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Ultrasonic Inspection:
Transducer Design for Bolt Inspection

EXTENDE CIVA
NON ■ DESTRUCTIVE ■ EVALUATION

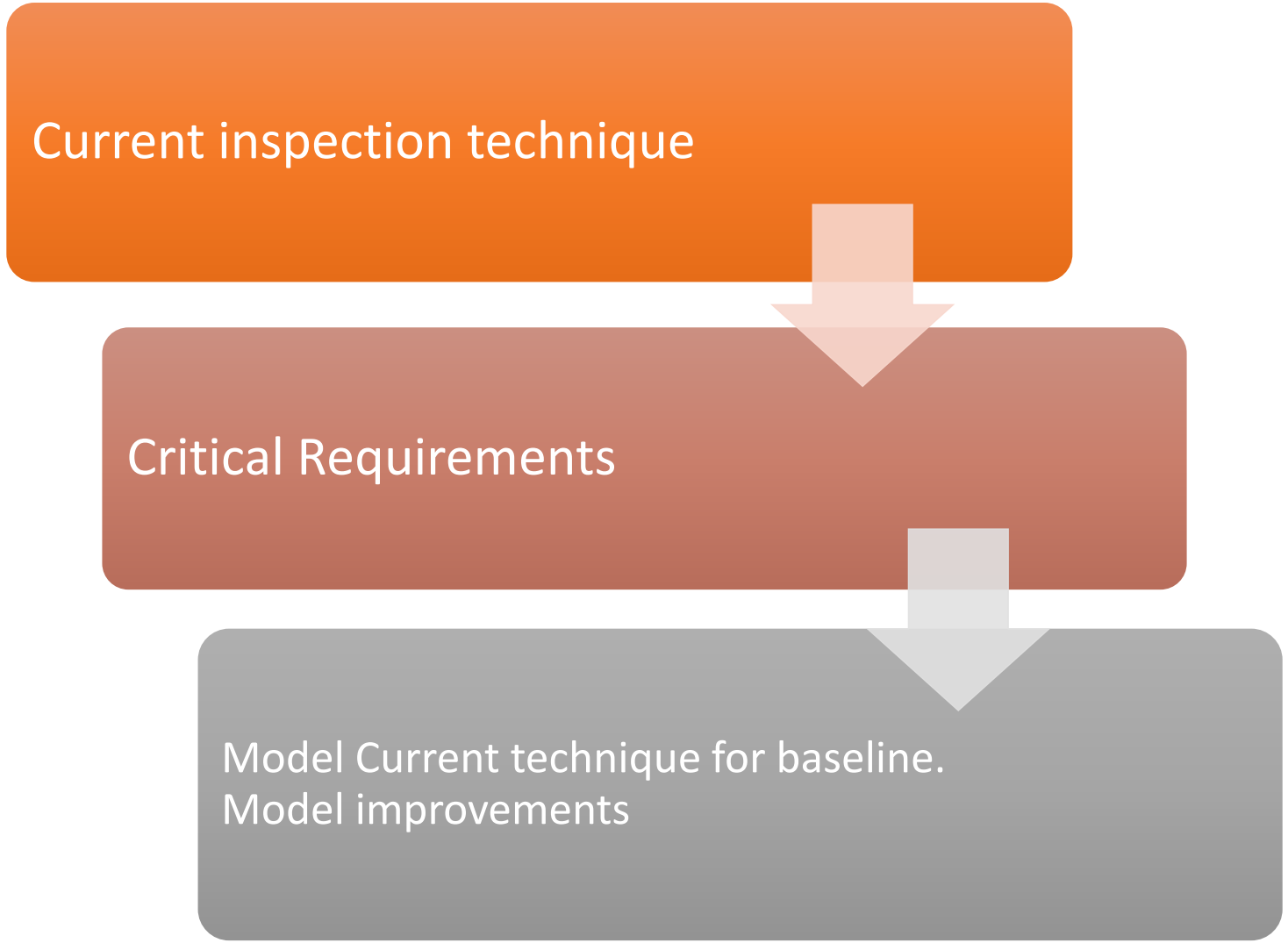
CIVA NA User Group Meeting
August 19, 2020

SENSOR® NETWORKS, INC
Inspection, Testing & Asset-Integrity Solutions

Outline

1. How to Model PAUT Applications
2. What are the Major Steps in the Process
3. How We Solved Real-World Problems
4. Conclusions

Project Overview



Why

- SAVINGS
- BETTER POD
- RELIABILITY
- CONFIDENCE
- TIME SAVINGS

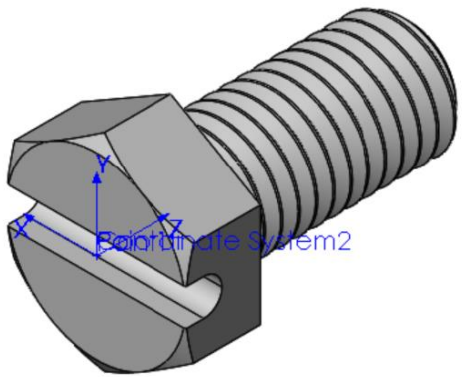
Outside Factors

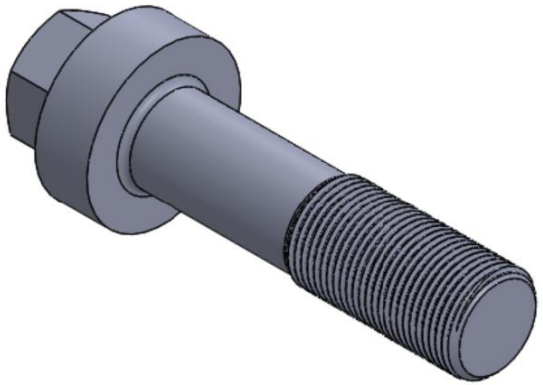
Instruments	• 16:64 / 32:128 / 64:128 • Linear / Sector / Matrix / DDF / FMC
Inspection Locations	• Flat, Curved, ID / OD • Access
Inspection Requirements	• Speed / POD / Data Storage • Cost

