

# AFCS

## Automatic Flaw Classification Software

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With ever increasing amounts of NDE data there is a need to automate some of the analysis functions to assist the evaluator identify the defects

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## Automatic Flaw Classification Software

### Acknowledgements:

- Paul Kulowitch at NAVAIR
  - For providing specimens and truth data for some of this research
- NDT Solutions, Inc.
  - for funding this research and development
- John Aldrin – Computational Tools
  - For the initial development of an Automated Data Analysis Tool (ADA)
- AFRL/MLLP – Initial funding for ADA development
- David Judd – Ultrasonic Level III Consultant
  - For assistance with flaw evaluation and A-scan analysis

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## Automatic Flaw Classification Software

### Design Goals

- Image Analysis Tool
- Assist the evaluator not replace
- Provide Near Real-time feedback during inspection
- Categorized Findings
- Simplify Field Results
- Graphical User Interface
- Help develop inspection procedures
- Modular Design
- Inspection Procedure Driven
- Multi Detection Types
- User Adjustments
  - Detection Parameters
  - Regions of Interest
  - Thresholds
  - Defect Sizes

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## Automatic Flaw Classification Software

AFCS is not designed to replace the NDT/NDI evaluator it is designed to help sort, size and prioritize defects/indications

### Premise:

The laws of physics still apply.

The indication or flaw must be in the data.

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## Automatic Flaw Classification Software

Design Goal is to increase data analysis throughput.

### Prior to Phased Array Data Acquisition

- *50% Data Acquisition & 50% Analysis time (Observation)*

### Phased Array Full Waveform Data Acquisition *(high speed scanning)*

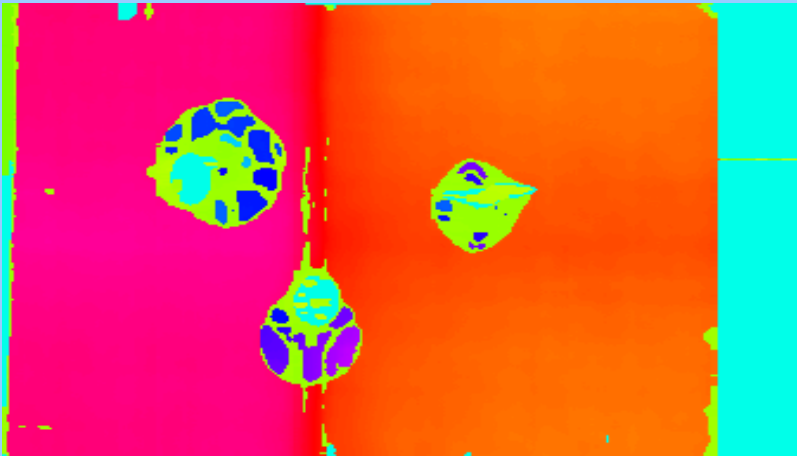
- *Data Acquisition time reduced by 75% (Observation)*
  - Analysis time remained approximately the same
- *AFCS is designed to help reduce the analysis/evaluation time to equal the acquisition time.*

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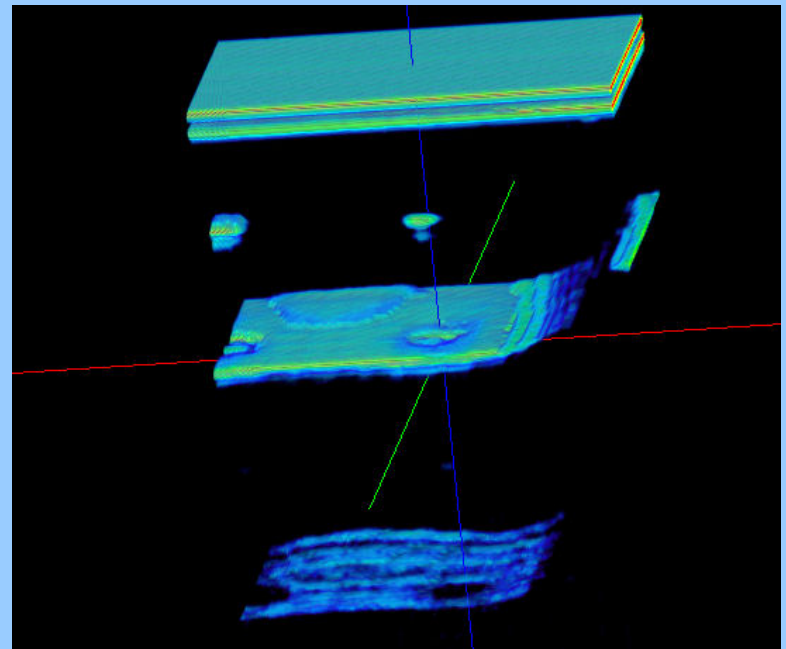
## Automatic Flaw Classification Software

