F-15 WWR 2024

JENTEK Eddy Current Array Inspections and Field Portable Systems

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Hans Foelsche,
Taylor Simon
jenteksensors.com

jET Hand-held
&
MWM-Array

…Introducing new field hardened jETi for bolt-hole and other NDT

Outline

- JENTEK portable systems (**jET, jETi & GS9000**) and MWM-Array sensors
- Bolt-Hole inspection for challenging holes
- Surface-breaking cracks on complex surfaces
- Sub-surface cracks on curved/variable thickness structures
- Detection of cracks at fasteners
- Corrosion imaging

MWM-Array Sensors & Parallel Architecture Instruments

jET®

JENTEK Eddy Current Array Tester

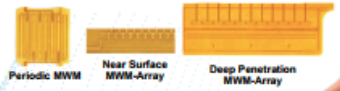
With conformable MWM-Array technology

- **BEST** detection and characterization performance
- **VERY LOW** false indication rates
- **REDUCED** surface preparation
- **NOW** in a small, convenient and lightweight package that **fits your budget!**

- **Engine Components Inspection**
  - Blades, disks, IBRs, holes, etc.
- **NDT of Complex Structures**
  - Surface breaking and subsurface cracks
  - Hidden corrosion
- **Coating Characterization** without need for expensive custom calibration standards
- **Complex Shaped Surfaces**
  - Firtree slots in engine disks, fillets in aircraft structures, etc.
- **Materials/Process Quality Characterization**

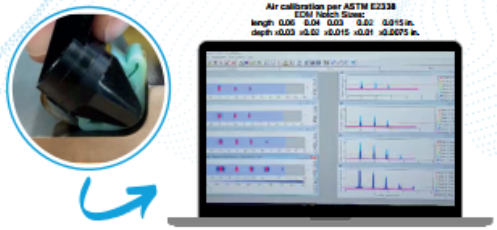
MWM-Array

jET weighs less than 1 lb.



JENTEK GridStation advanced eddy current inspection systems have been called "the gold standard" of inspections at U.S. Navy Depots.

Highest Performance Crack Detection Capability



"The Leader in Eddy Current Testing Performance."

jETi®

with MWM-Array Technology

"The Leader in Eddy Current Testing Performance."

- **NDT of Complex Structures**
  - Surface breaking and subsurface cracks
  - Hidden corrosion
- **Bolt hole inspection multi-material stack-ups**
- **Coating Characterization** without need for expensive custom calibration standards
- **Materials/Process Quality Characterization**

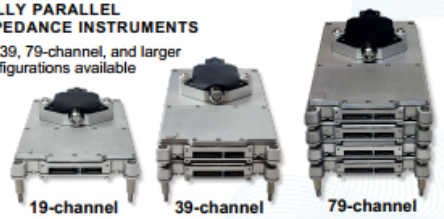
Air calibration and crack detection (ASTM E2338; E2884)

GS9000™

"The Leader in Eddy Current Testing Performance."

FULLY PARALLEL IMPEDANCE INSTRUMENTS

19, 39, 79-channel, and larger configurations available



SPECIFICATIONS

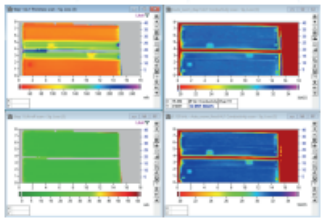
- Rapid wide area scanning
- 19, 39, and 79 channel MWM-Arrays
- Battery packs for portable operation
- System configuration up to 396-channels +
- Surface and sub-surface crack detection, corrosion imaging, coating characterization, and material property mapping

GS9000 for Weld Inspection/ Crack Detection

±45° MWM-Arrays

GS9000 for Automated Internal Surface Tube and Pipe Scanner

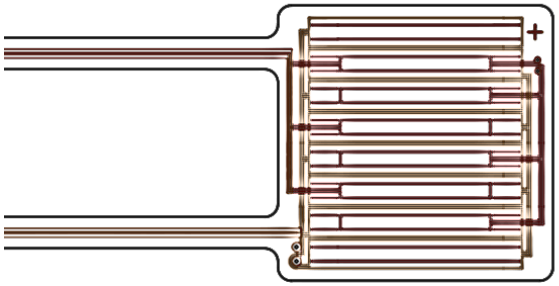
- 39-channel GS9000 MWM-Array
- Helical Scan Path
- 1ft/min Scan Time
- Crack Detection
- Coating Characterization
- Conductivity and Thickness
- Coated-Uncoated Tubes
- 120-180mm Diameter Range



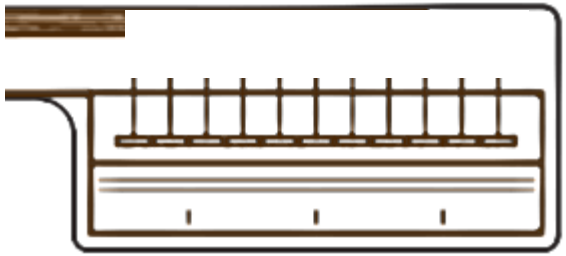
Corrosion Loss Imaging

GS9000 for Corrosion Imaging

MWM and MWM-Array Sensors

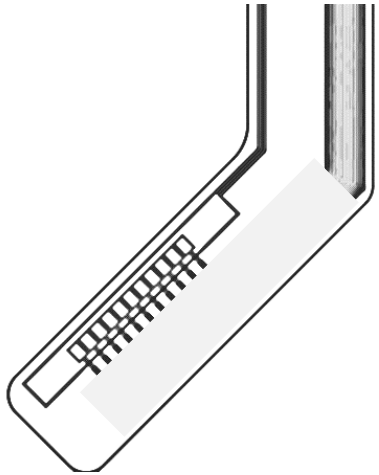


MWM® (FS42)

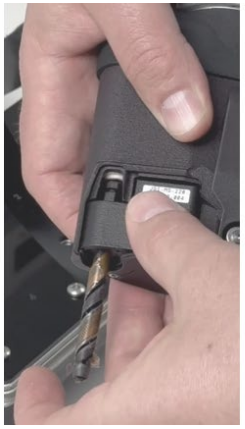


MWM®-Array (FA296)
Dual Rectangle Drive

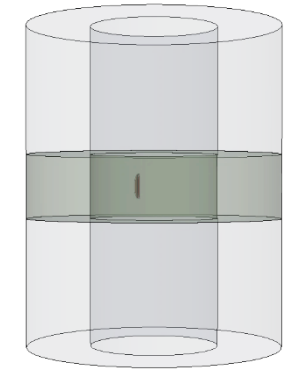
New Bolt Hole
MWM®-Array
FA318/FA360



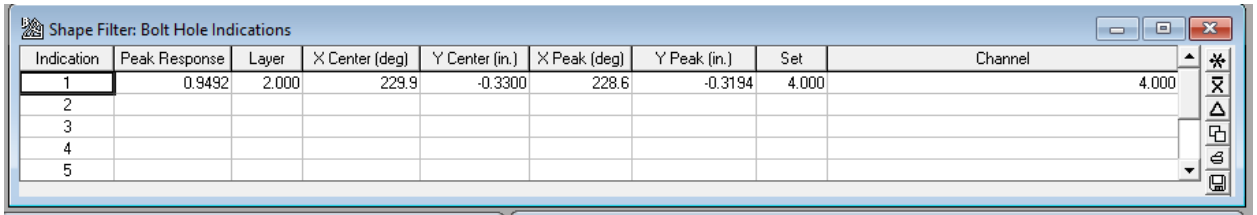
jETi Bolt-Hole Inspection System



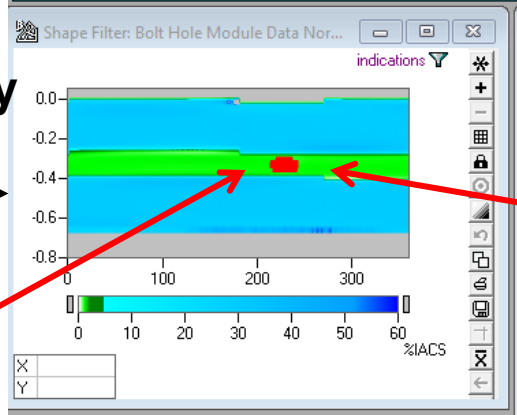
Example Result: 3 Layer Stack-up (50 x 25 mil; mid-wall flaw)

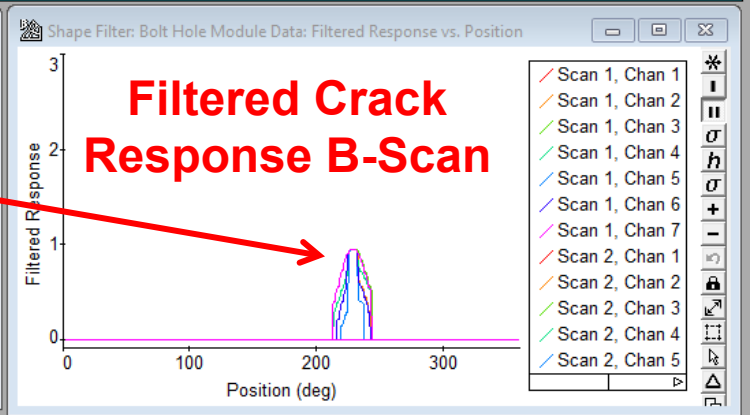


Automatic Reporting

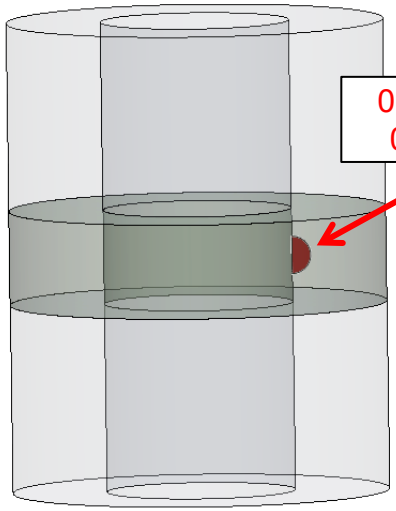


Conductivity C-Scan



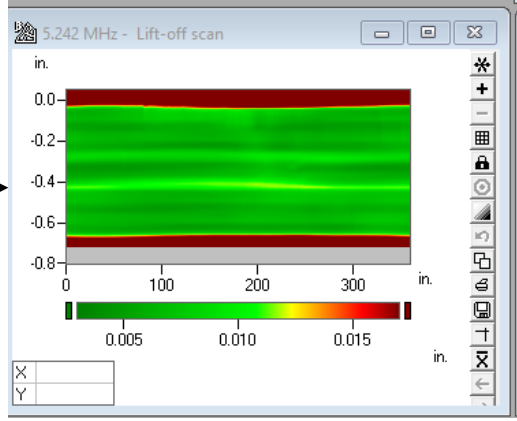


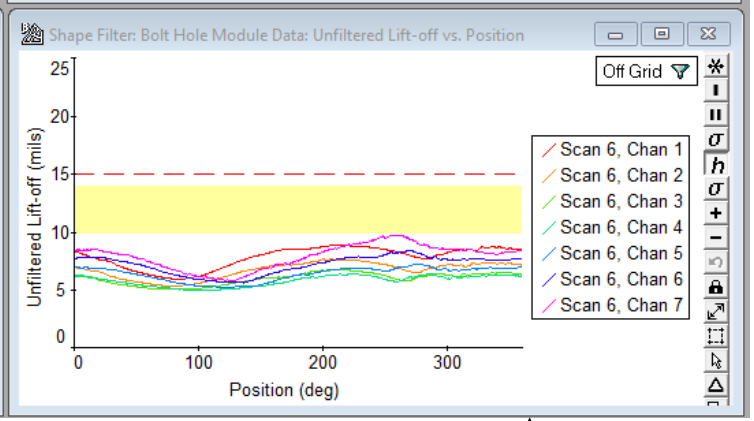
Filtered Crack Response B-Scan



0.050 in. x 0.025 in.

