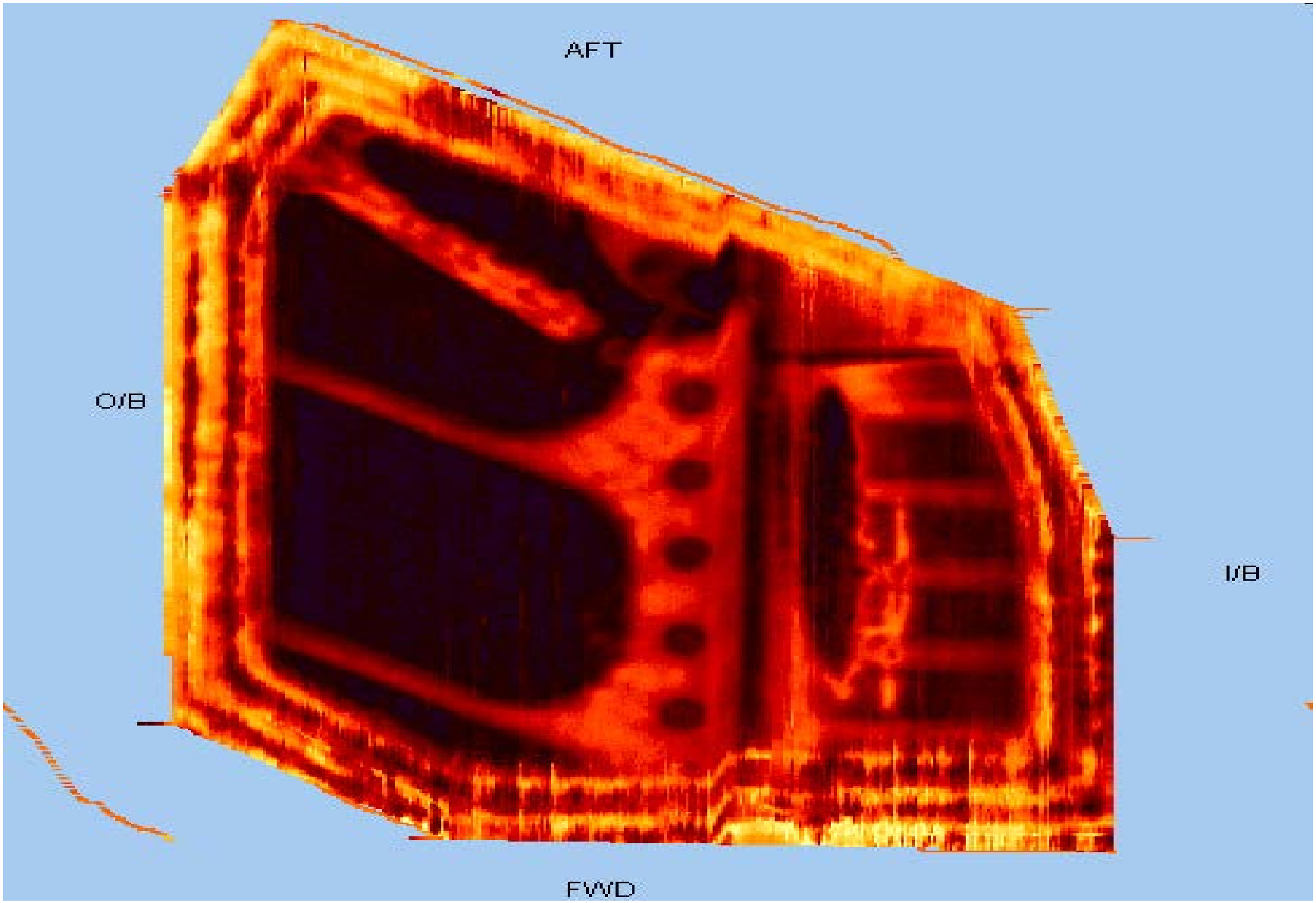
Reference Standard Scan Resonance X



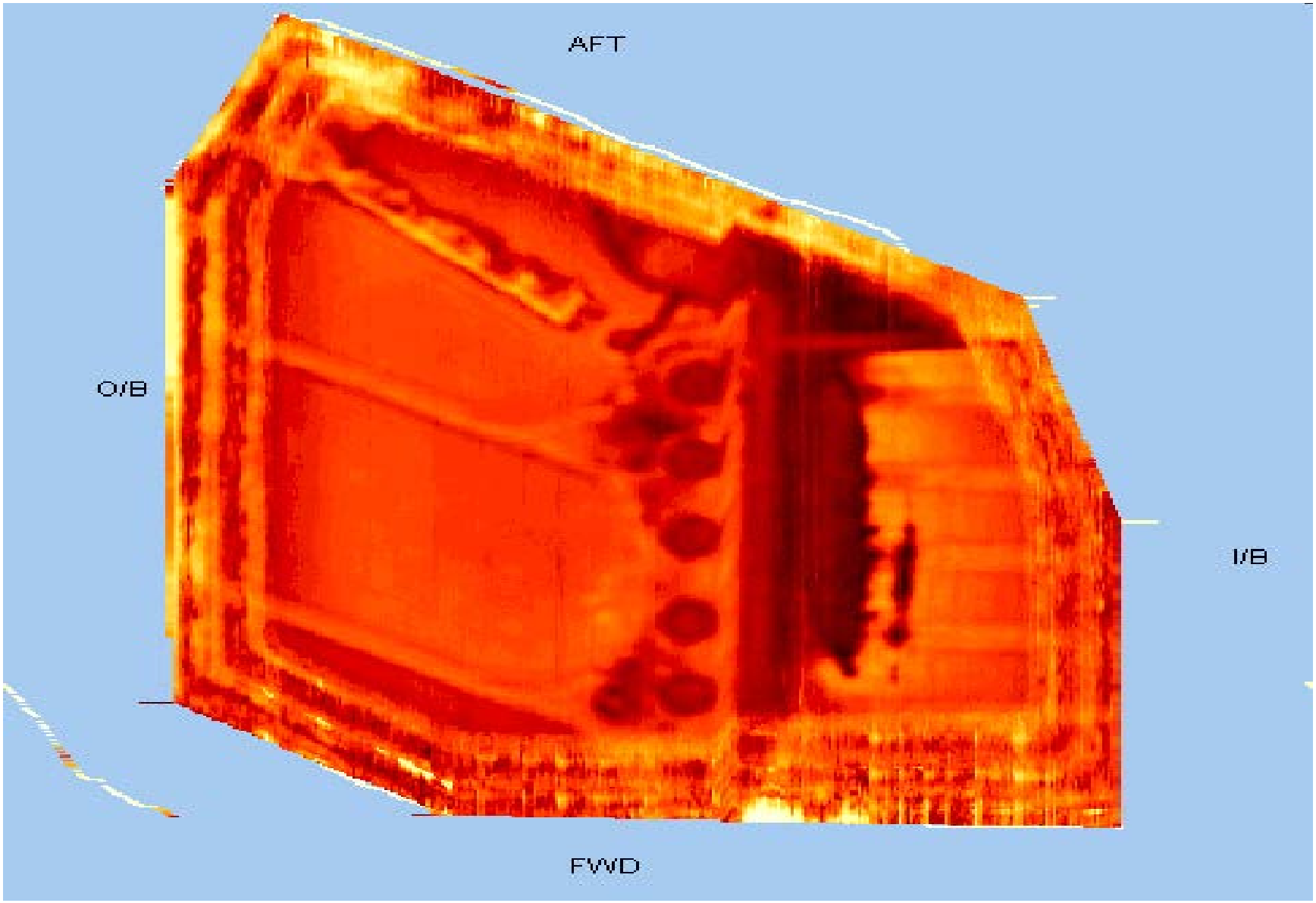
Reference Standard Scan Resonance Y



