Description of Sandia/AANC Fatigue Crack Samples
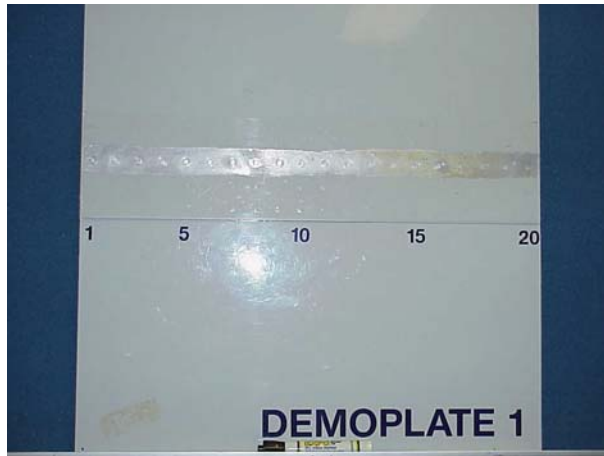
Mike Bode
June 10, 2005
Model Assisted POD Meeting
Orlando, FL

Fatigue Crack Samples

- Two Separate Experimental Panel Sets
  - Eddy Current Inspection Reliability Experiment (ECIRE)
  - Inner Layer Crack Experiment (ILC)

ECIRE Surface Crack Samples

- Number of Specimens = 38
  - 36 specimen panels
  - 2 demonstration or "training" panels
- Paint Condition
  - 14 Unpainted specimen panels
  - 22 Painted specimen panels
- Specimens simulate Boeing Lap Splice on early model B737 aircraft

ECIRE Surface Crack Samples

- Material
  - Clad aluminum 2024-T3
  - Layer thickness = 0.040"
  - Specification: QQA 250-5/AMS 4041
- Conductivity: 31.6 IACS

ECIRE Surface Crack Samples

- Crack Growth Methodology
  - Holes drilled in single panel & EDM starter notches placed at desired location around circumference of hole
  - Panel clamped in hydraulic pulsing machine
  - Pulsed at specific calculated load & appropriate frequency
  - Crack growth orientation achieved by rotational positioning
  - Holes oversized to remove EDM notches

ECIRE Surface Crack Samples

- Crack lengths confirmed via optical microscopes with magnification

- Defect distributions and lengths
  - Demo Panel # 1 has 9 cracks at 0 degrees angle from rivet row center line
  - Demo Panel # 2 has 8 cracks at plus or minus 22 degrees angle from rivet row center line

- All cracks in top rivet row of top skin layer

ECIRE Surface Crack Samples

- Bonding two layers performed IAW BAC 5514
  - Bonding Material: FM73
  - Manufactured by American Cyanamid
  - Specification MIL-A-25463B, Type I, Class 2
- Bonding layer thickness not stated (expected nominal thickness 0.005")

ECIRE Surface Crack Samples

- Riveting performed IWA Boeing specification BAC 5004-1 & Boeing 737 Structural Repair Manual
- Rivet Type: BACR 15CE
  - Material 2017 (D)
  - Countersunk 100 degree shear head
- Two (2) layers joined with 3 rows of rivets
  - Pitch and Back Pitch are nominally one inch