Lift-off C-Scan



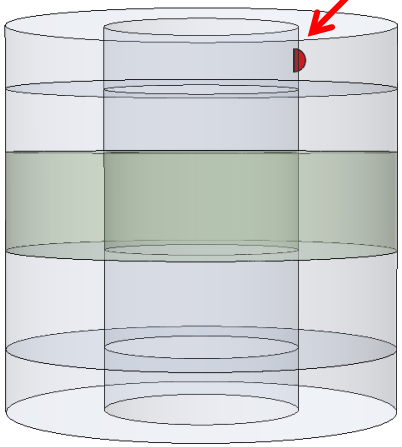


Lift-off B-Scan

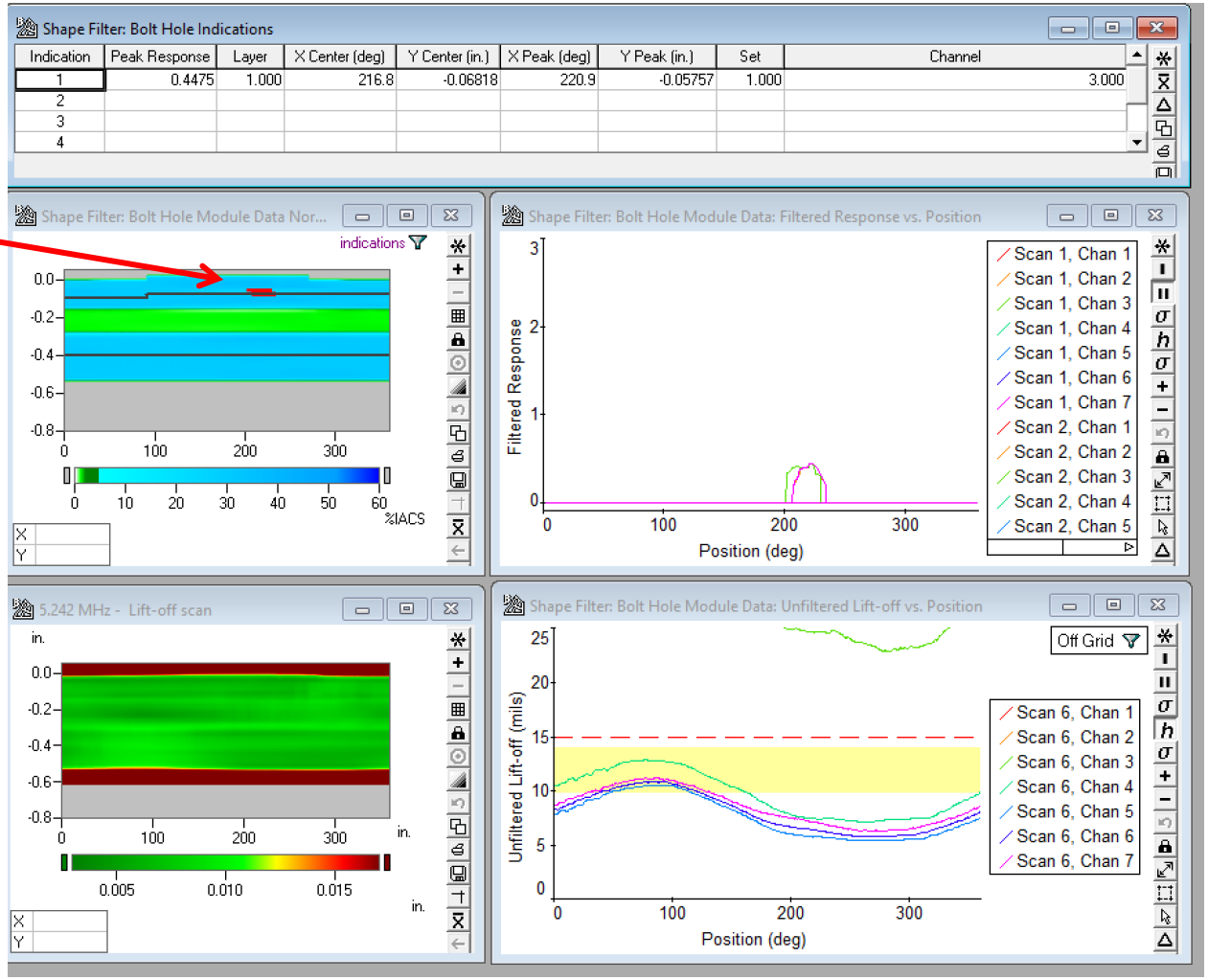
Aluminum
Titanium
Aluminum

Study Specimen 1701 Hole 3 (30 x 15 mil; mid-wall flaw)

0.030 in. x 0.015 in.



Aluminum
Aluminum
Titanium
Aluminum
Aluminum



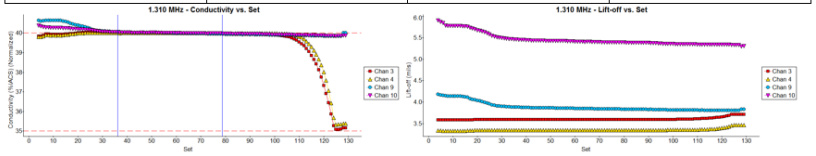
Real Crack Specimen Fabrication

Material	Thickness (in)	Hole Diameter (in)
6061-T6	0.125	¼ (0.250)

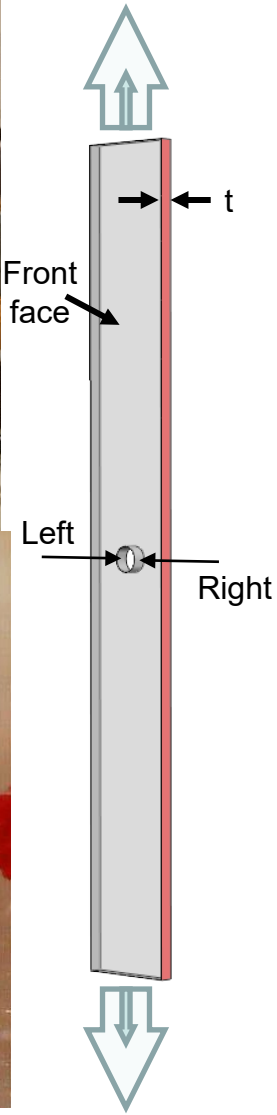
Note: Conductivity measurements are **NOT** consistent with 6061-T6

Maximum Load (lbs)	Minimum Load (lbs)	Frequency (Typical)	Max. # Cycles
3000	300	25Hz	19,773

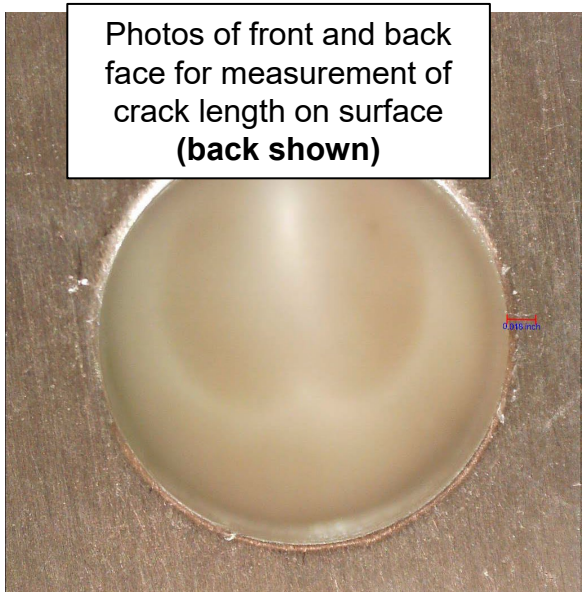
Left		Right	
Length in Hole (in)	Length on Surface (in)	Length in Hole (in)	Length on Surface (in)
0.000	0.000	0.044	0.018



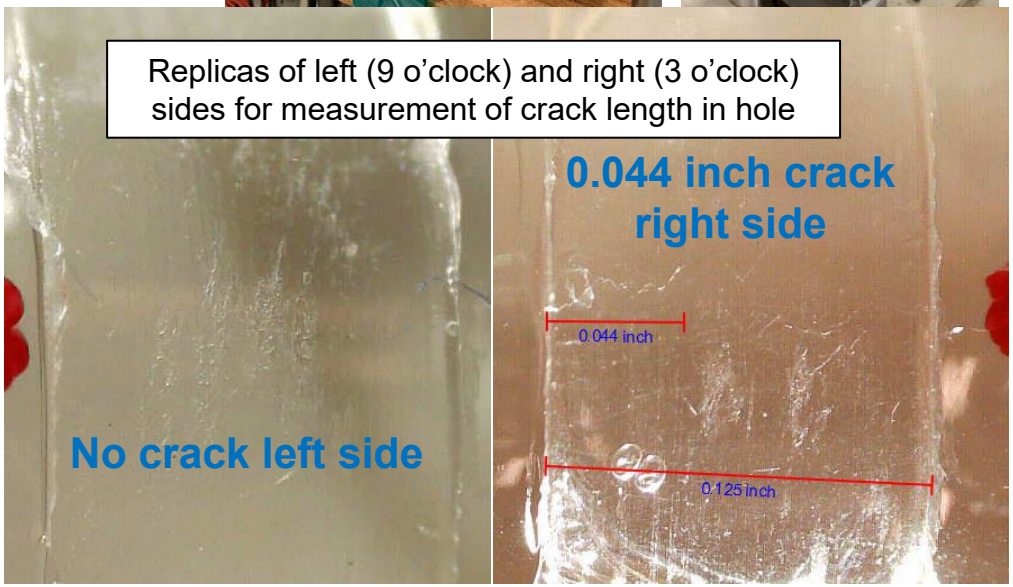
Sample **1**



Photos of front and back face for measurement of crack length on surface **(back shown)**