### Versatile Analysis Tool

- 2 Dimensional Format
- 3 Dimensional Format
- C-scan data
- Full waveform data



AFCS is designed to work with a variety of data formats



# AFCS

## Assists the Inspector/Evaluator

AFCS offers the end user many benefits:

- *Automatic Field Level Data Quality Check*
- *Provides Near Real-Time Feedback*
- *Reports Anomalies for Further Analysis*
- *Quickly Provides Inspection Analysis Results*
- *Potentially Reducing Human Factors*

# AFCS

## Provides a Flexible Analysis Platform

- The detection parameters can be tailored to individual inspection procedures
- Sensitivity adjustments can be user defined
- Adjustable for part geometry
- Adjustable according to inspection type
- Region of Interest Adjustments

Spatial distances between geometry & indication

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## Automatic Flaw Classification Software

Designed to Evaluate Various Ultrasonic Inspection Data

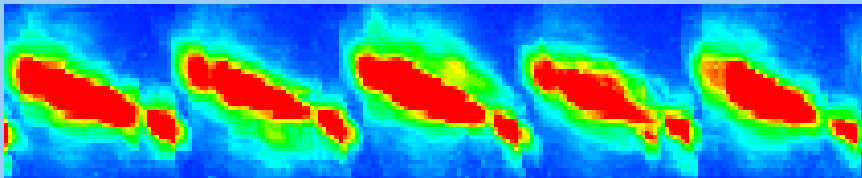
- **Longitudinal**
  - Composite Inspection
  - Corrosion Inspection
  - Delaminations
  - Thickness Profiling
  - Bonding
- **Shear wave**
  - Crack Detection
  - Fastener Holes
  - Weld inspection

# AFCS

## Geometric Transformations/Corrections for Shear and Skew Angles

### Before Transformation

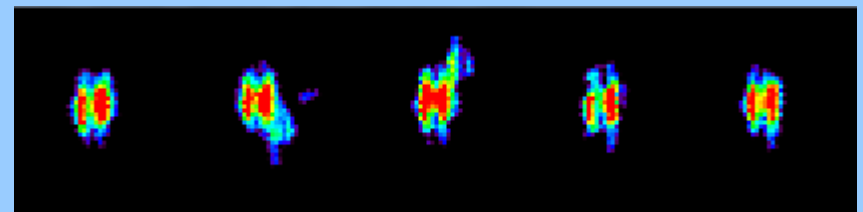
C-scan image of an angle  
beam inspection of a splice  
joint fastener row