ECIRE Surface Crack Samples

- Priming & Painting per Boeing Material Spec 10-60 and 10-79
- Sikkens 3 layer paint system
  - Metaflex FCR primer
  - Aerodur Primer S 15/90
  - Aerodur Finish HF Top Coat
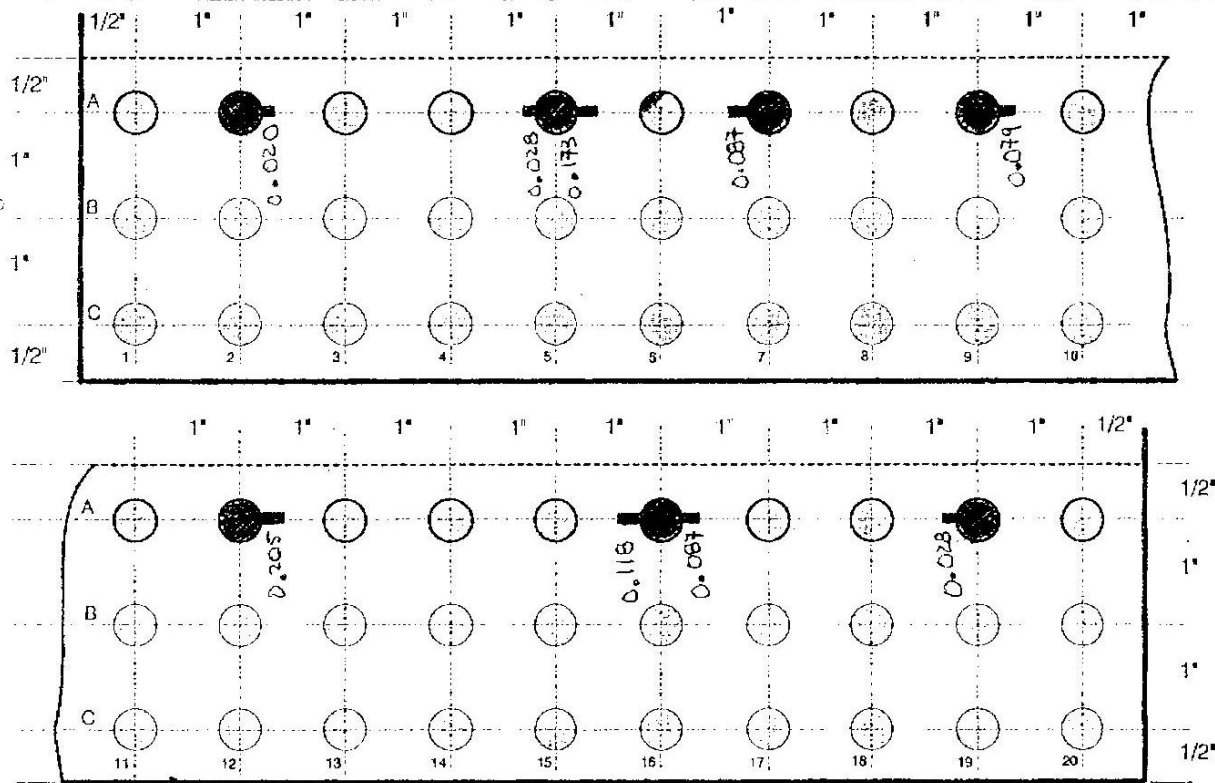- Paint Thickness = 0.004" – 0.005"

ECIRE Demo Panel #1

Rivet Number	Crack Length (in)	Angle (deg)
2R	0.020	0
5L	0.028	0
5R	0.173	0
7L	0.087	0
9R	0.079	0
12R	0.205	0
16L	0.118	0
16R	0.087	0
19L	0.028	0

ECIRE Demo Panel #1

PANEL NUMBER: DEMO PANEL #1 0°±5°

1) MATERIAL: 2024 T3
2) SPECIFICATION: QQA 250-5 / AMS 4041
3) SKIN THICKNESS: 0.040"
4) PAINT THICKNESS: 0.004 - 0.005" Upper Row "A"