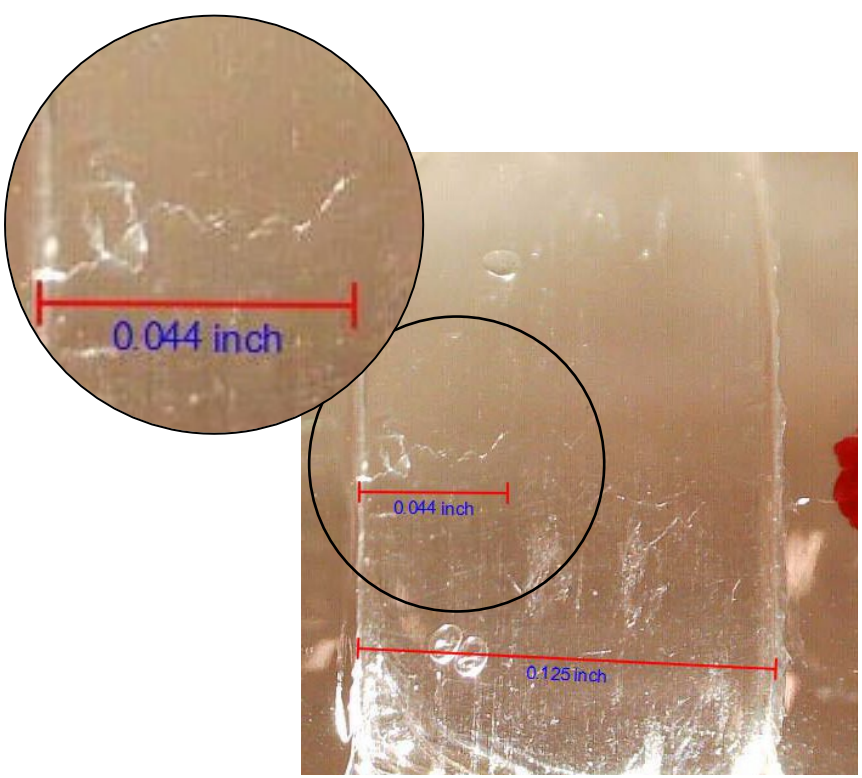
Replicas of left (9 o'clock) and right (3 o'clock) sides for measurement of crack length in hole

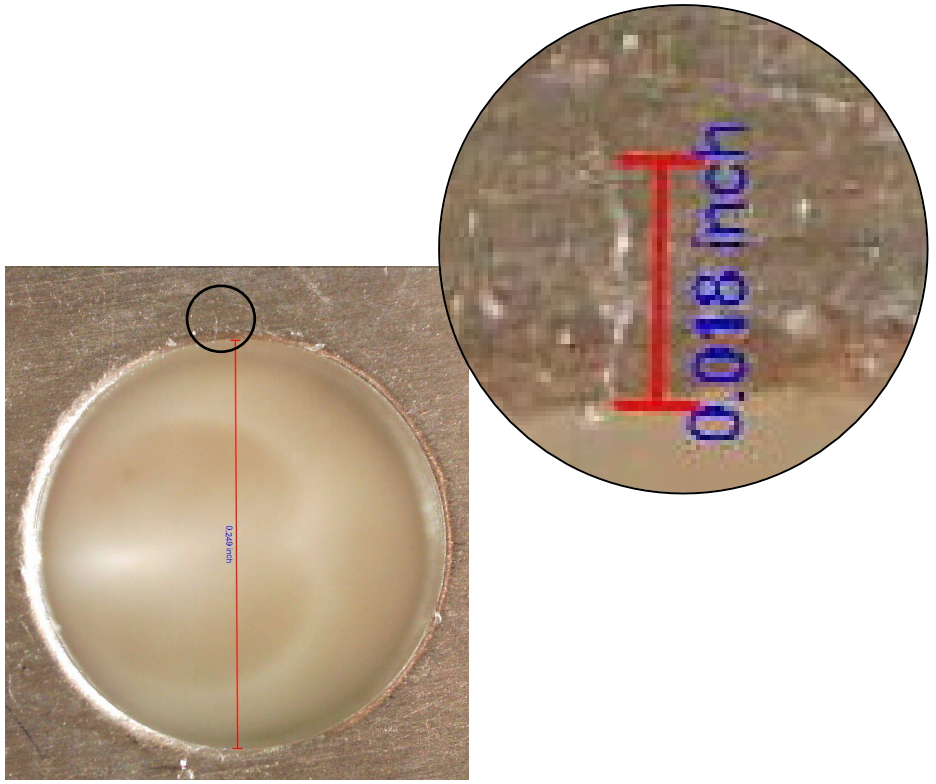


Real Crack Specimen 1

- ¼ in. hole; Al alloy
- Left inside: No defect
- Right inside: 0.044 in. corner crack (0.018 in. external surface crack)

Note the jagged nature of real cracks





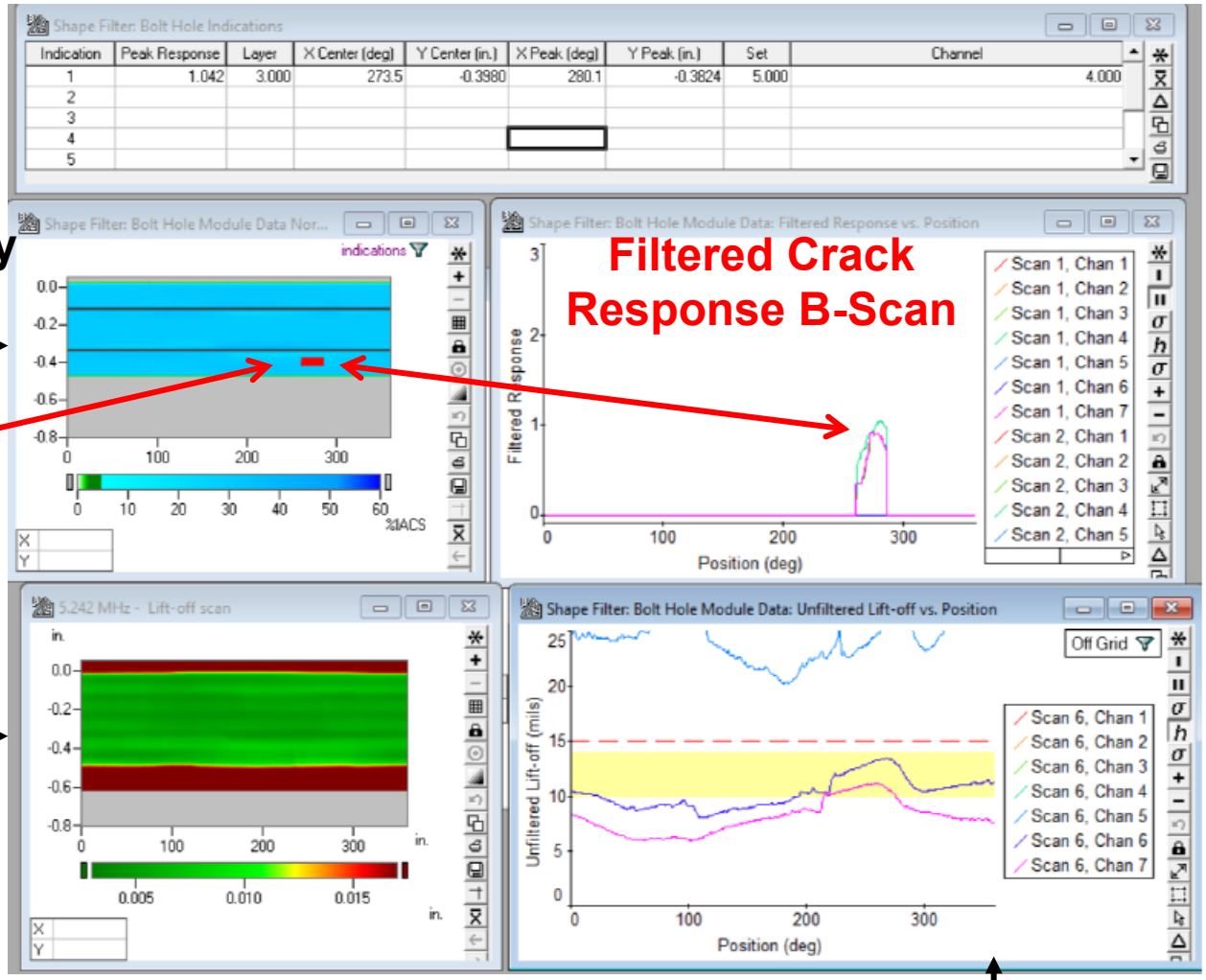
Real Crack Specimen 1 – (44 x 18 mil; corner crack)

Automatic Reporting

Conductivity C-Scan

0.044 in. x 0.018 in.