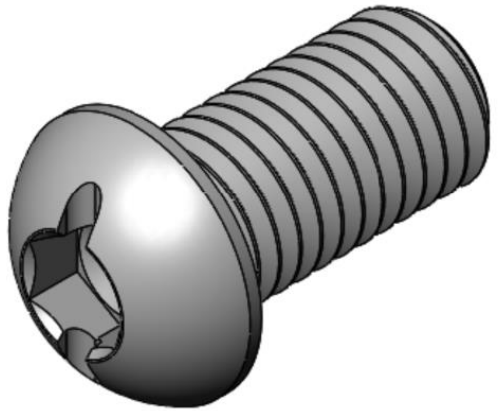
Modeling Inputs

Specimen	• Geometry • Material
Probe / Wedge	• Acoustic Performance • Style / Inspection Type
Flaws	• FBH , Notch, SDH, Multifaceted

Specimen Types



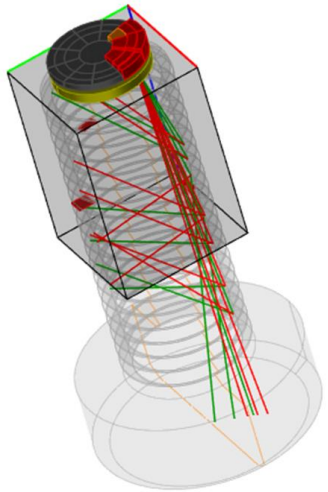


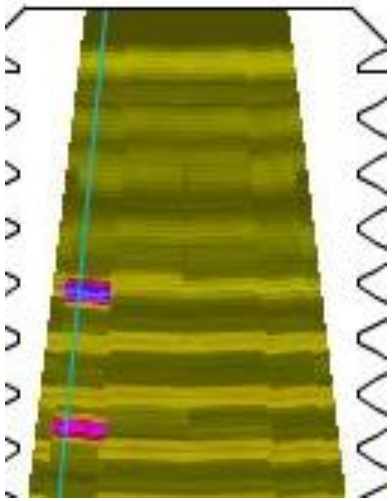


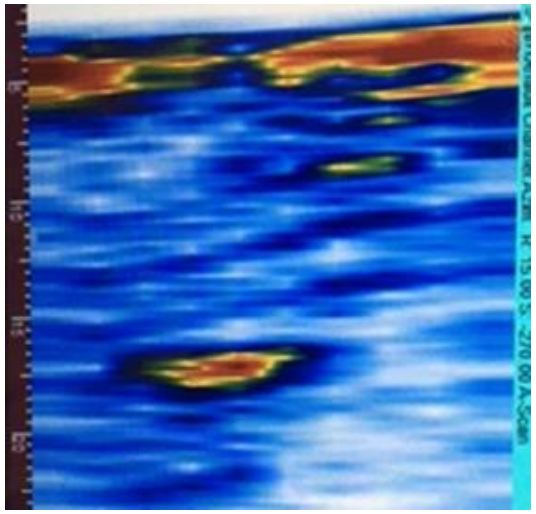
Verification

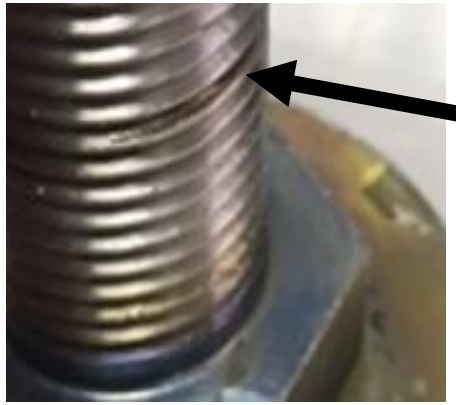
Modeled Results ≈ Empirical Results

5MHz Segmented Annular Transducer







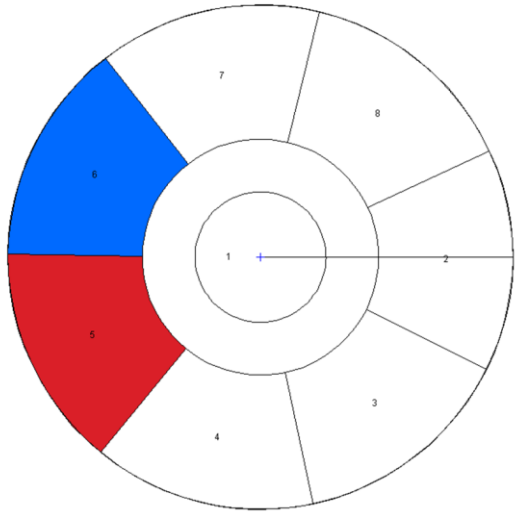


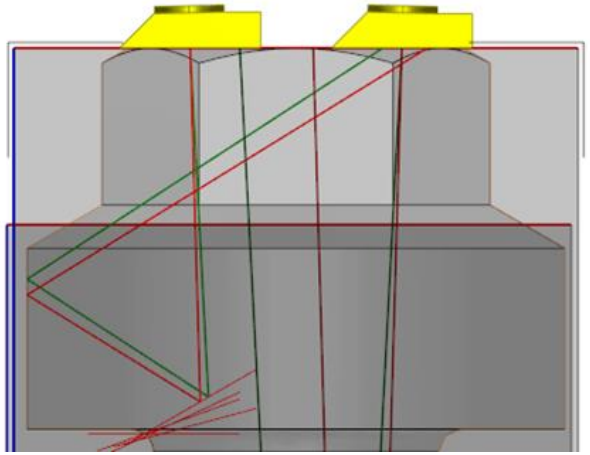
Optimization

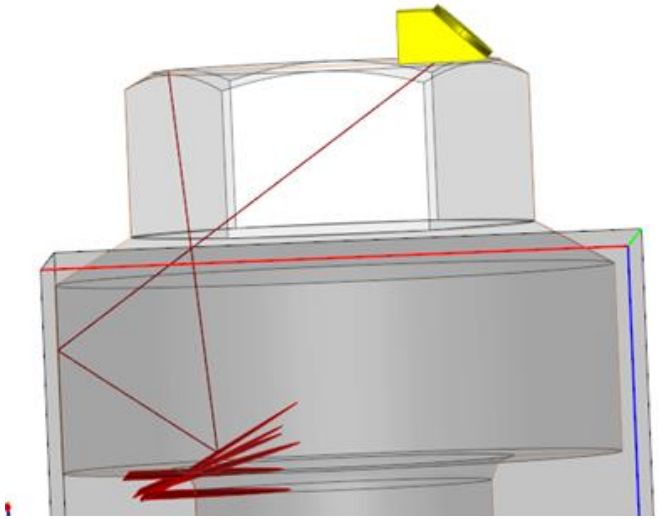
Probe

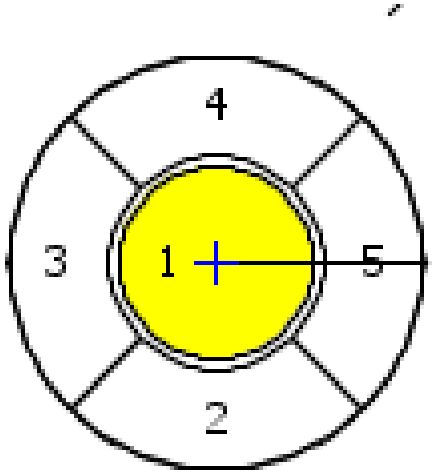
- Frequency
- Style
  - Annular
  - Matrix
  - Segmented
- Virtual Probe
- Instrument Setting
  - Angles
  - Focus