Amplitude C-scan Image  
45° Shear – 30° Skew

### After Transformation

Corrected C-scan splice joint  
fastener row

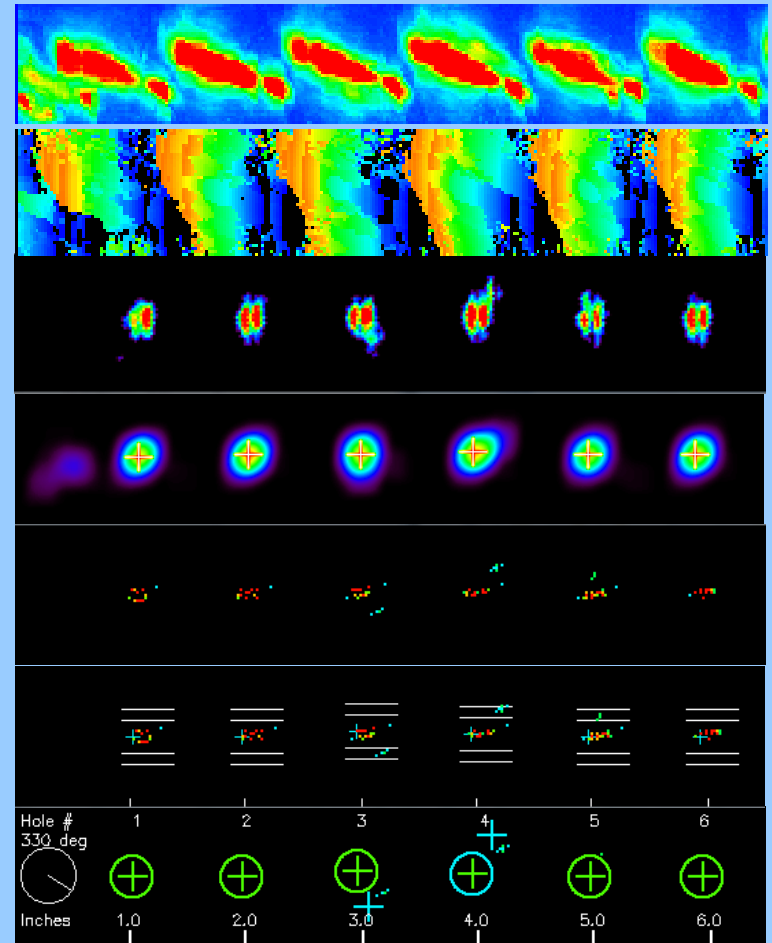


Amplitude Slice @ 0.180" depth

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## Example of fastener crack detection process

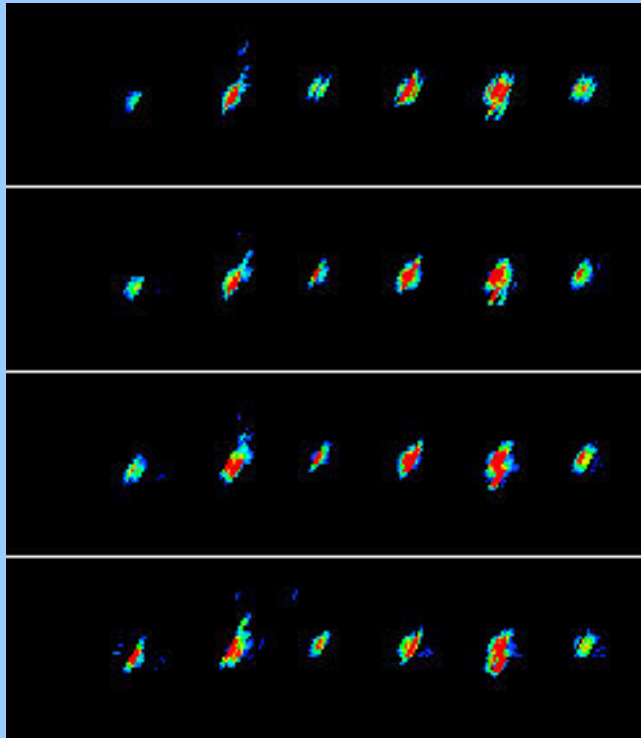
- Transform the shear wave data in proper x-y-z coordinates
- Locate fastener holes
- Search for indications
- Classify indications by size, location and signal strength
- Compare results against truth tables
- Output Results Map



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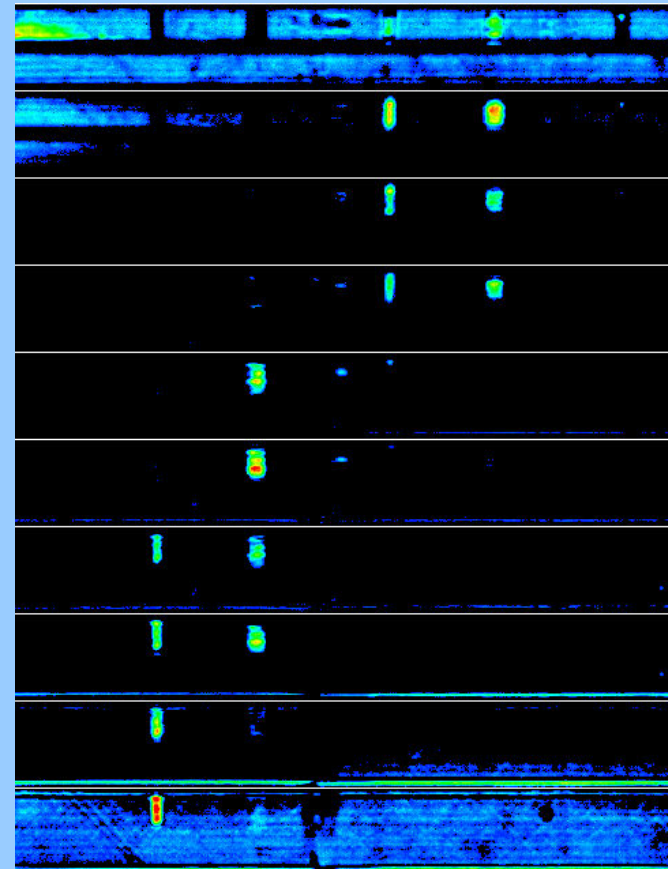
## Data Depth Slice Presentations