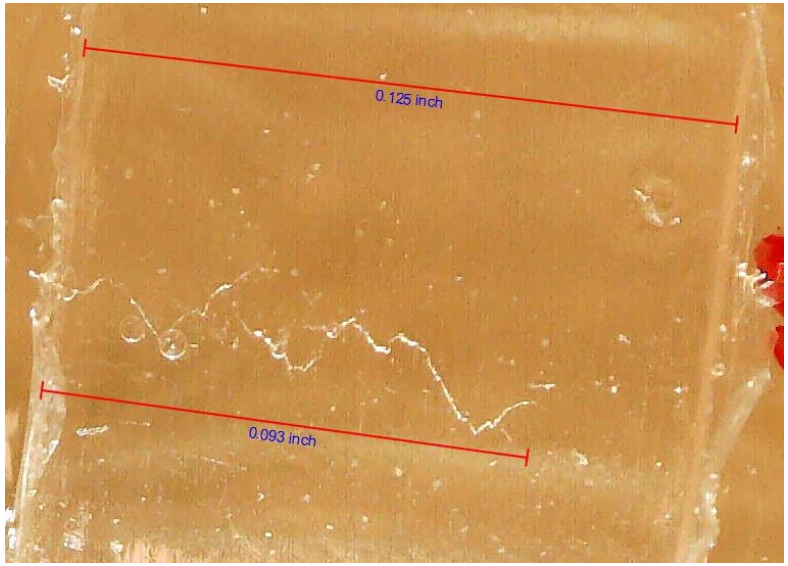
Lift-off C-Scan

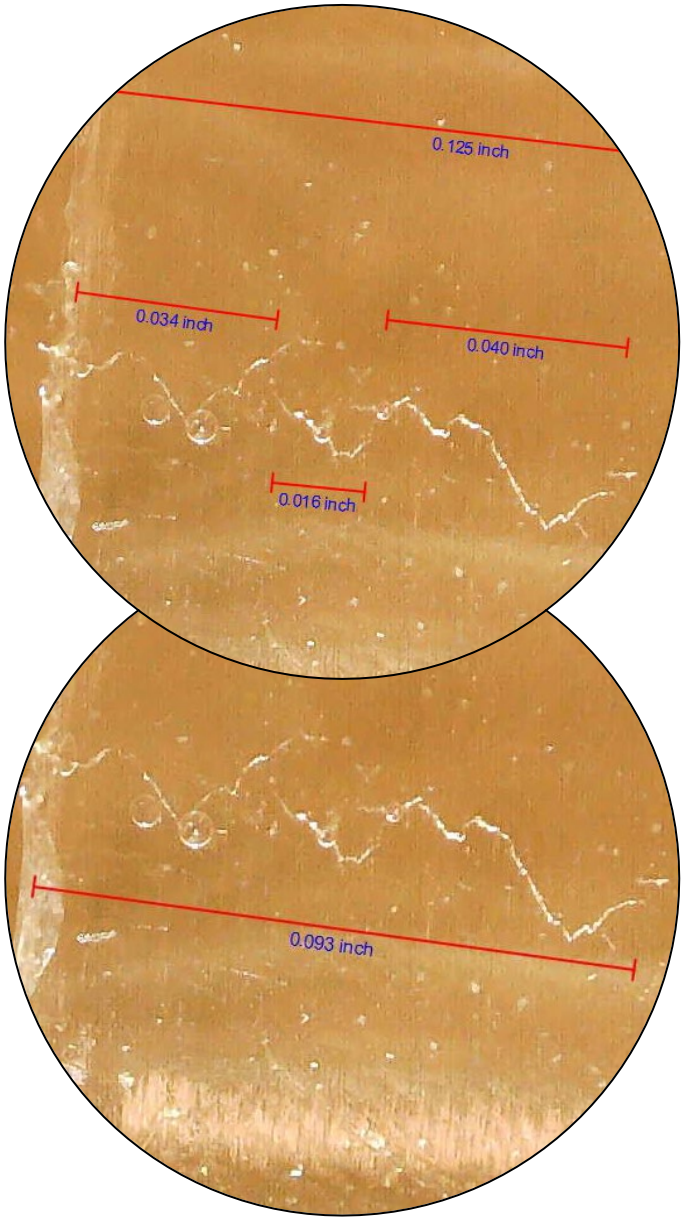


Lift-off B-Scan

Real Crack Specimen 2

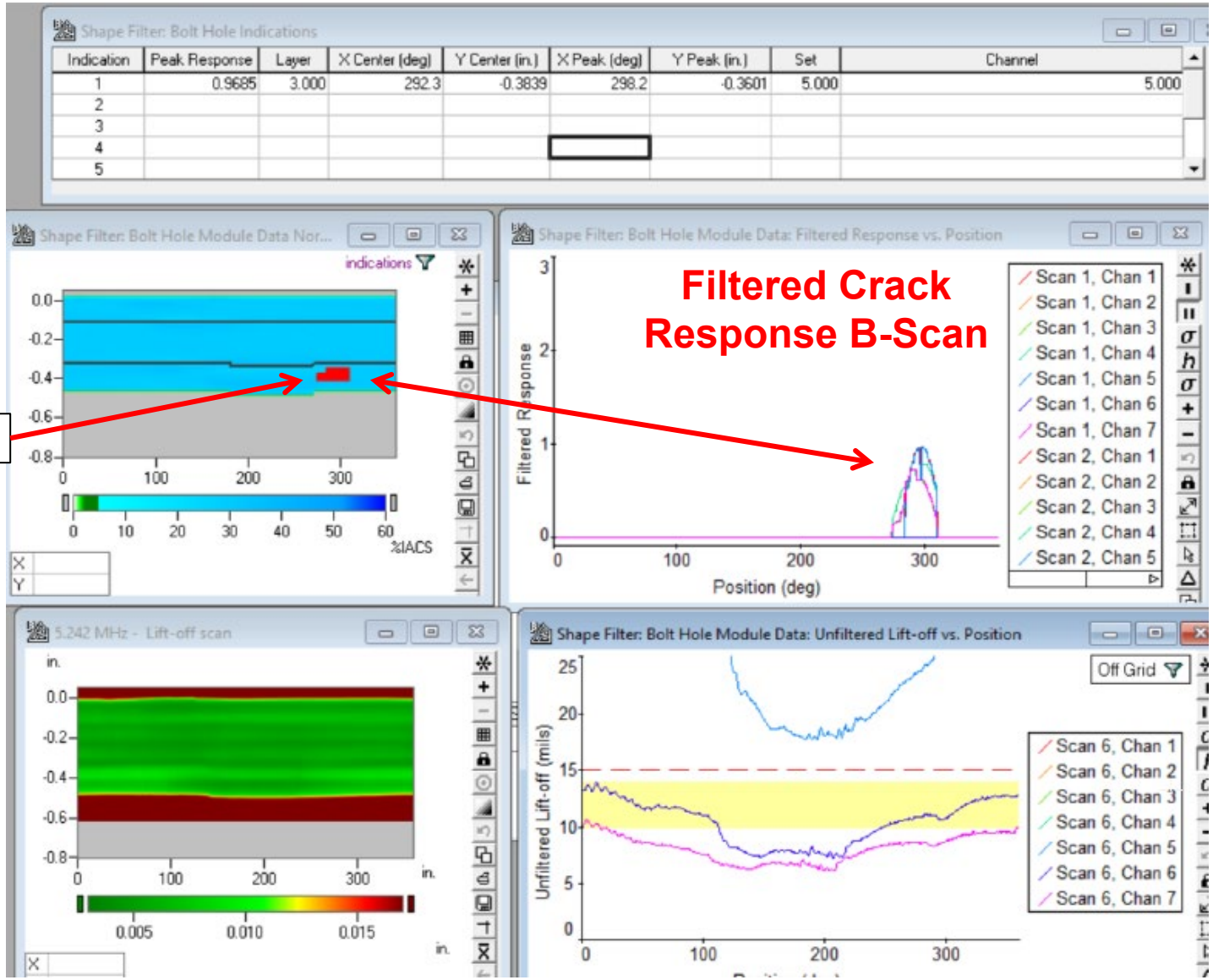
- ¼ in. hole; Al alloy
- Left inside: No defect
- Right inside: 0.093 in. crack near edge (no external surface crack visible)
- Appears to be three nearly coalesced cracks of lengths 0.040 in., 0.016 in., and 0.034 in.





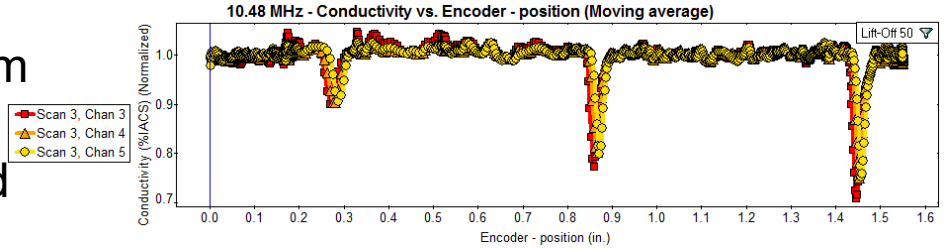
Real Crack Specimen 2 – (93 mil mid-bore/coalesced)

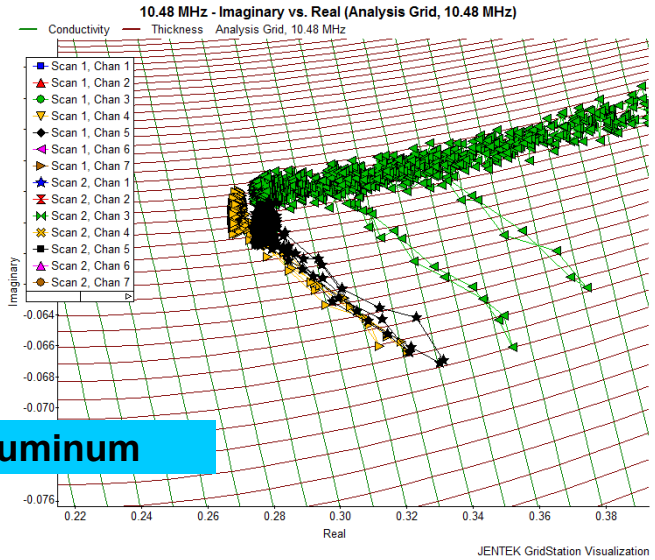
0.093 in. total length

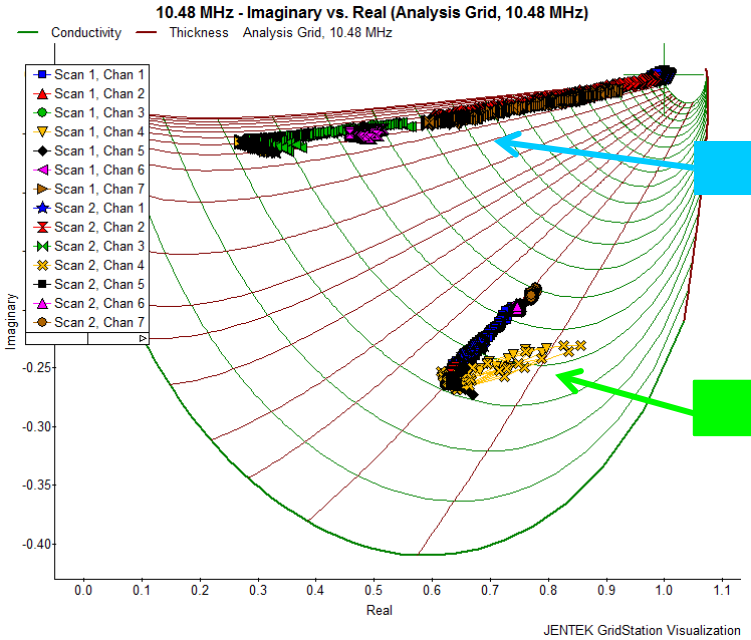


Automatic Correction for Part Conductivity (and Temperature)