5) CONDUCTIVITY: 31.6 IACS
6) NUMBER OF CRACKS: 9
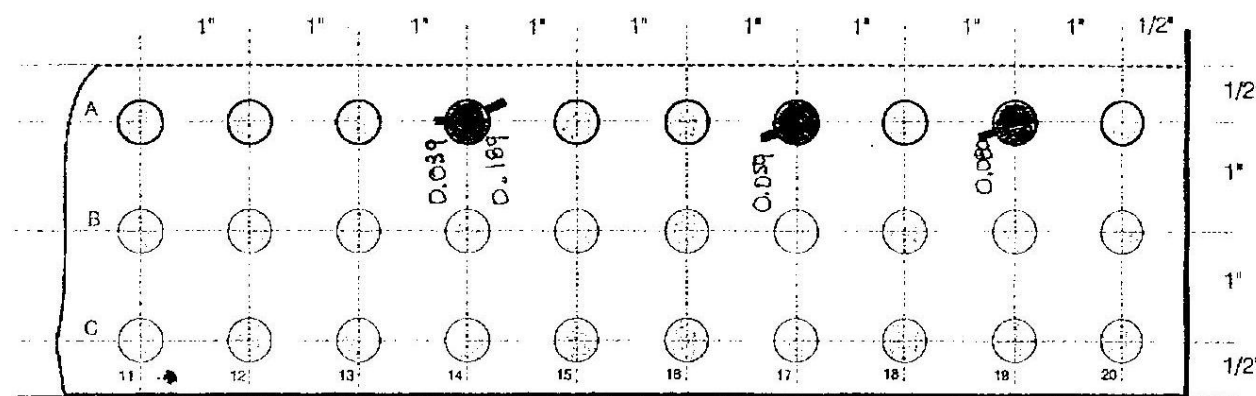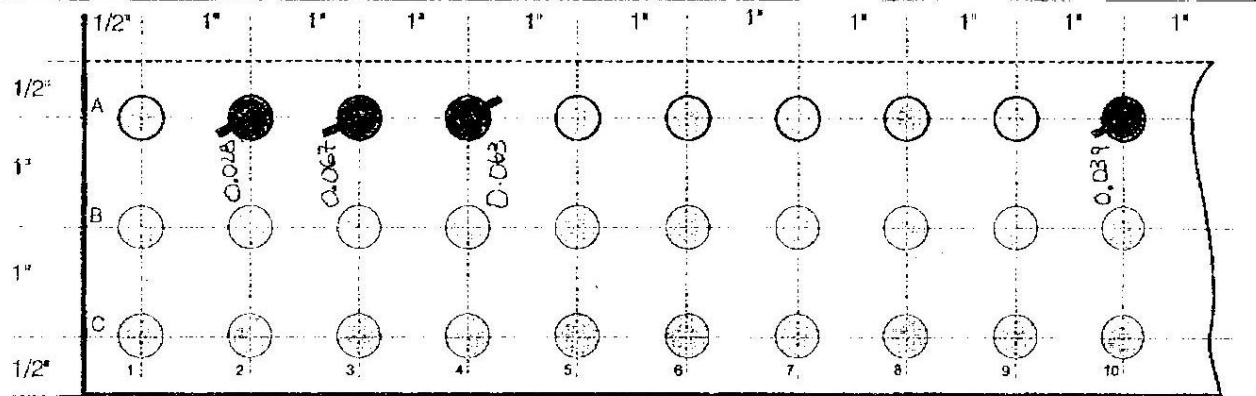7) FABRICATION DATE: 26 MAR 1992
8) INSPECTED: R.A. Zichuy

ECIRE Demo Panel #2

Rivet Number	Crack Length (in)	Angle (deg)
2L	0.028	-22
3L	0.067	-22
4R	0.063	+22
10L	0.039	-22
14L	0.039	0
14R	0.189	+22
17L	0.059	-22
19L	0.080	-22

ECIRE Demo Panel #2

ECIRE POD Specimen Panels

- Total number of cracks = 217
- Total number of rivets with cracks = 154
- Number of rivets with double cracks = 63
- Number of defect free rivets = 606
- Crack length distribution = 0.812" to 0.013"
- Crack origin location angles = 0, 11, 22 (plus and minus degrees, includes left and right)