Probe Styles

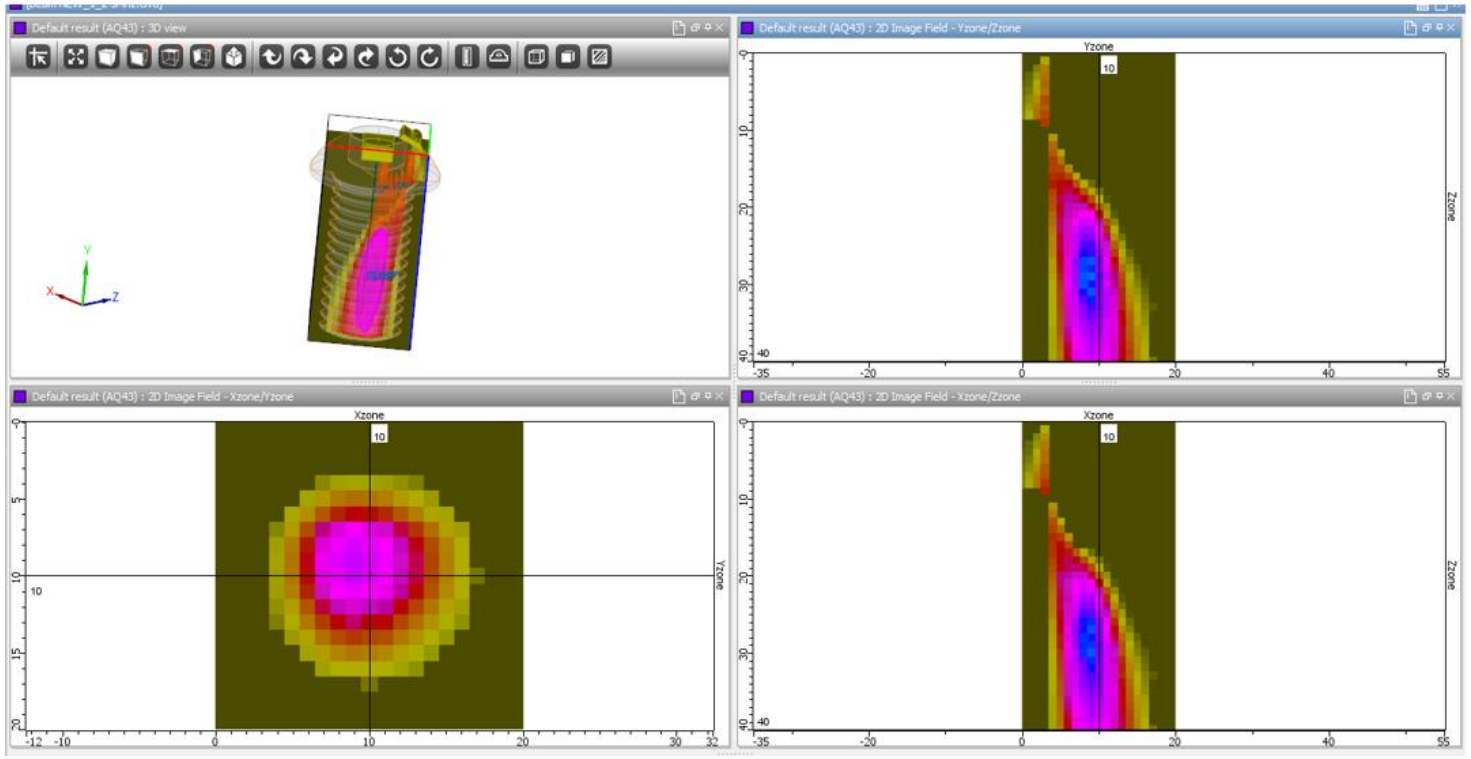






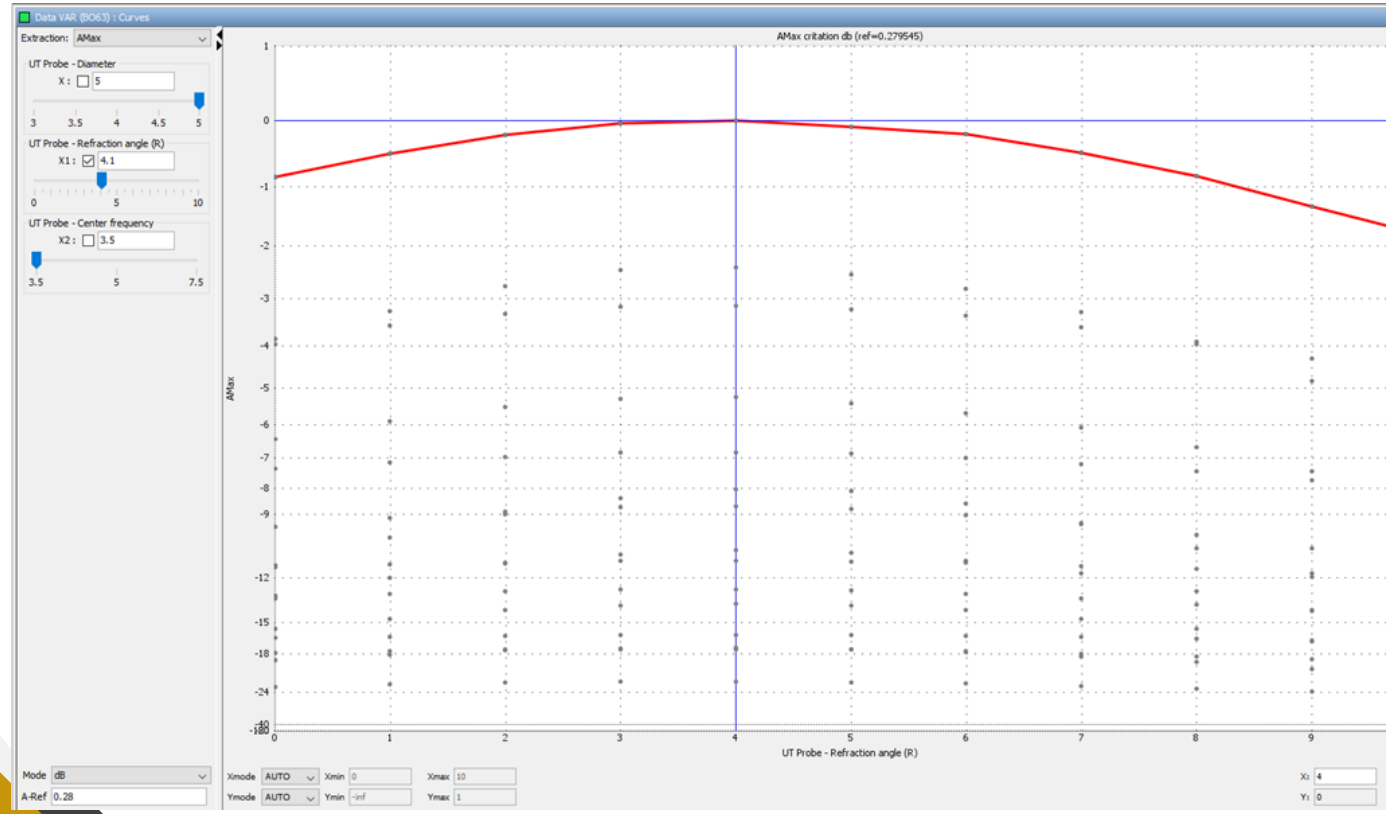


BEAM PROFILES



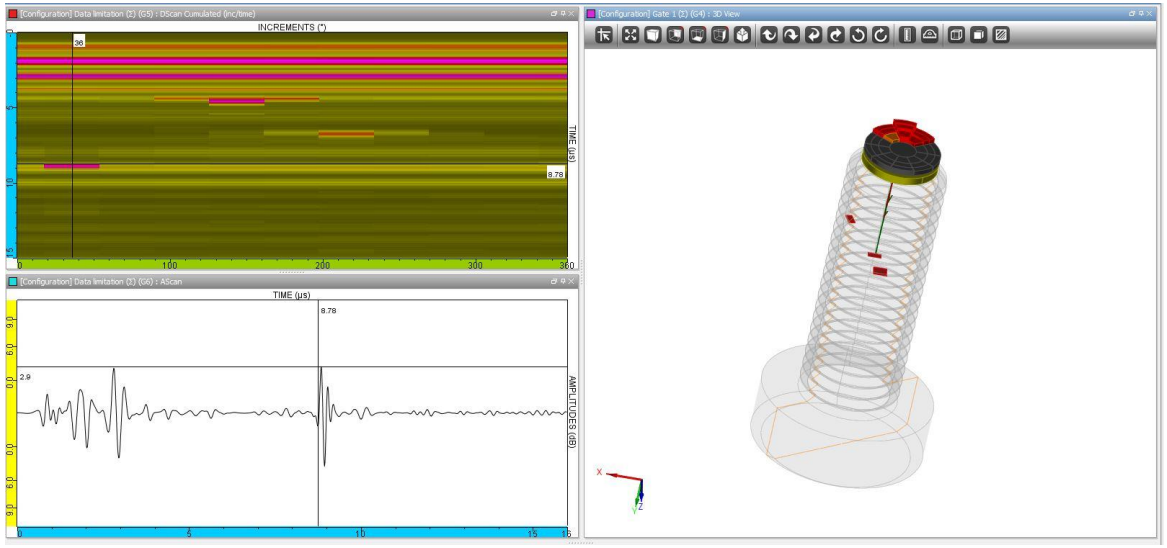
- **SOUND INTENSITY**
- **GEOMETRY RESTRICTIONS**

Optimizations – Variation Study



- **PROBE SIZE**
- **REFRACTION ANGLE**
- **FREQUENCY**

Nuclear Vessel Shroud
Support Bolts

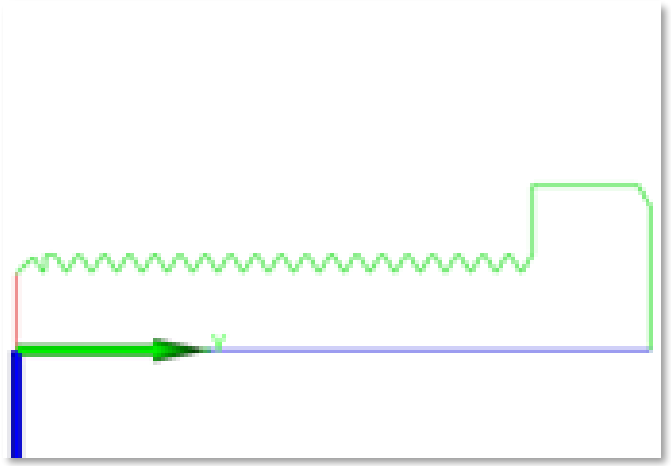


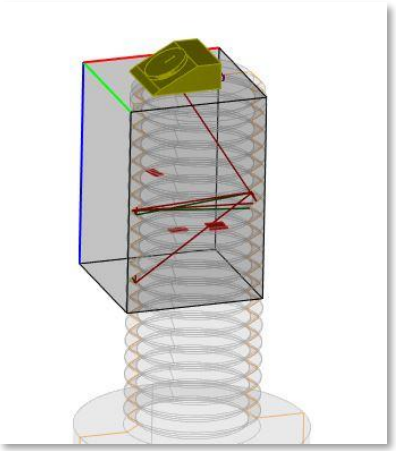