Aluminum Alloy Standard

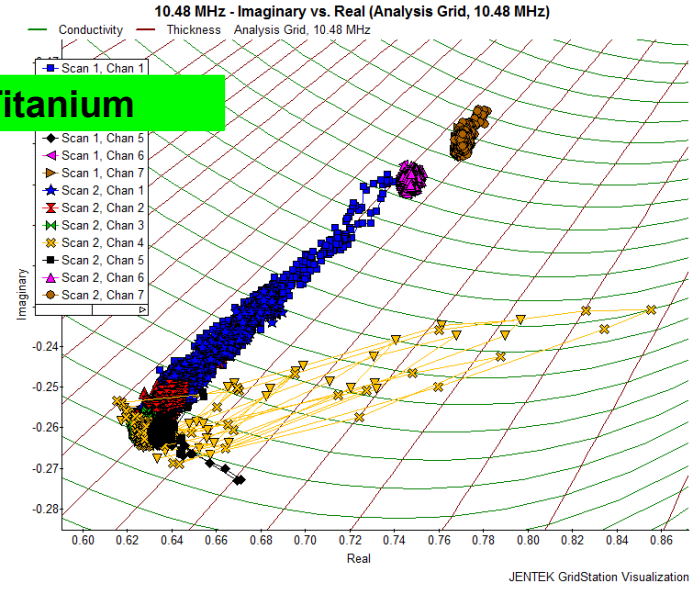




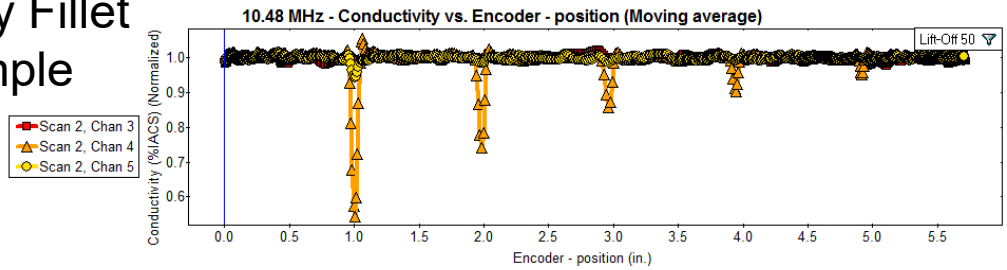


Aluminum

Titanium



Titanium Alloy Fillet Sample



Surface Crack Detection at fillets with MWM-Arrays

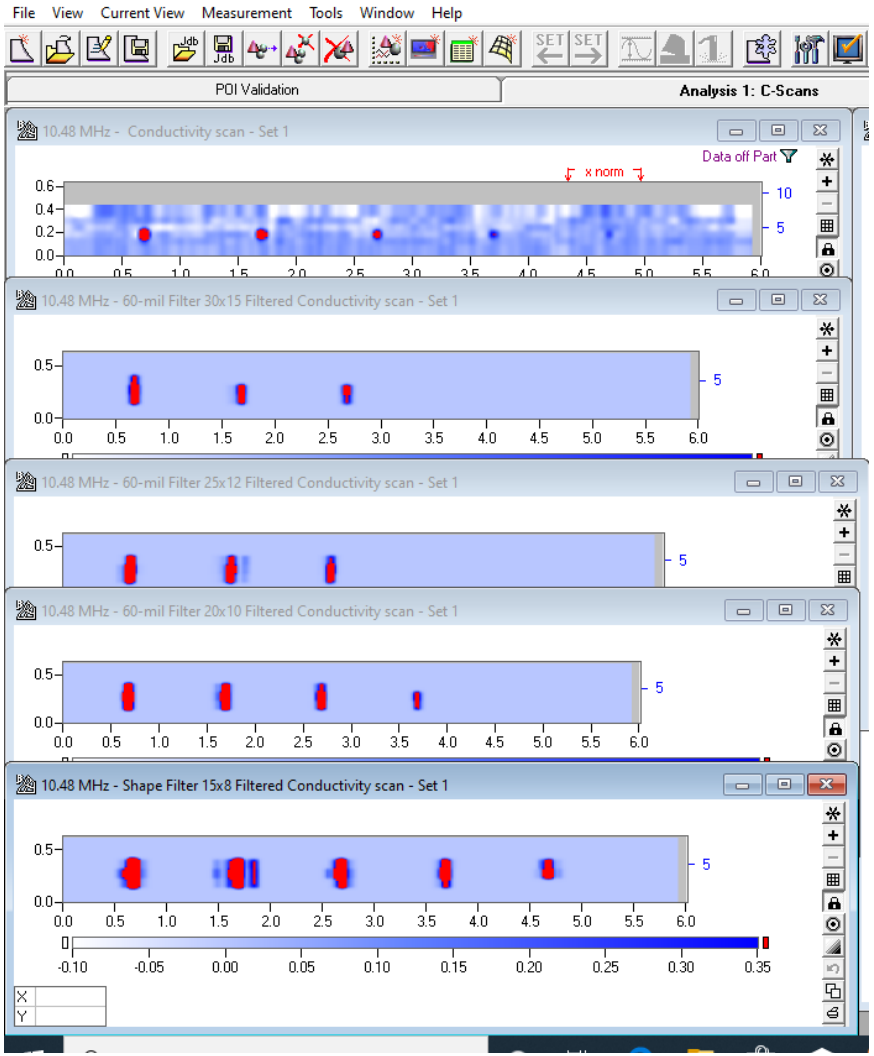
Liftoff & coverage verification

Six EDM notches at fillet

Depths 0.030, 0.020, 0.015, 0.010, 0.007 in.

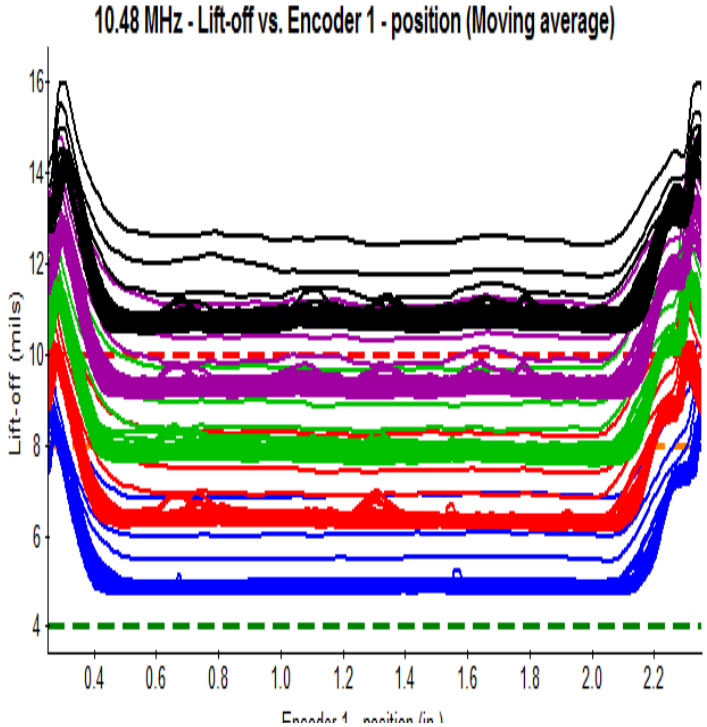
Filtered by size

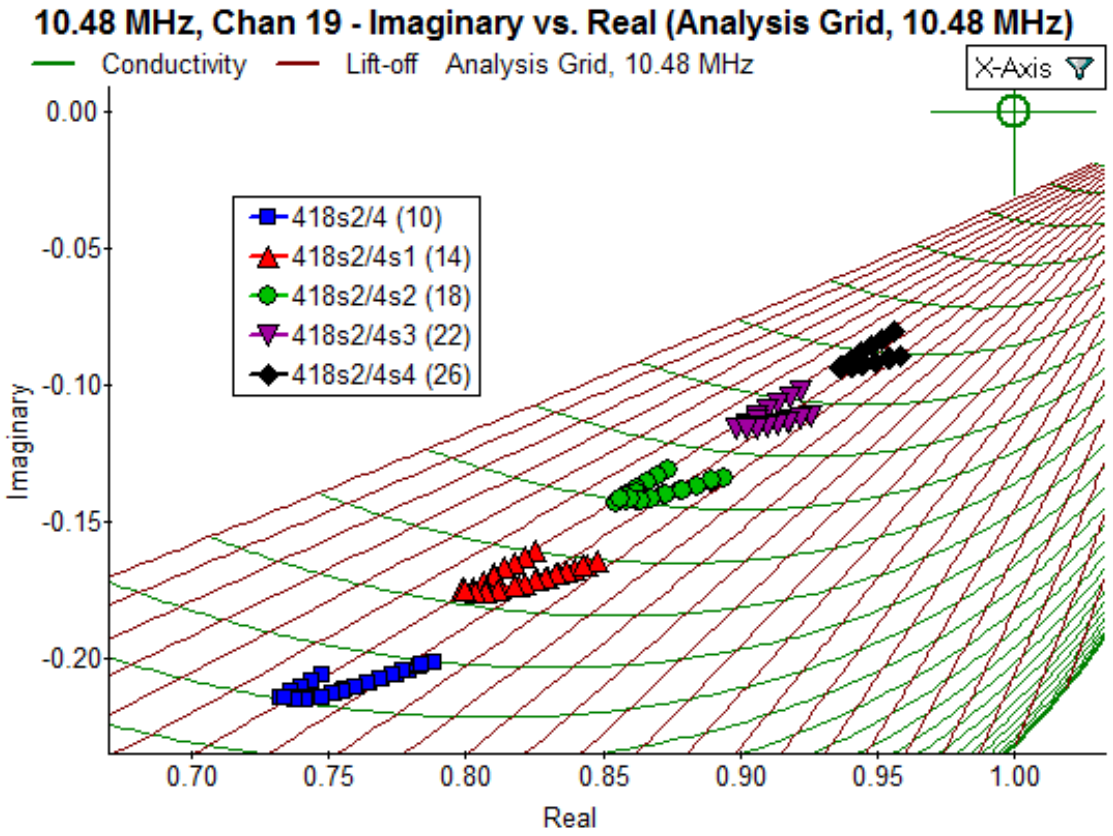
All detected, with “air calibration”

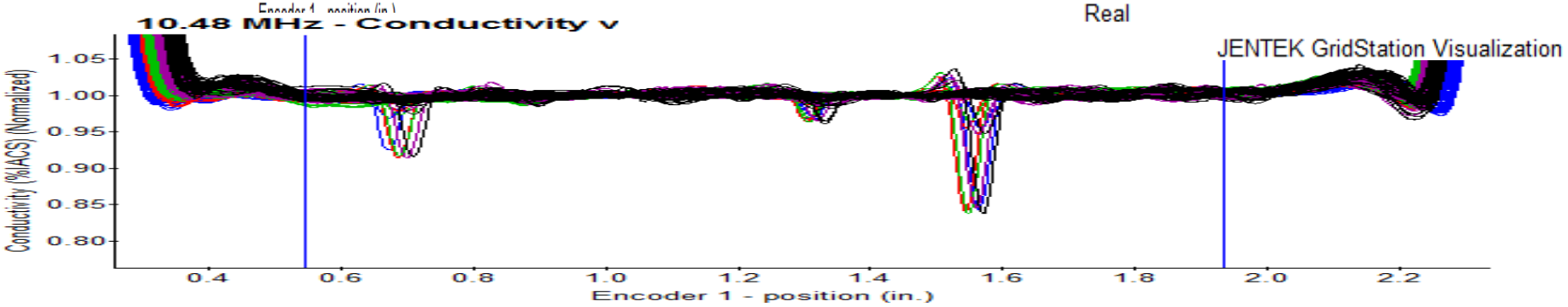


Unfiltered (top) and Filtered C-Scans

Automatic Rescaling of Crack Response with Lift-off





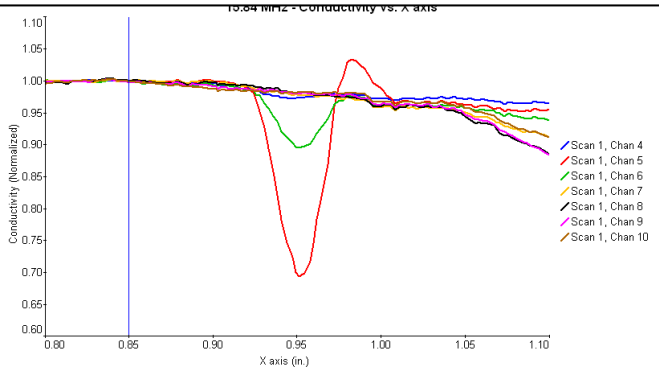


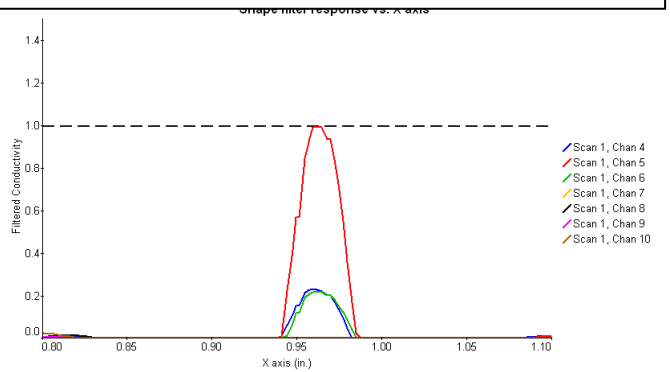
Automatic Rescaling of Crack Response with Position within Array