### Splice Joint Fastener Row



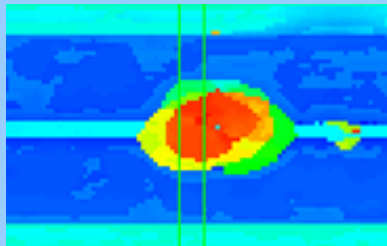
Data can be sliced at variable user defined depth increments

### Composite Layers

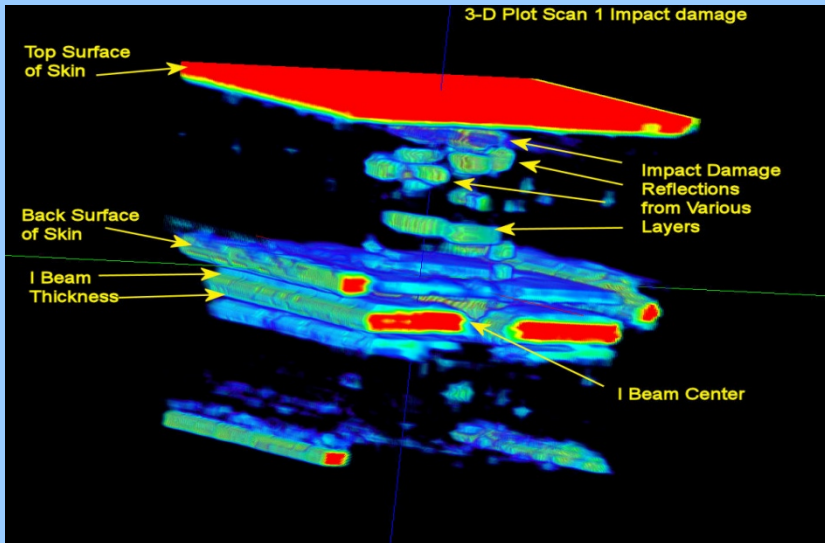
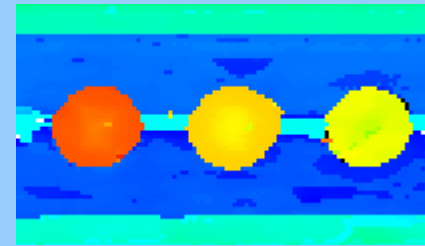


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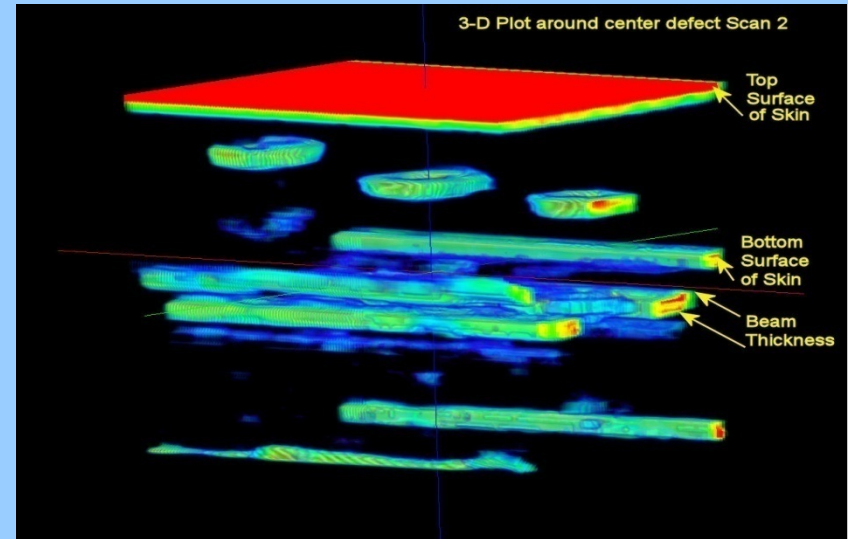
## True 3-D Volume Rendering from Full Waveform Data