Test Requirements / Inputs

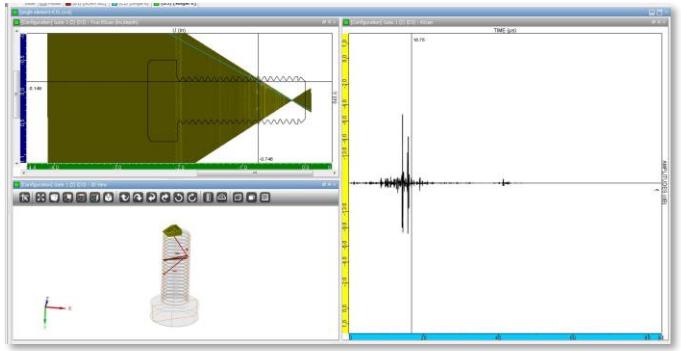
- Contact test
- Full 360 scan electronically
  – eliminate need to rotate probe
- Fixed access area- max OD of probe 0.580”
- Set location for defects
- Maximum 32 element probe
- Topaz instrument

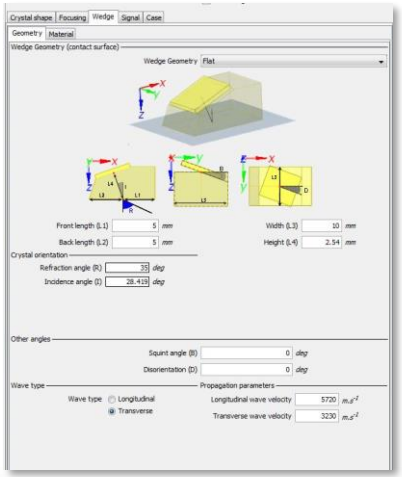
Initial Model Setup

- Input bolt geometry
- Input current probe/wedge
- Add defects to bolt
- Verify model