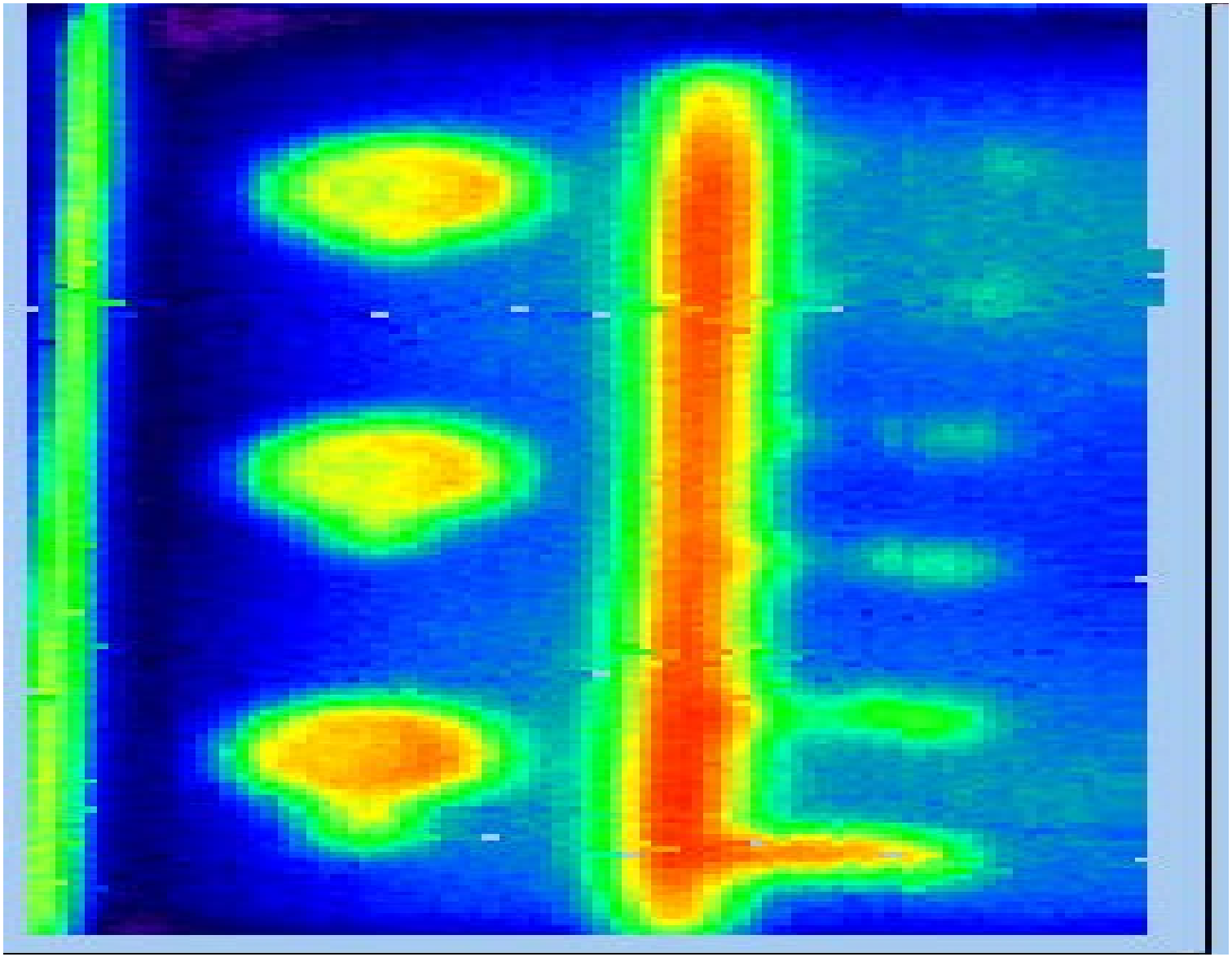
Installed Repair Resonance X



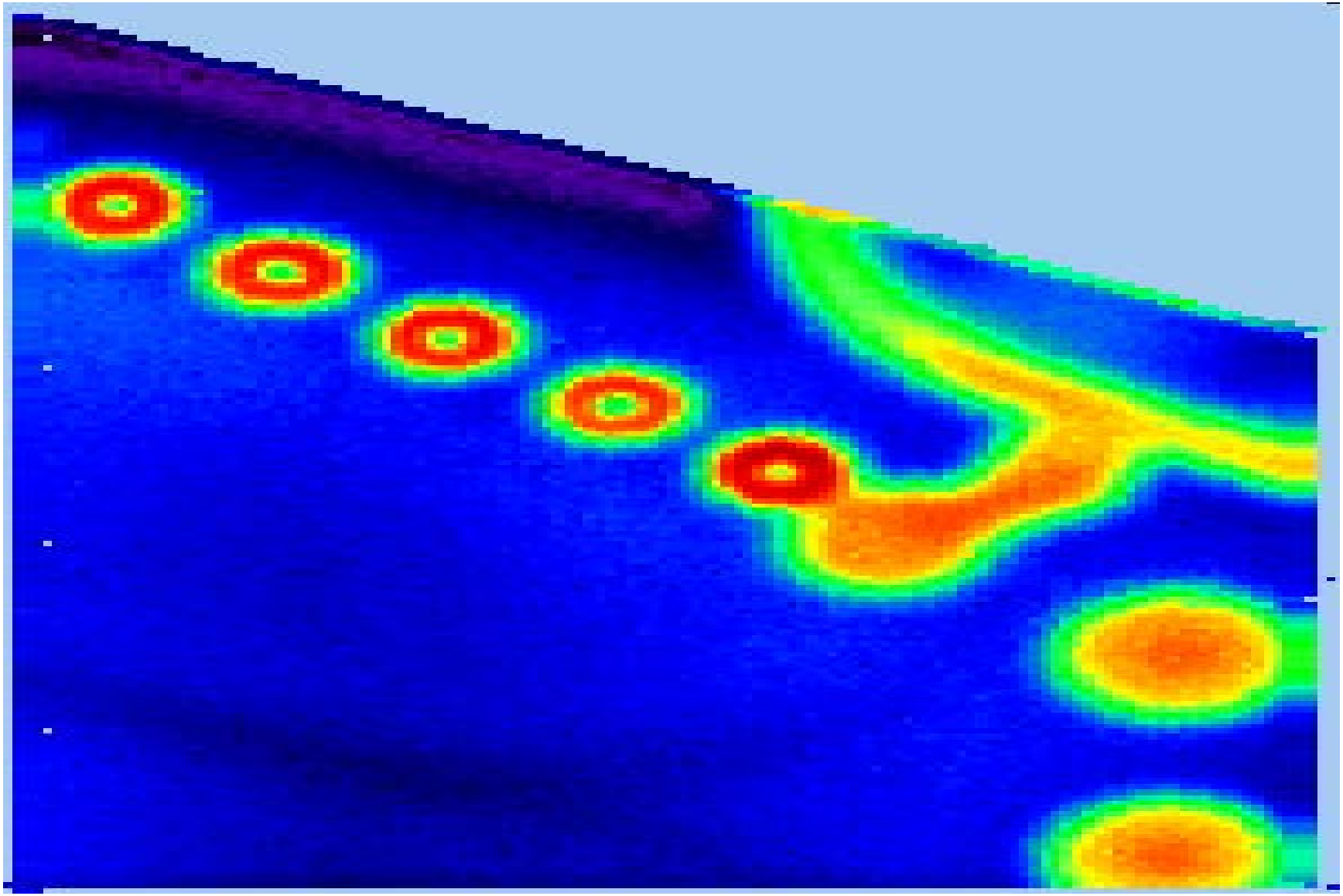
Installed Repair Resonance Y



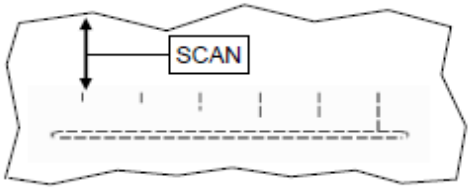
Reference Standard Eddy Current Scan



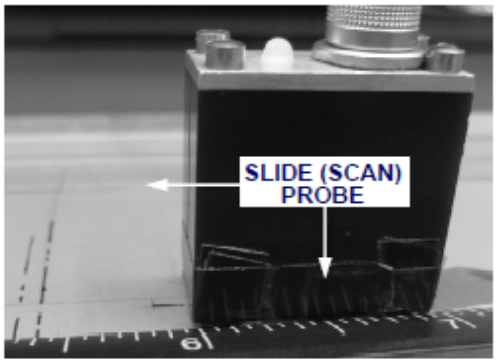
MAUS V Eddy Current Example



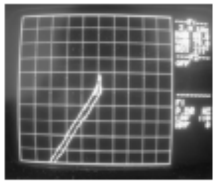
Repetitive Eddy Current – Conventional Equipment



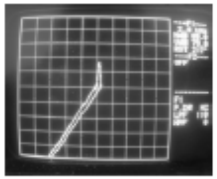
DRAW PRECISE LOCATIONS OF EDM ARTIFICIAL ANOMOLIES ON REFERENCE STANDARD SURFACE