ECIRE POD Specimen Panels



ECIRE Crack Length Distribution
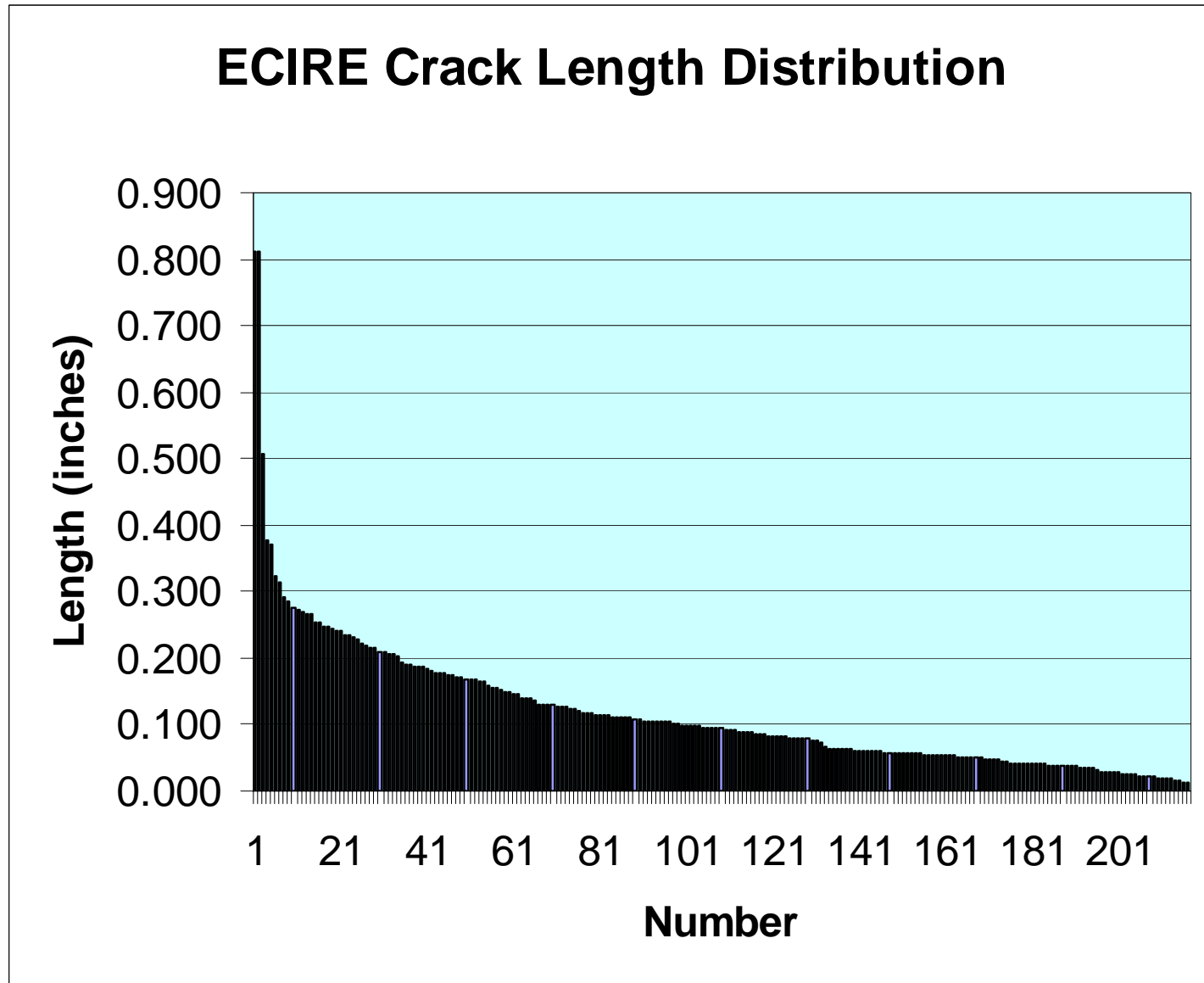
ILC Subsurface Crack Panels