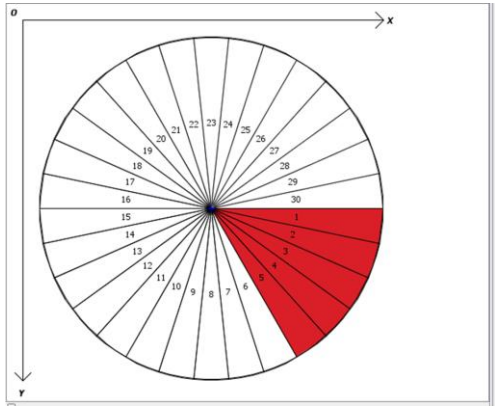






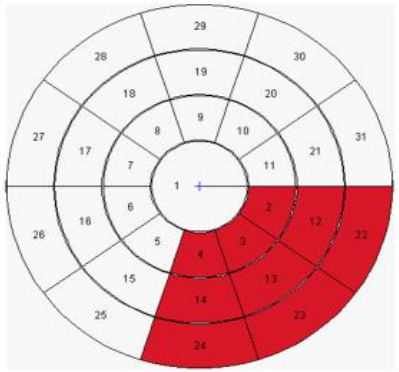


Optimization



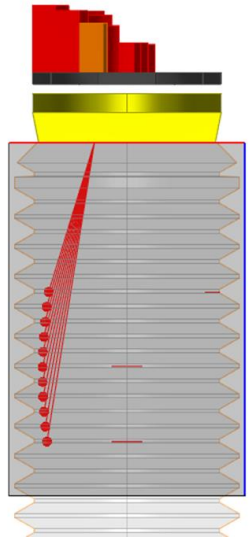
Set-up 1

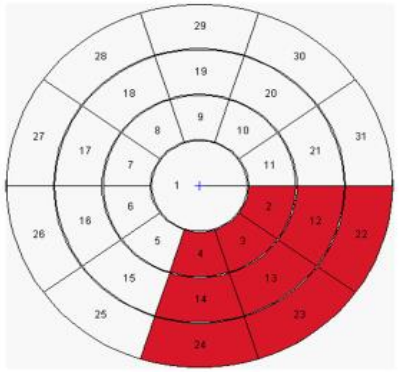
30 Elements
12.7mm Element Dia
12 Degree segments
5 element Virtual probe
1 element step
0 Delay laws



Set-up 2

31 Elements
12.7mm Element Dia
36 Degree segments
9 element Virtual probe
1 sector element step
Direction & Depth Scan
9 deg @ 25.4 to 17 degree @ 12.7





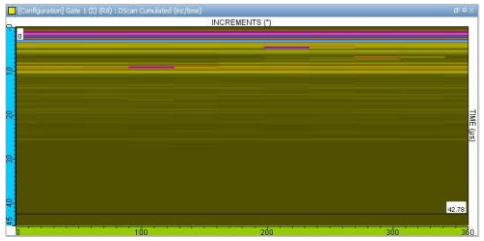
Set-up 3

31 Elements
16mm Element Dia
36 Degree segments
9 element Virtual probe
1 sector element step
Direction & Depth Scan
9 deg @ 25.4 to 17 degree @ 12.7

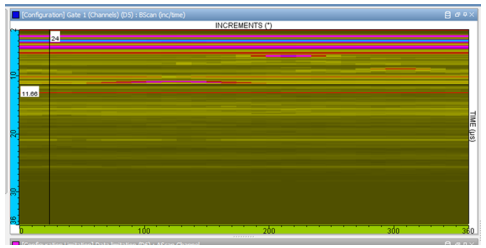
Model Results

- Larger diameter produced better response
- Delay caused noise issues (NOT SHOWN)
- Segmented outperformed annular