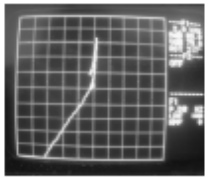
REFERENCE STANDARD CALIBRATION



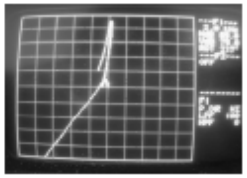
.125 INCH NOTCH



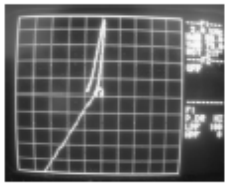
.200 INCH NOTCH



.300 INCH NOTCH

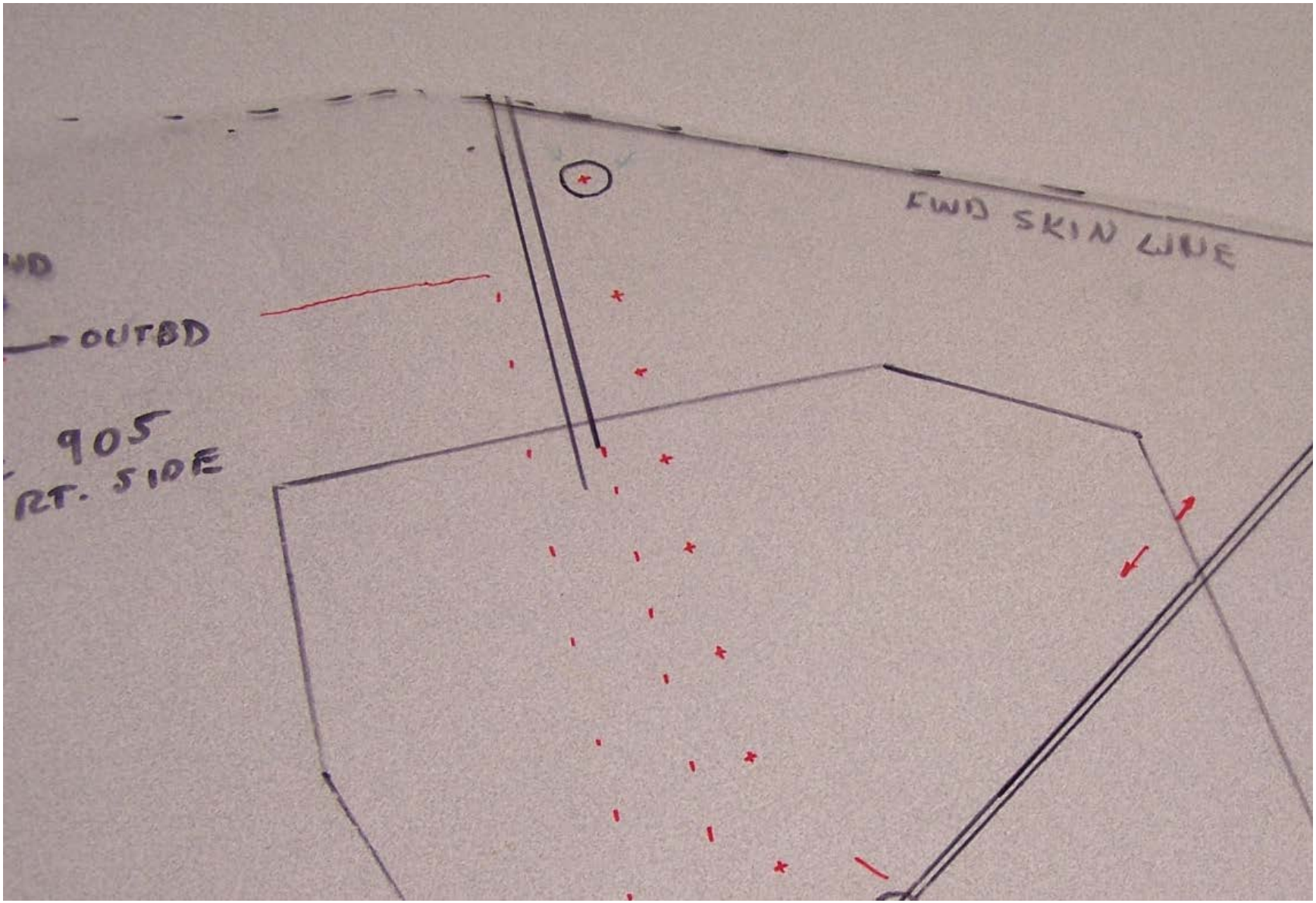


.400 INCH NOTCH

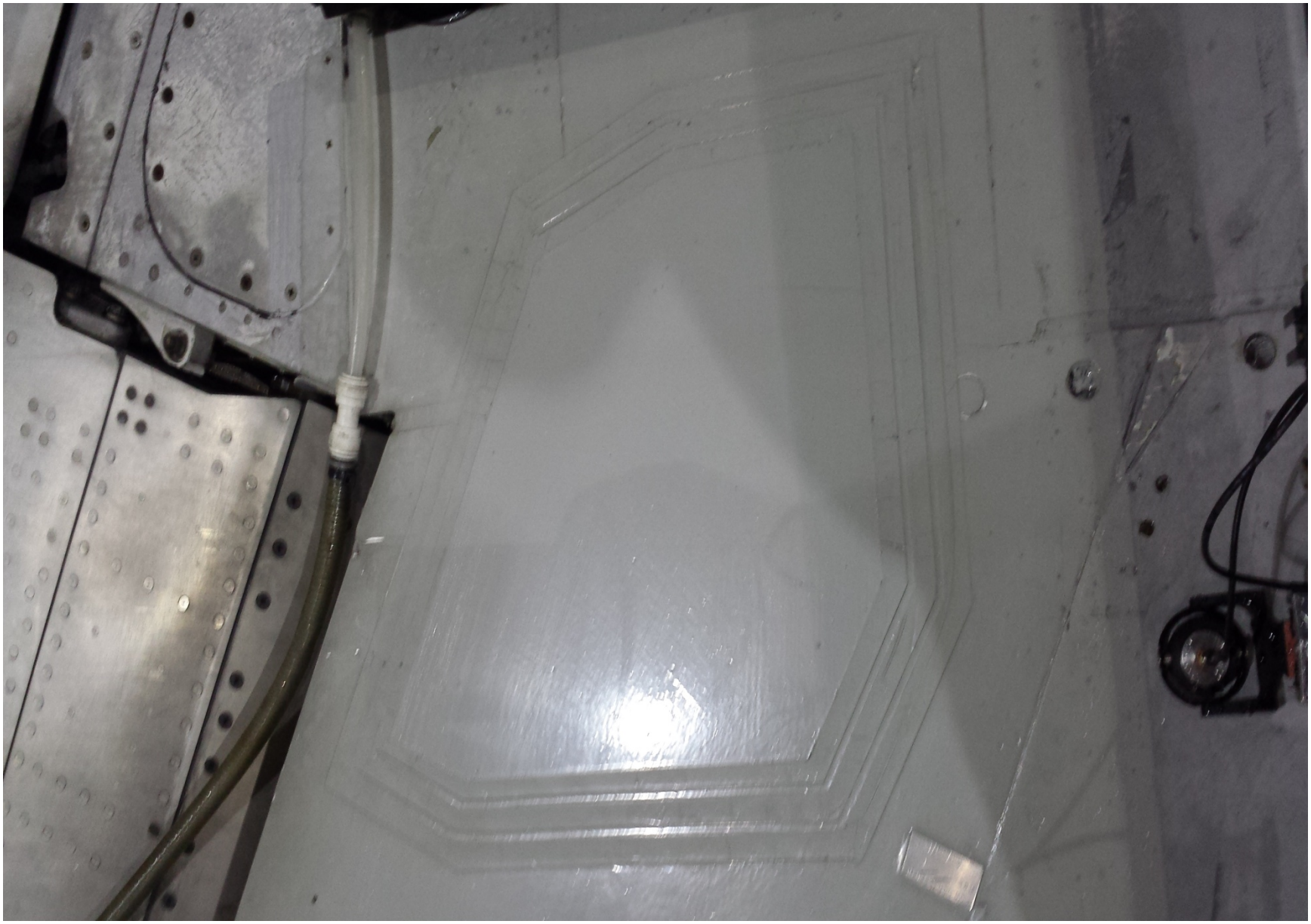


.500 INCH NOTCH

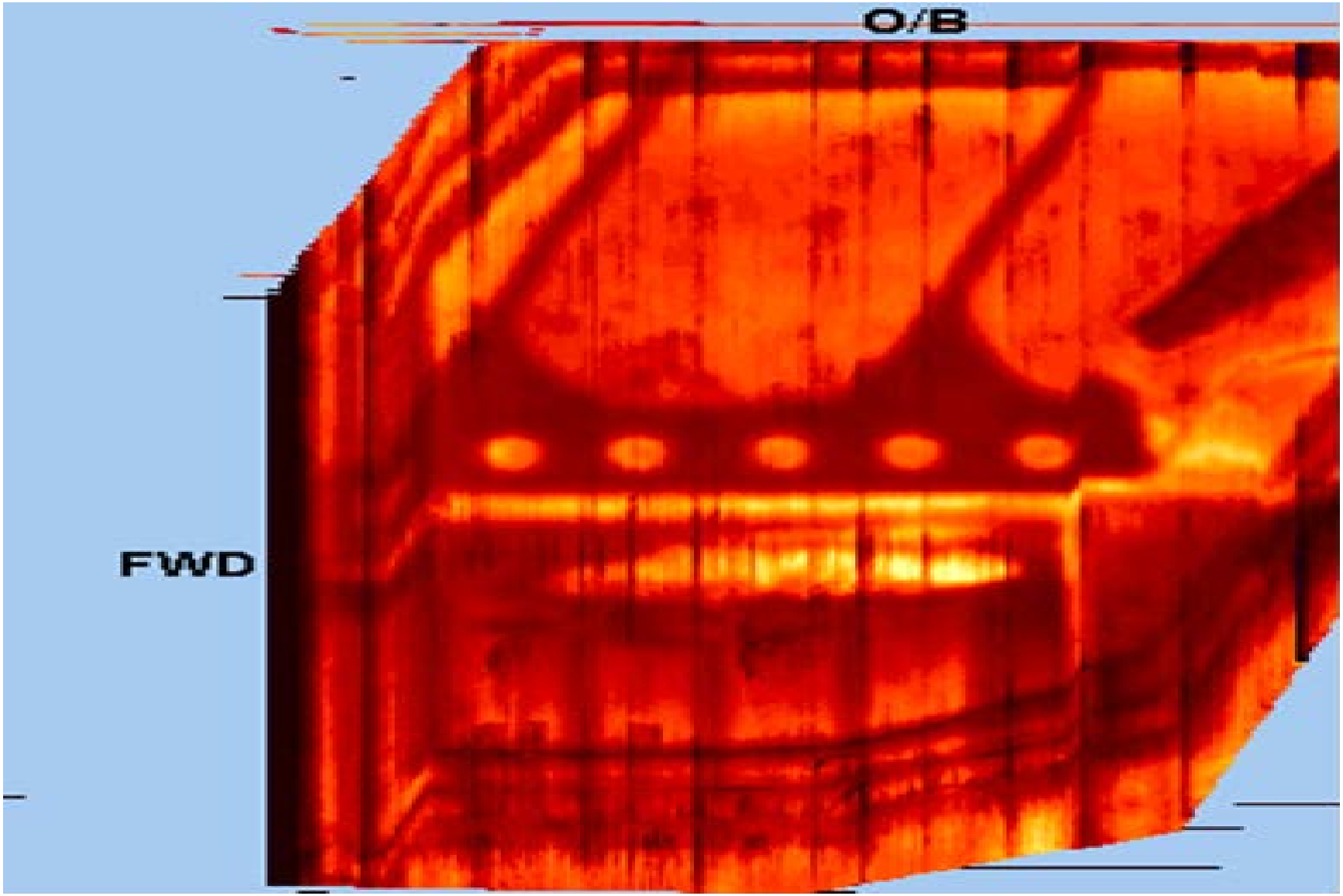
Repair Template



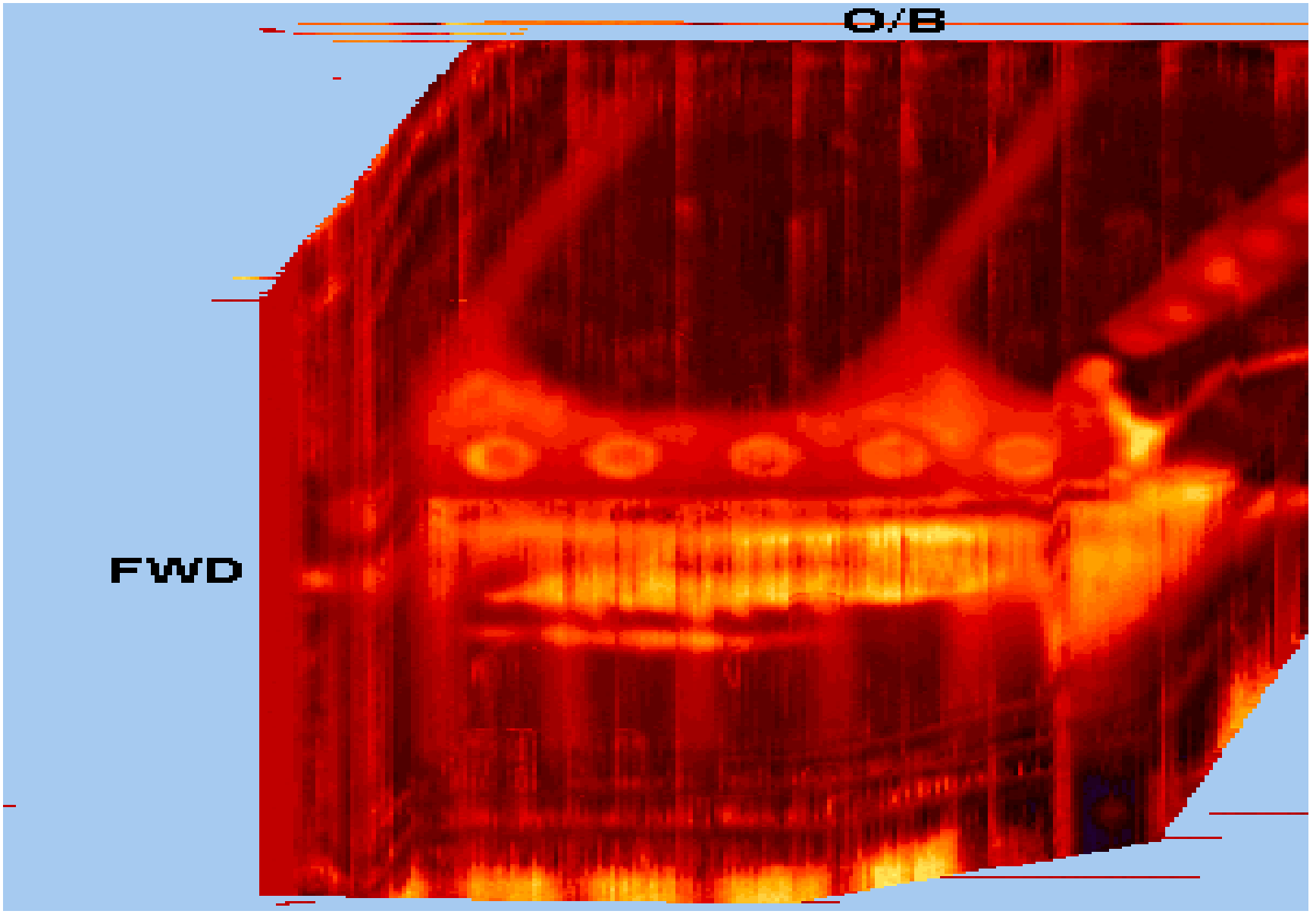
Repair at 4000 Cycle Resonance Repetitive



4000 Cycle Resonance X Scan 4/2014