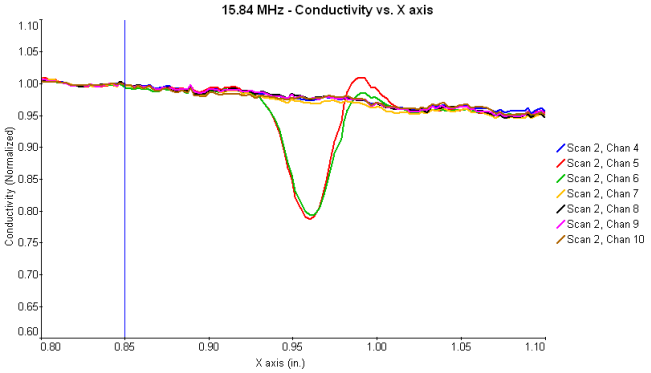
Unfiltered Crack Response

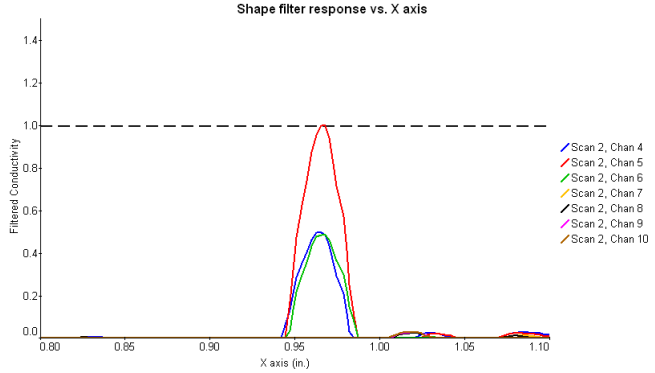
Filtered Crack Response

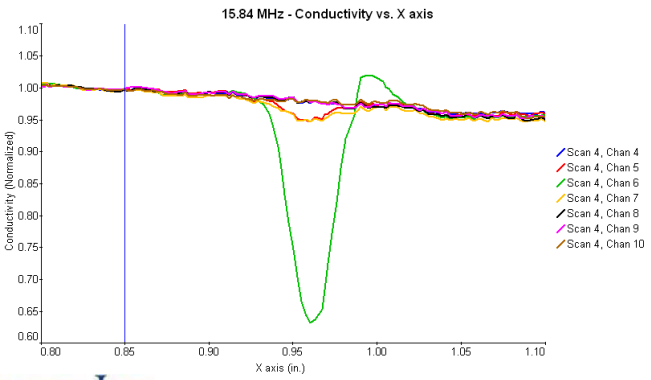
Varying Transverse Position

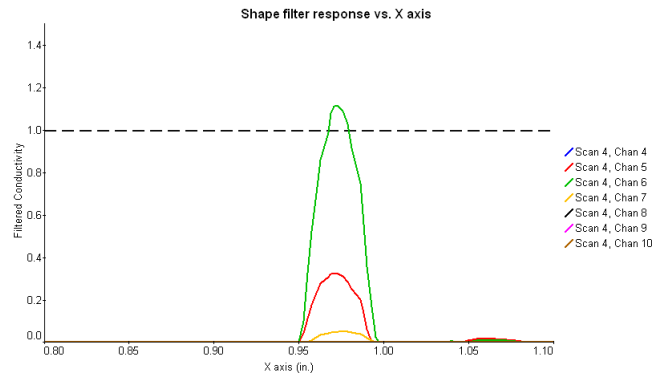








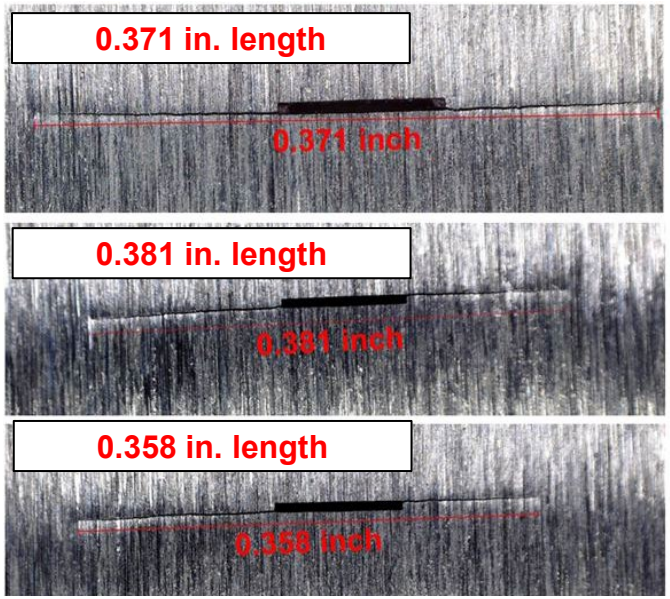




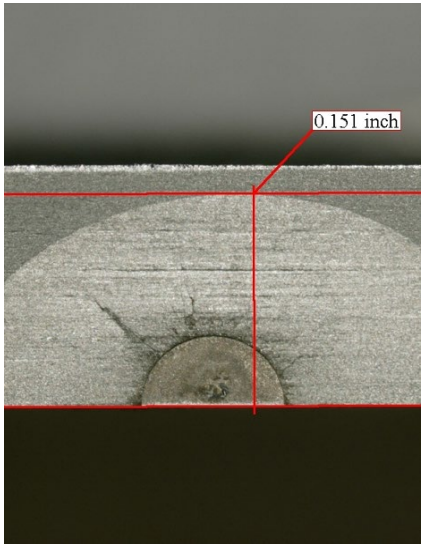
Subsurface cracks in curved and complex parts

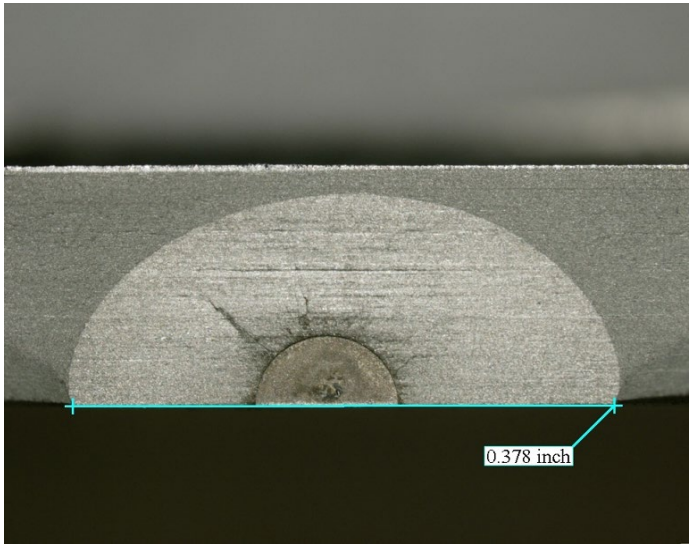
- **Air Force funded POD study**
- **Fractography for largest defect shown below**
- **Real crack generated with starter EDM notch**

Crack length measurement
Specimens 1, 2, 3

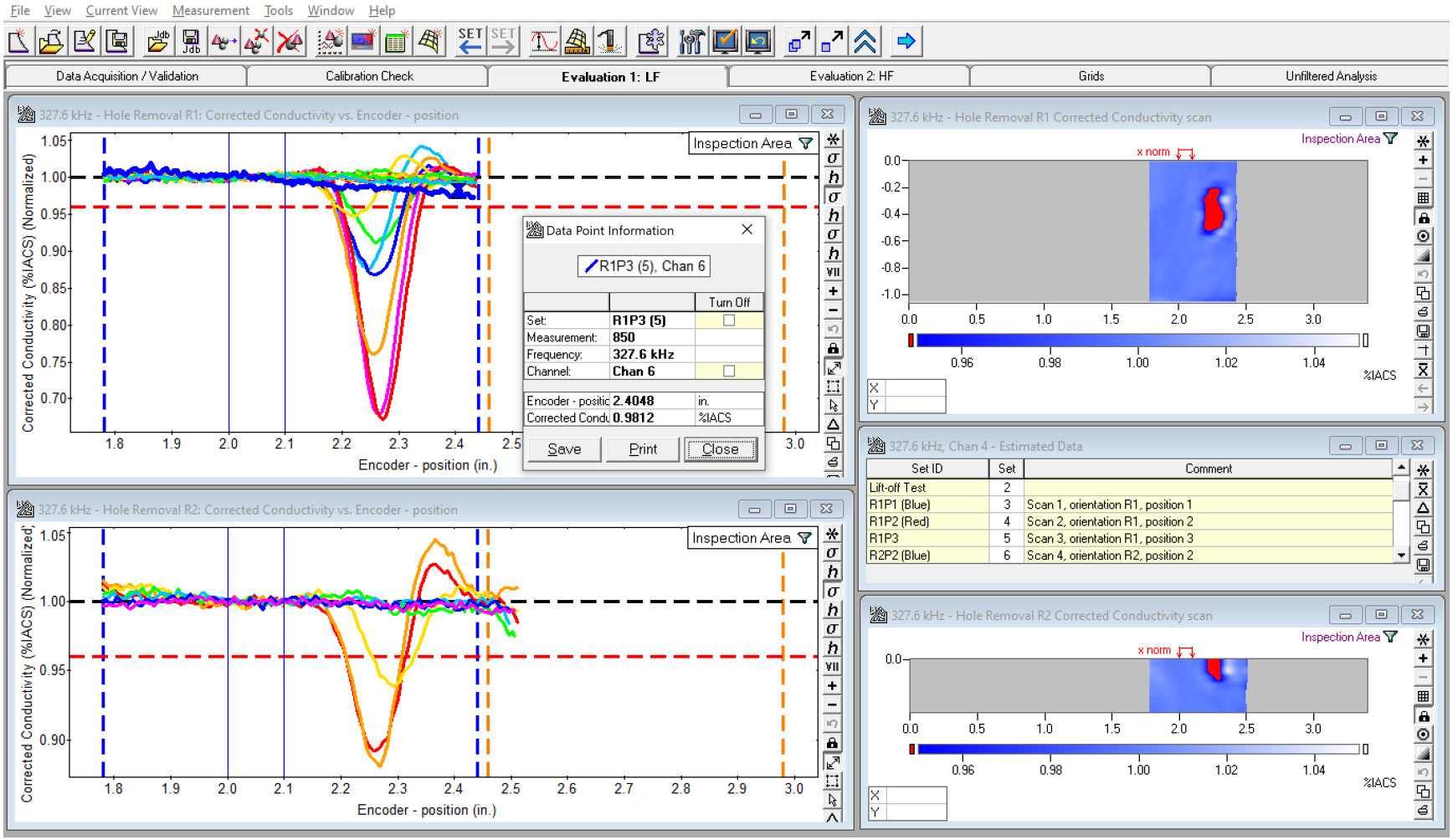


Destructive analysis of Specimen 2
Specimen thickness measured at 0.168 in.