- Number of Specimens = 17
  - 16 specimen panels
  - 1 demonstration or "training" panels
- Paint Condition
  - 17 Unpainted specimen panels
- Specimens simulate Boeing Lap Splice on later model B737 aircraft (300 series and later) – internal doubler and tear straps
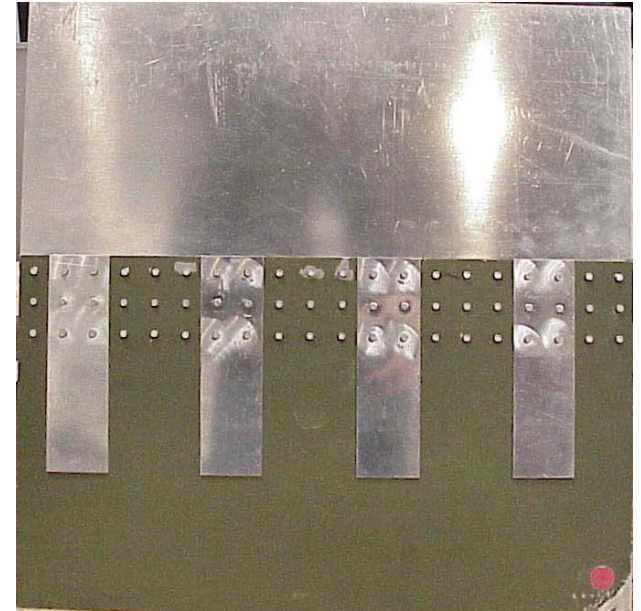- Many of the fabrication details are similar to ECIRE panels

# ILC Subsurface Crack Panels

FRONT
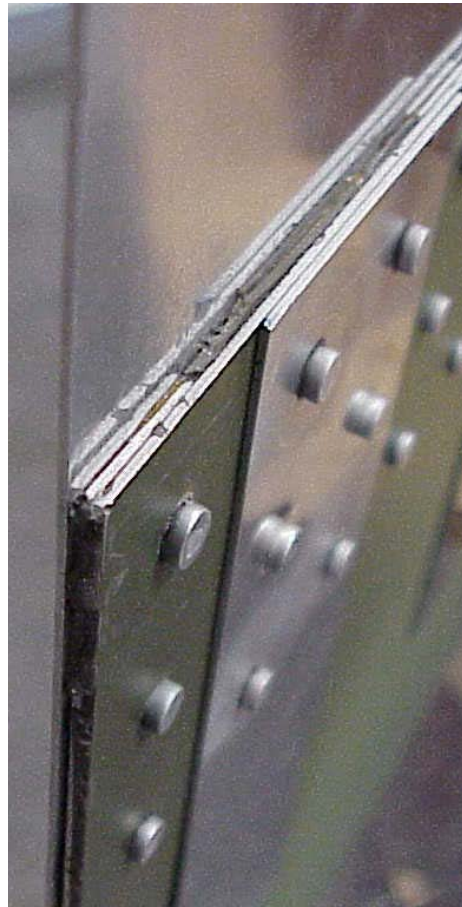
LAP EDGE

BACK

ILC Demo Panel

Rivet	Left Length	Right Length	Double Flaw	Tear Strap?	Tear Strap Left Edge Margin	Center of Rivet to Nearest Tear Strap Edge
1				0		
2				0		
3		53.5	0	1	0.5	0.5
4		29.5	0	1	0.5	0.5
5		51	0	0		
6		33.5	0	0		
7		40	0	0		
8	74		0	1	0.5	0.5
9				1	0.5	0.5
10				0		
11				0		
12		120	0	0		
13				1	0.5	0.5
14				1	0.5	0.5
15		102	0	0		
16				0		
17				0		
18				1	0.5	0.5
19				1	0.5	0.5
20				0		

ILC POD Specimen Panels

- Total number of cracks = 123
- Total number of rivets with cracks = 98
- Number of rivets with double cracks = 25
- Number of defect free rivets = 242
- Crack length distribution = 0.584" to 0.010"
- Crack origin location angles = 0 degrees (all cracks either left or right only)