2-D C-scan Images



3-D rendering of CFC impact damage

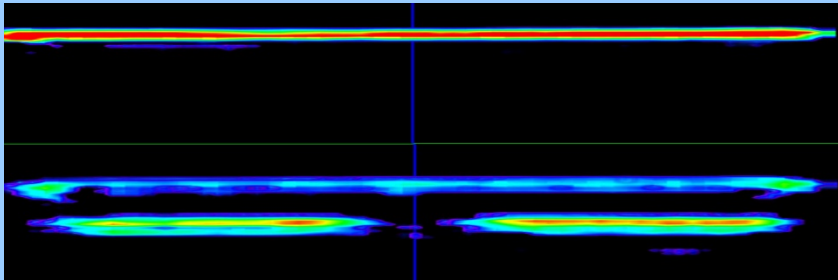


3-D rendering of CFC multi-layer defects

Example of 3-D image of Composite Defect Areas

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## 3-D Volume Rendering Example Side view of a Composite Stiffener



3-D Composite Stiffener side profile

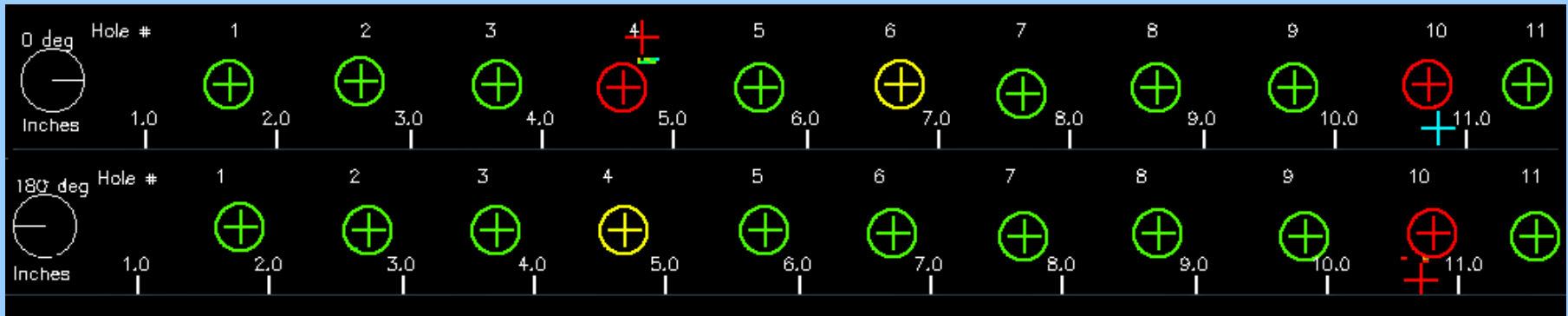


Picture of Stiffener side profile

Note: Bond line between skin and stiffener beam can displayed and analyzed

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## Automatic Hole Locator with Crack and Hole Quality Identification on Fastener Rows



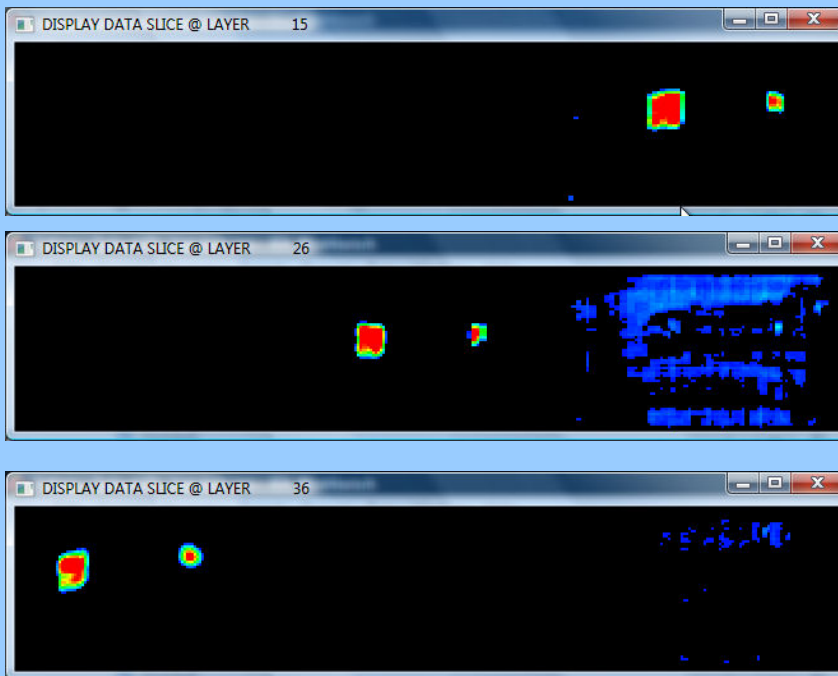
Two output images showing 0 and 180 degree skews  
of the same fastener row