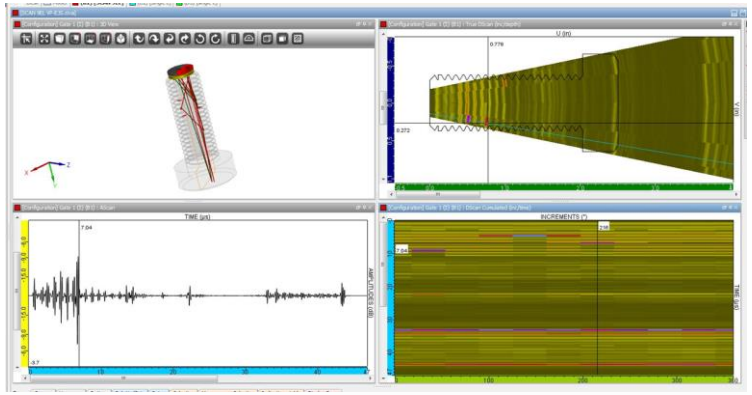
Set-up 1

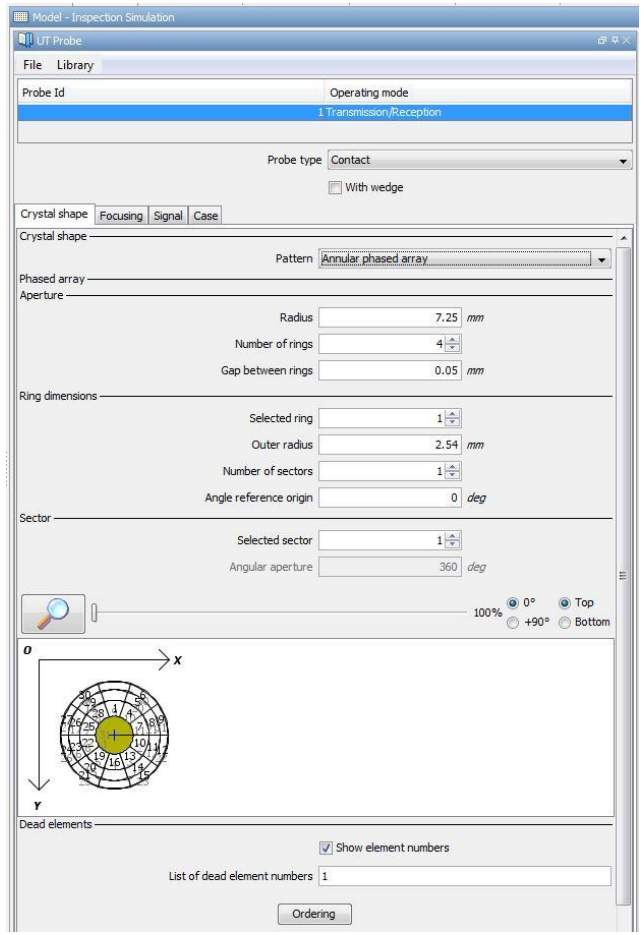


Set-up 2

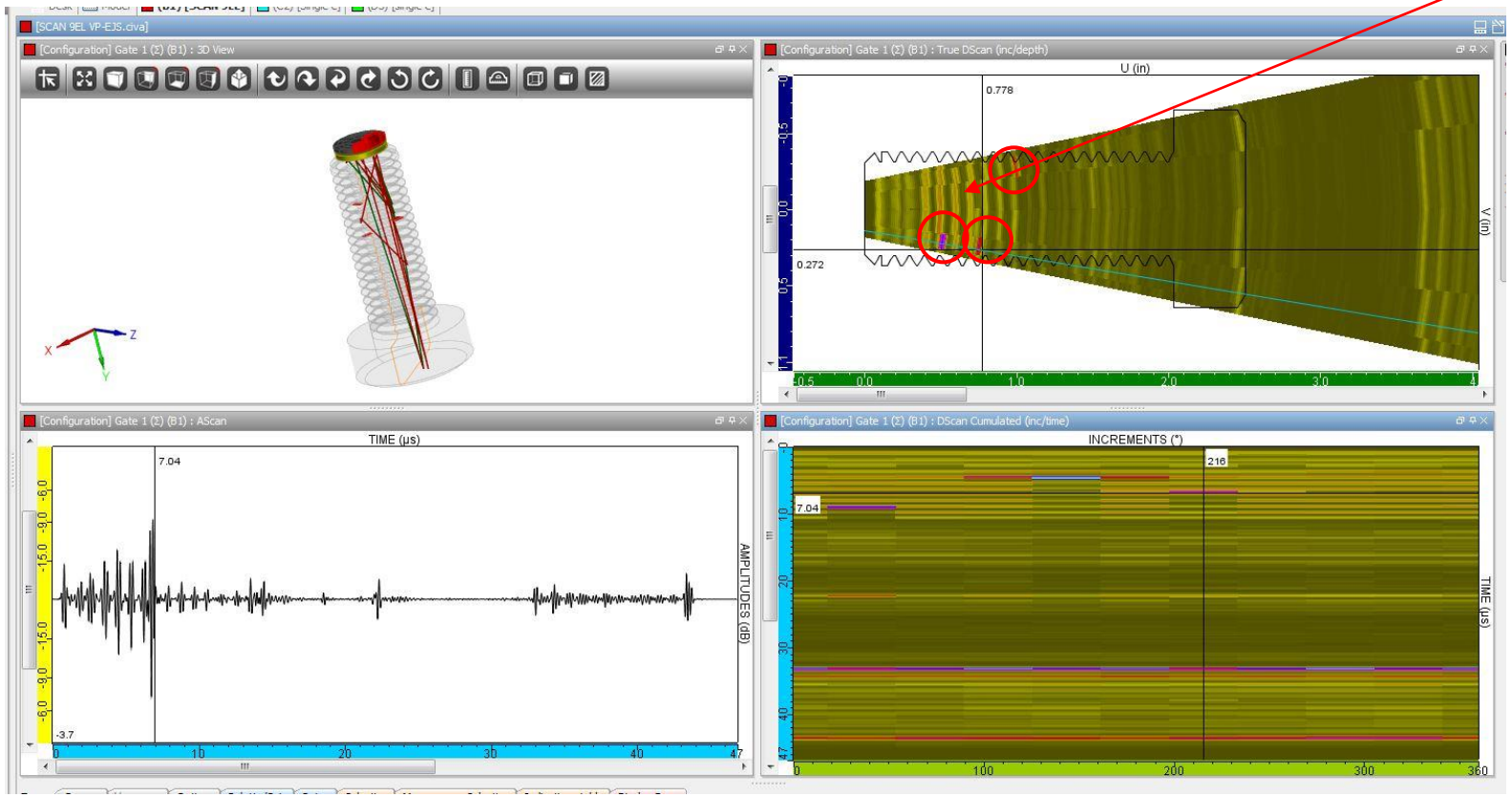


Set-up 3



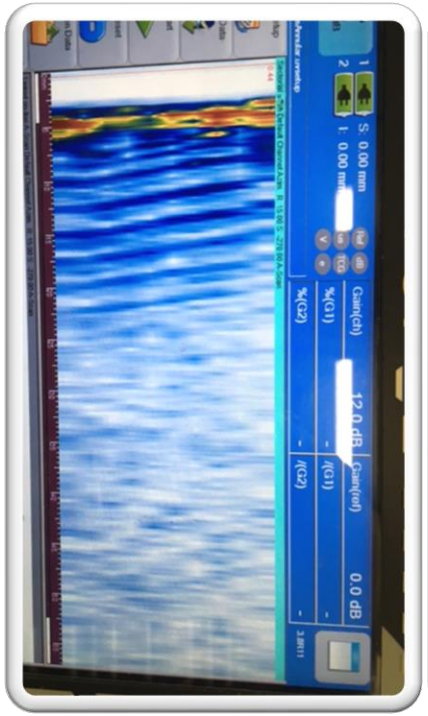


Prototype Design Build Model Results

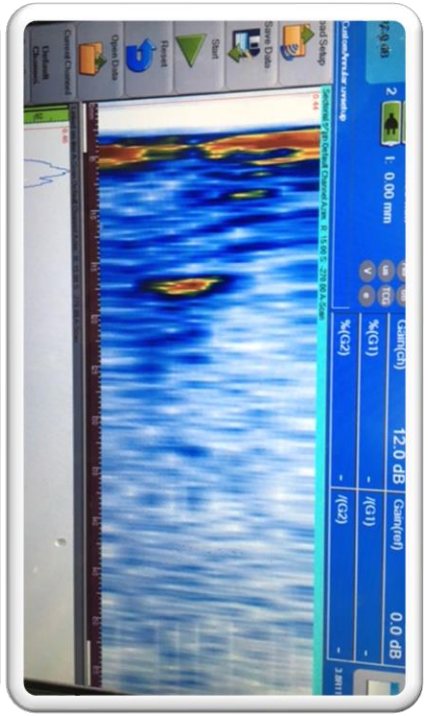


3 notches
Thread noise

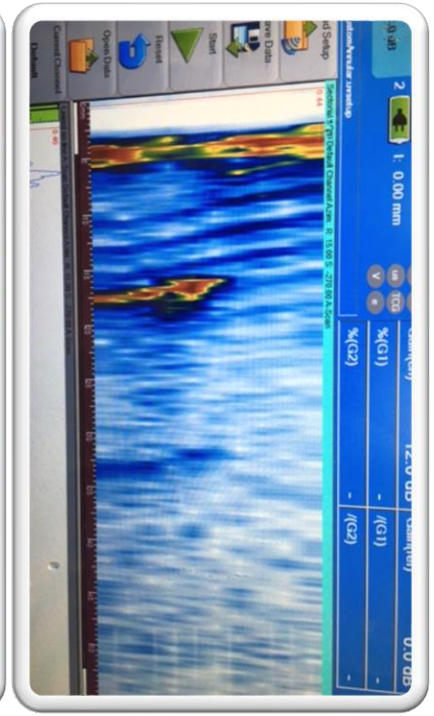
Empirical Results