ILC POD Specimen Panels

ILC Crack Length Distribution
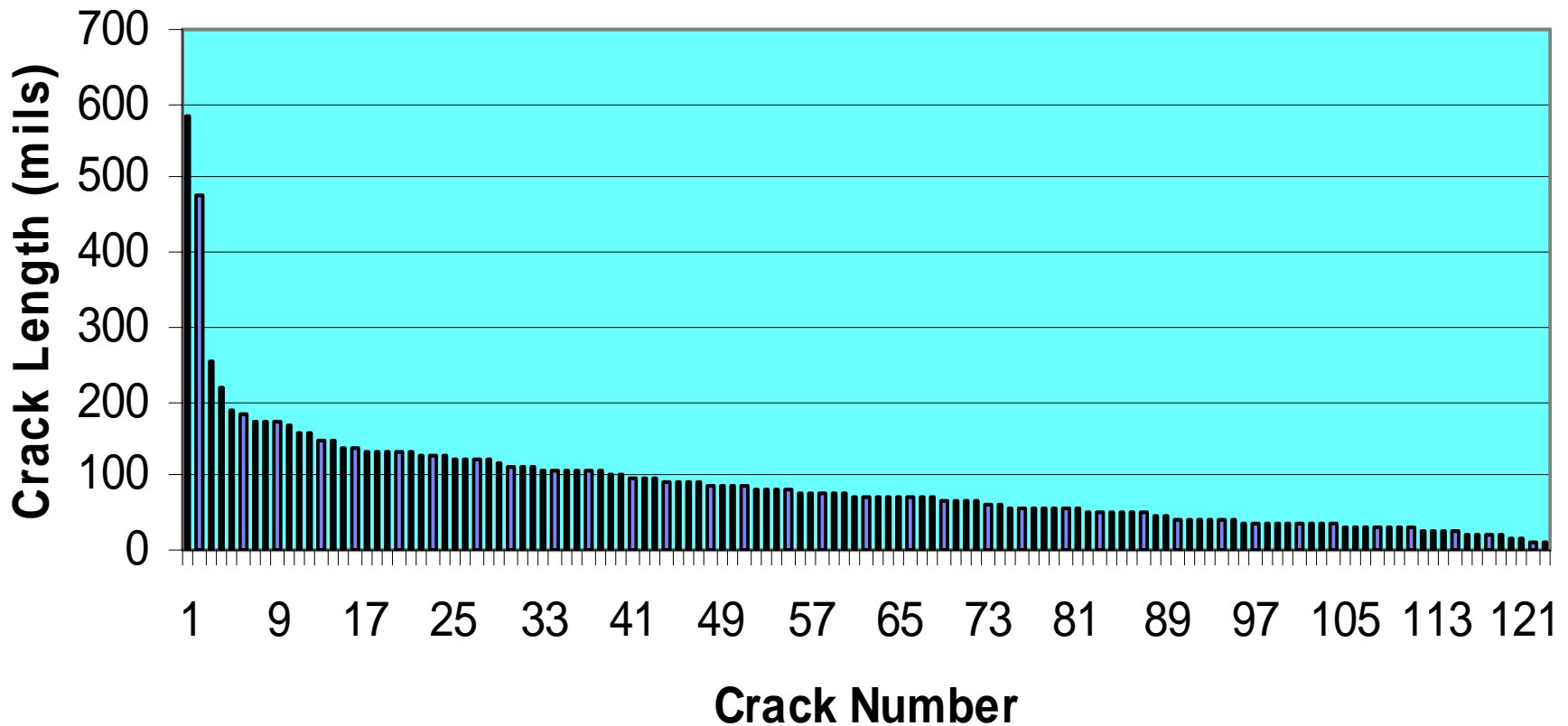
Usefulness of Panel Sets

- Full association of length and location in the "demonstration" panels
- "Blind" nature of full panel sets will be protected (i.e. no direct association of lengths and locations)
- Statistical feedback can be provided for subsets to allow comparison to model predictions
  - (e.g. the average signal strength and variation for flaws between 60 and 80 mils in length)