AFCS can automatically detect fastener hole centers and also provide the operator with signal quality feedback all in one simple operation

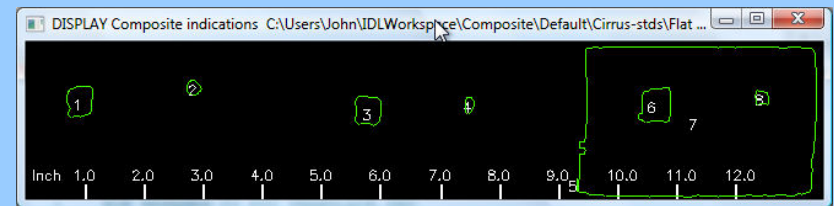
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## Automatically Identifies Composite Indications

### Depth Slices



### Results



Defects/Indications are identified by number and reported on a spreadsheet

C:\Standards\Flat Standard before midcmp.txt  
JR Mandeville NDI Consulting Services 2008 (c)  
AFCS Output Flawinspectra Data - COMPOSITE DATA INDICATION REPORT  
Wed Sep 24 15:32:47 2008

INDICATIONS Sorted by DECENDING AREA SIZE

Ind #	Layer #	X Center	Y Center	Pixel Area Sq-in	Rectangular Area Sq-in
1	22	11.292	1.270	9.982	9.878
2	15	10.572	1.540	0.306	0.300
3	36	0.902	1.602	0.225	0.223
4	26	5.755	1.446	0.213	0.221
5	36	2.822	1.835	0.058	0.062
6	15	12.378	1.669	0.054	0.063
7	26	7.459	1.536	0.038	0.051
8	23	9.271	0.227	0.005	0.015

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Provides Statistics on Regions of Interest

## Composite Data

- Indication/Defect Depth (ply layer)
- Indication Location
- Indication Size (area)

## Crack Detection Data

- Hole Location
- Crack Location
- Indication Classifications (Weak, Soft, Hard)
- Hole Data Quality

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## Surface Following Features

- Eliminate Variable Water Path Delays
- Front Surface Detection
- Back Surface Detection
- Variable Thickness Parts
- Tapers and Steps

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## Variable Modes Of Operation

### Operator/Field Mode

- Automatically Analyzes data minimal operator intervention
- Provides instant feedback on data quality and indication results
- One Click Analysis
- Field Report Generation
- Procedure Driven

### Reviewer/Engineering Mode

- In depth Review of Data
- Can adjust detection parameters and rerun acquired field data
- 3-D review of A-Scan data
- Review Cross Sectional data planes Visualizations
- Detailed Report Generation

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## Splice Test Panel Results

### Four EDM Notched Panels Inspected

45° Degree Shear wave with Four Skew Angles

Inspected 358 holes

68 Notches .035" to .210" in size

1<sup>st</sup> and 2<sup>nd</sup> layers

Various notch angles, 12:00, 1:30, 4:30, 6:00, 7:30 & 10:30

Some notches are not detectible due to:

- layer bonding
- notches filled with sealant

### **Results:**

Detected 100% visible (in the data) notches equal to or greater than 0.100"

Detected ~50% notches under 0.100"

2 False Calls

Reviewed False calls and determined no notch in the data

# AFCS - Supported Inspection Platforms

AFCS has the capability to support various platforms and we are interested in working with you to provide a Solution for your inspection needs

## Currently Supported Inspection Systems :

- FlawInspecta ultrasonic array system
- Ultra Image Systems
- Others Platforms are being considered
- Versatile Data Import feature
- Customer Driven Design
- Data Format details are needed for importing image data

# AFCS

## Automatic Flaw Classification Software

### Potential Future Applications

- UT Weld Inspection and Classifications
- UT Corrosion Mapping
- EC Corrosion Mapping
- Digital Radiography
- Multi Method Data fusion
- Your Ideas or Projects?

# Thank you for you attention!

## Questions?

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***FlawInspecta***  
***Ultrasonic Array Technology***