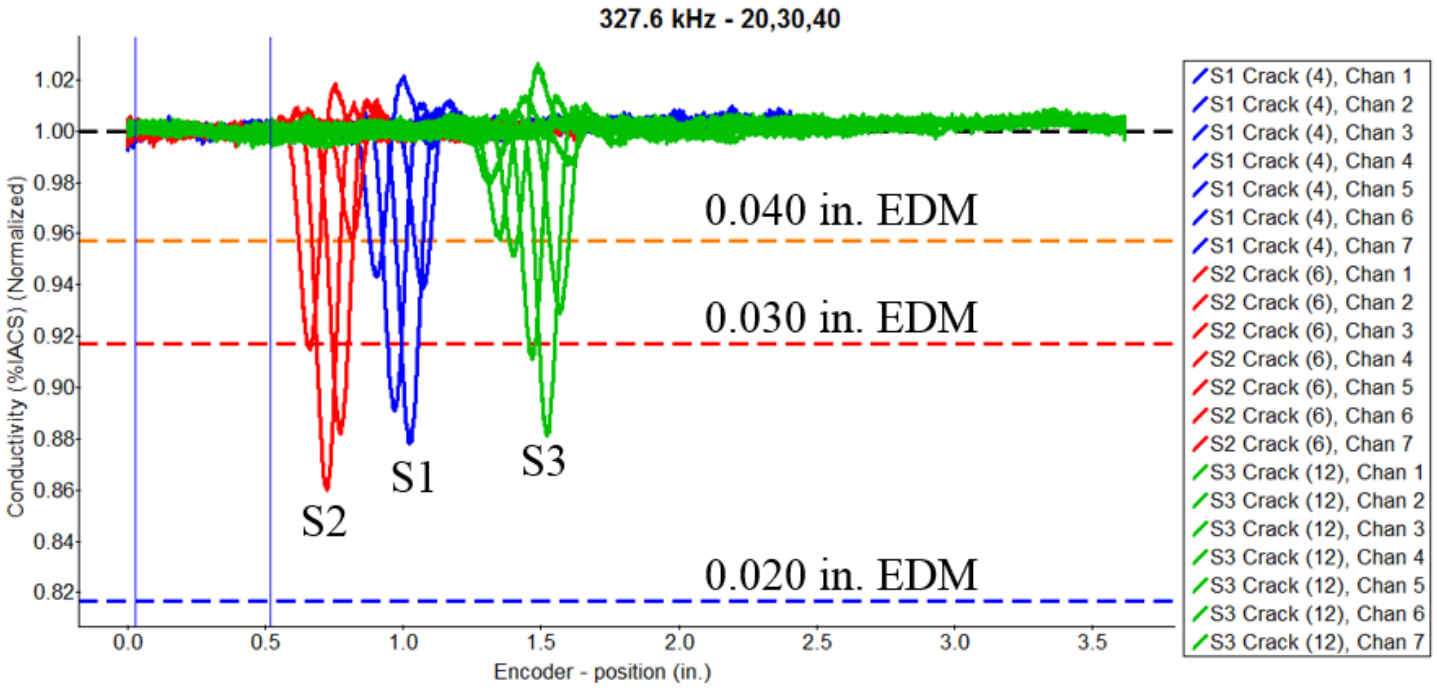


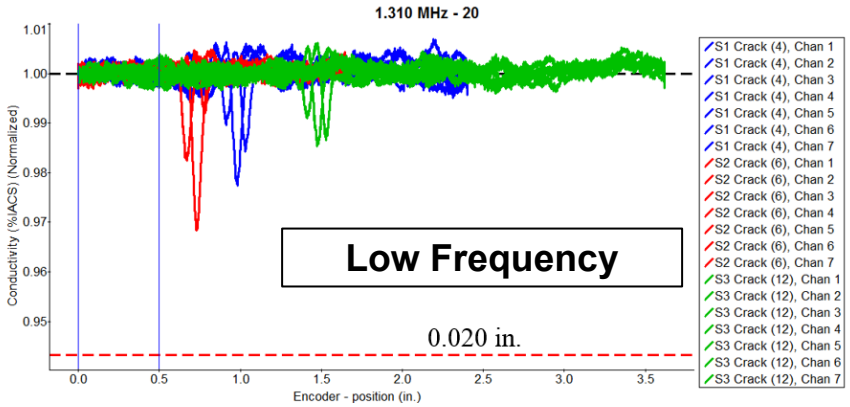


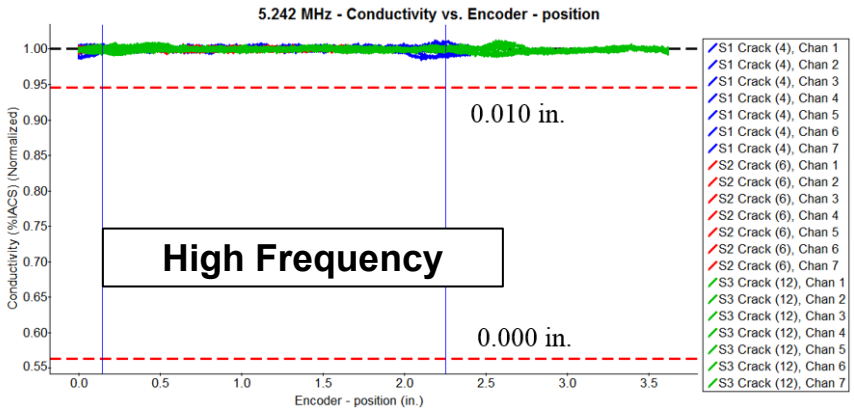
Sub-surface Real Crack Response



Sub-surface Real Crack vs. EDM Notch Responses





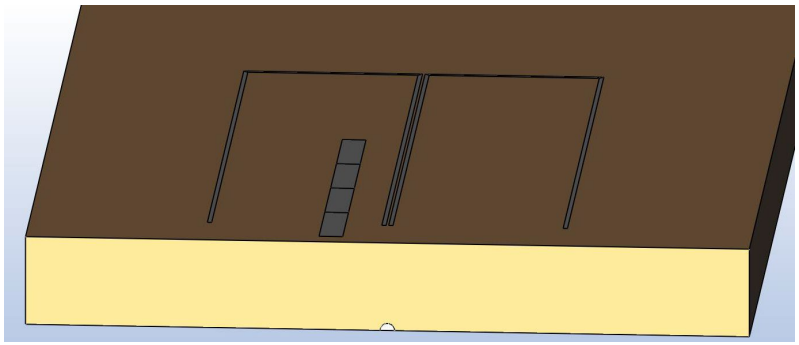


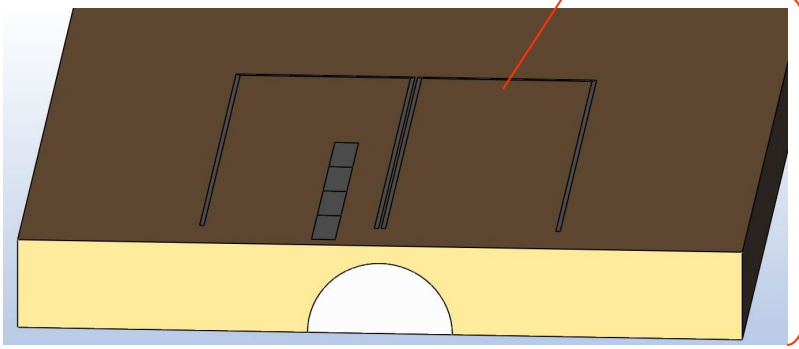
Subsurface crack modeling

Smaller Flaw

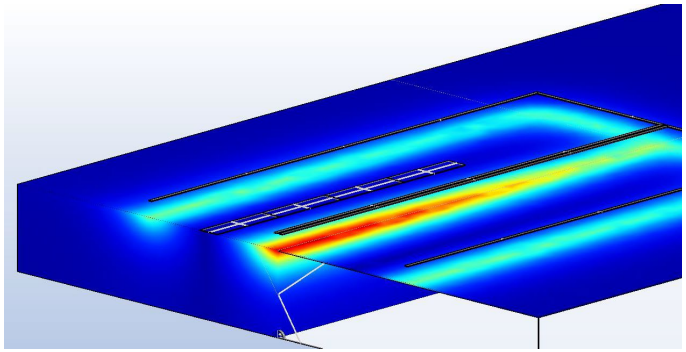
Larger Flaw

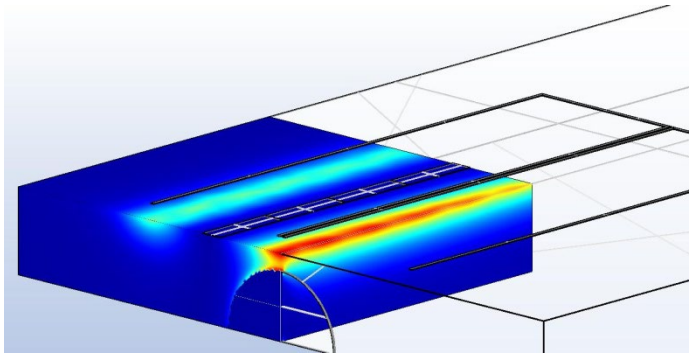
½ of FA258 MWM-Array





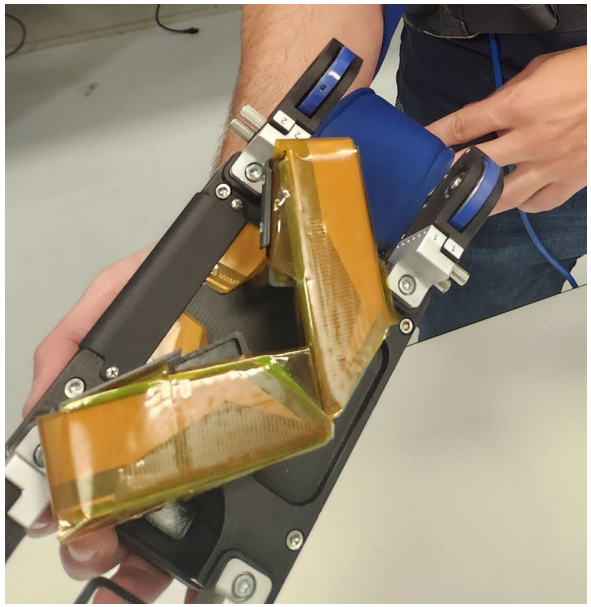
½ of physical geometry (using symmetry)