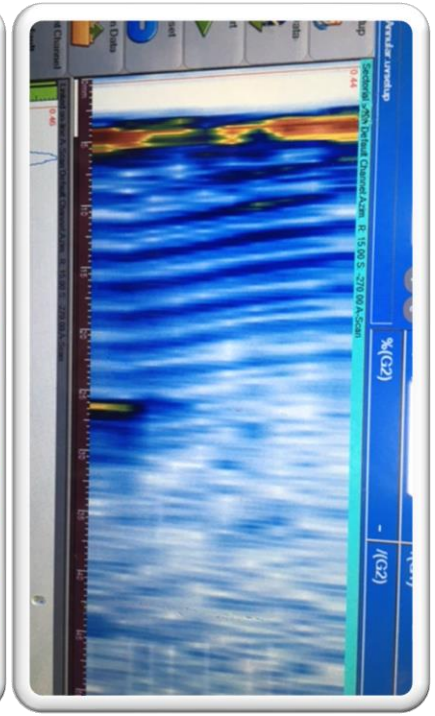
CLEAN



EDM NOTCH 1



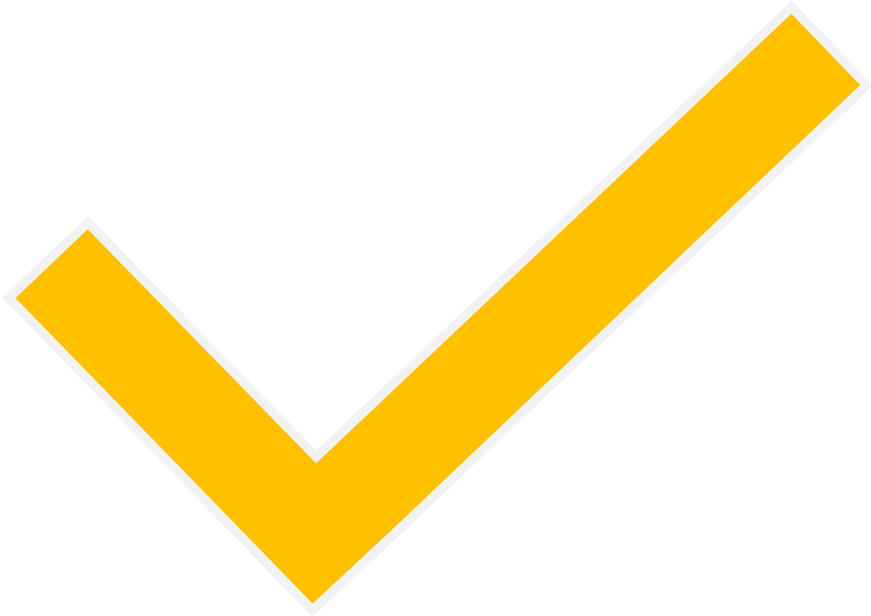
EDM NOTCH 2



EDM NOTCH 3

Project Conclusion

- **Production probes were made and used for inspection with great results**
- **New order received for production probes for other inspections**
- **New project for a smaller diameter bolt with smaller access area started and completed with customer**



Conclusions

- Modeling saves time
  - Dozens of configurations modeled in a week compared to months to build custom probes
- Modeling saves money
  - Confidence to manufacture one probe compared to multiple probes
- Modeling provides confidence
  - Provided technical validation of inspection
- Model results can only be as good as the data provided to the model