4000 Cycle Resonance Y Scan 4/2014



So where are we now?

- Two installations since 2012: One MD88 / One MD90
- Tail Specific AMOC has been obtained for both installations
- Multiple Eddy Current Repetitive (MAUS V & Conventional) performed on both aircraft with no findings
- MD88 installation repeat Resonance completed with no findings.
  - No further resonance inspections required – scan's submitted to Boeing
  - Eddy Current repetitive inspections continue
- MD90 installation Resonance inspection likely to be scheduled late 2015
- Additional installations being considered by DAL Fleet Engineering

Summary

- Bonded repair to AD affected Principal Structural Element (PSE) allows postponement of terminating action (Replacement of horizontal stabilizer skin panel and rear spar cap) to convenient maintenance opportunity
- FAA has been engaged through development, installation, AMOC, and on-going support of repairs
- Data gathering and collaboration with Boeing continues
- Bond strength verification enigma remains. At this time this repair is not envisioned as permanent.
  - No strength restorative credit applied to repair
- Follow-on eddy current NDT inspections continue: 500 Cycle Interval
- Flying proof of concept bonded repair on an AD affected structural element may serve as a gateway to the development of additional applications of bonded repairs

Acknowledgements

- **Malcolm Berner**
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  Technical Specialist, Nondestructive Testing

- **David Piotrowski**
  Principal Engineer

Questions?