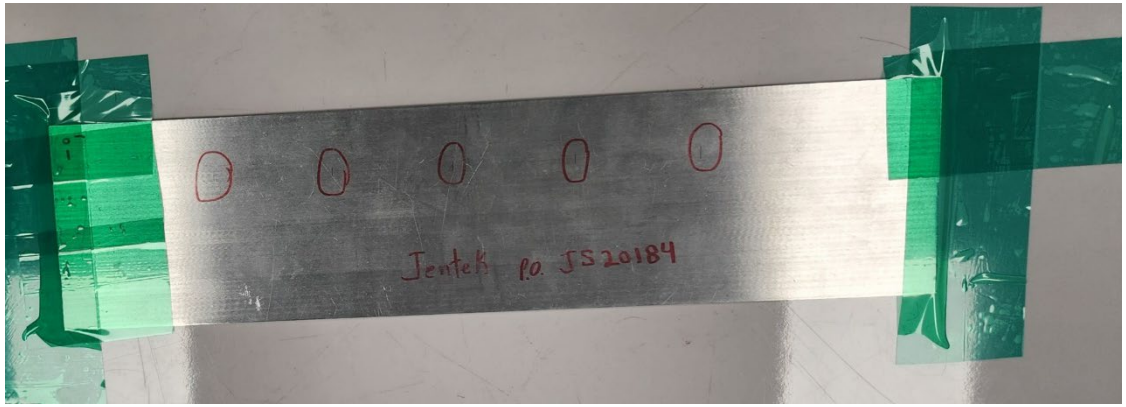


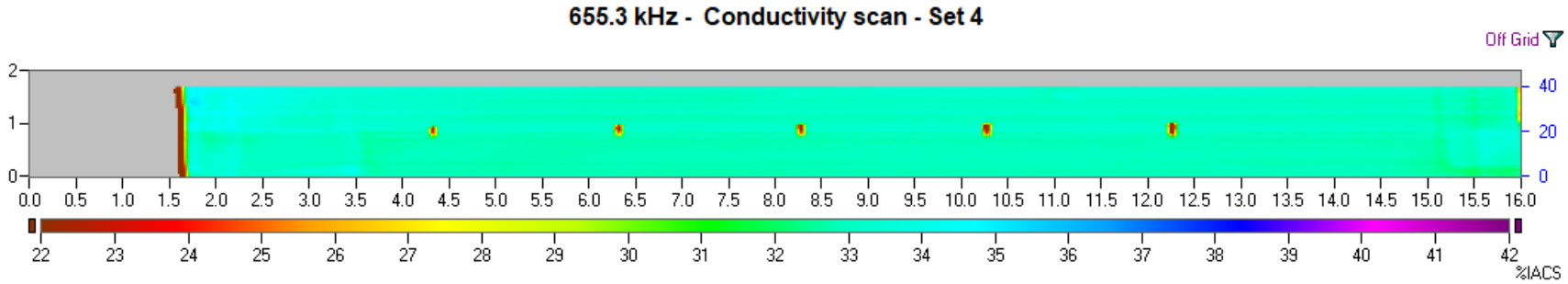
Induced current density contour plots [100 kHz; 0.05 in. lift-off; 0.4 in. long larger notch]

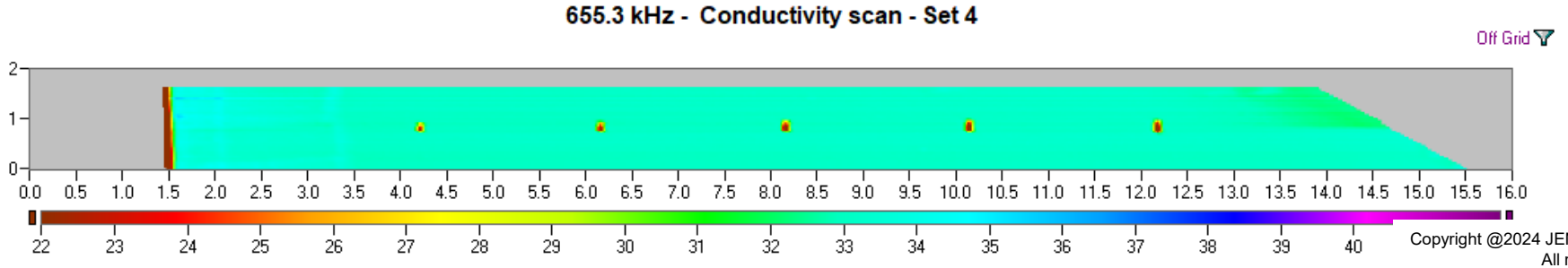
GS9000 Crack Detection



- 79-channel MWM-Array
- Simultaneous ±45° scan for improved defect detection

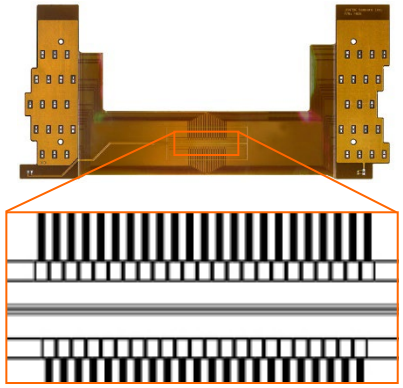


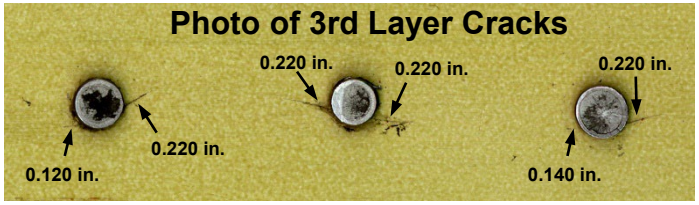


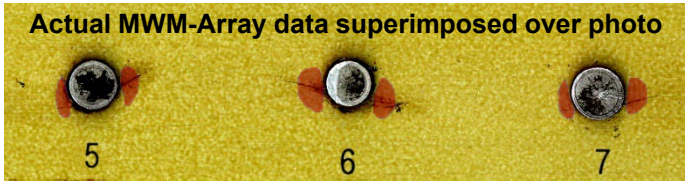


Example: Subsurface Cracks Near Fasteners

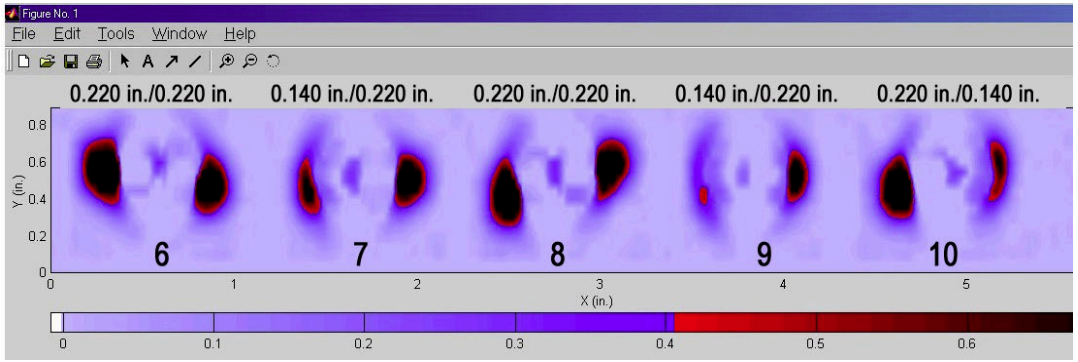
- For the FAA in ~2003 JENTEK participated in a performance study for the Probability of Detection (POD) of 2nd layer cracks in lapjoints for 727 aircraft. JENTEK had the best POD performance in the initial blind tests.
- Representative response images are shown below for a single pass of a sensor array across the fasteners. These scans were very slow but demonstrated excellent detection capability for the multiple crack sites; the current program would extend this work to accommodate a variety of fastener types and increase speed.





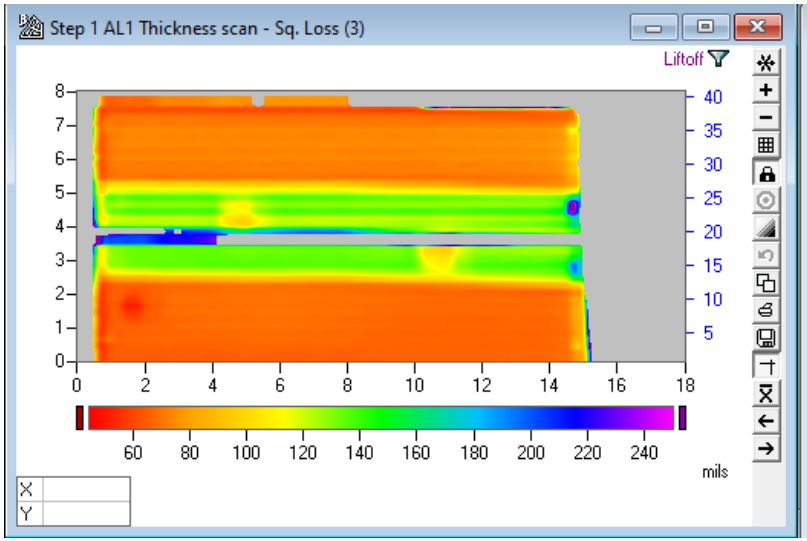


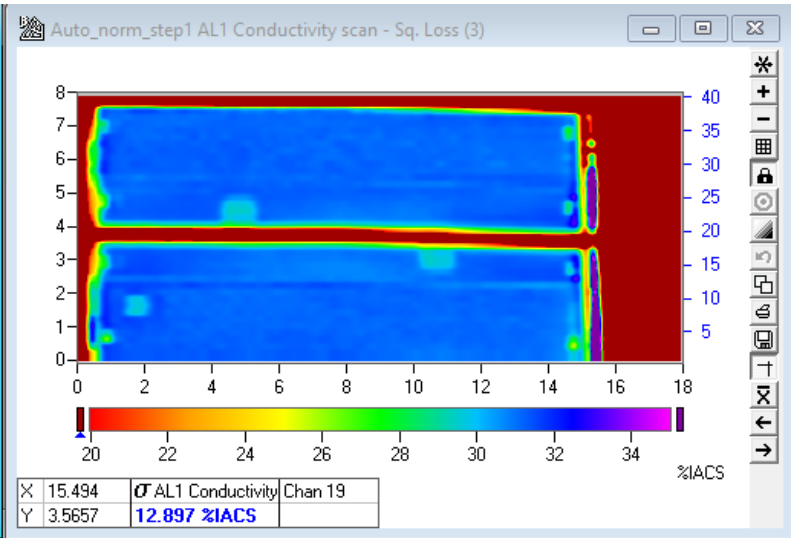
MWM-Array Data



GS9000 Corrosion Imaging

- 39-channel MWM-Array
- 9-inch scan width
- Battery operable
- Surface/subsurface imaging
  - Through paint
- Rapid single-person setup
- Rapid scanning





Summary

- **MWM-Array crack detection for bolt-holes and complex structures:**
  - Air calibration (ASTM E2338; ASTM E2884)
  - Three frequencies simultaneously
  - All sensing elements simultaneously (fully parallel)
  - Automatic crack response rescaling for liftoff
  - Automatic rescaling for defects between channels
  - Surface and sub-surface crack detection
- **Additional applications include: detection of cracks at fasteners, corrosion imaging, coating characterization, and in-process layer-by-layer sensing for additive manufacturing**