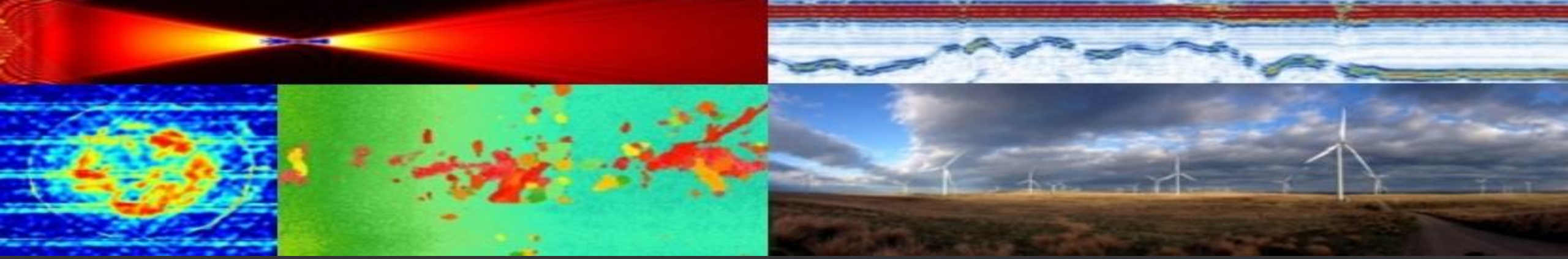


Ultrasonic Inspection
the challenges of a diverse marine sector

Richard Freemantle

Wavelength NDT Limited

www.wavelength-ndt.com

WavelengthNDT
in tune

Overview

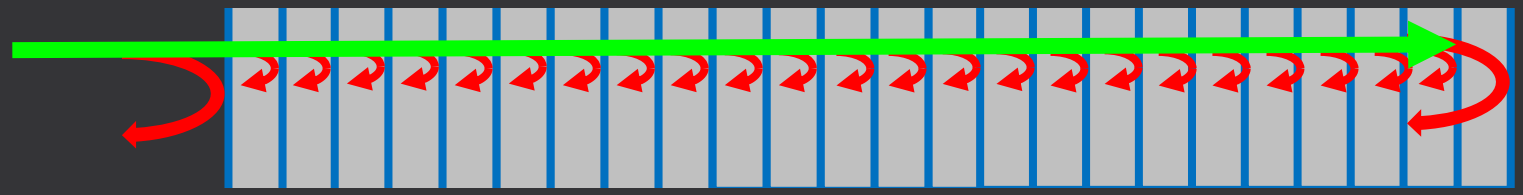
- Ultrasound and composites
- Specifications
- Stakeholders
- Need for standards
- Case studies – void detection, porosity analysis

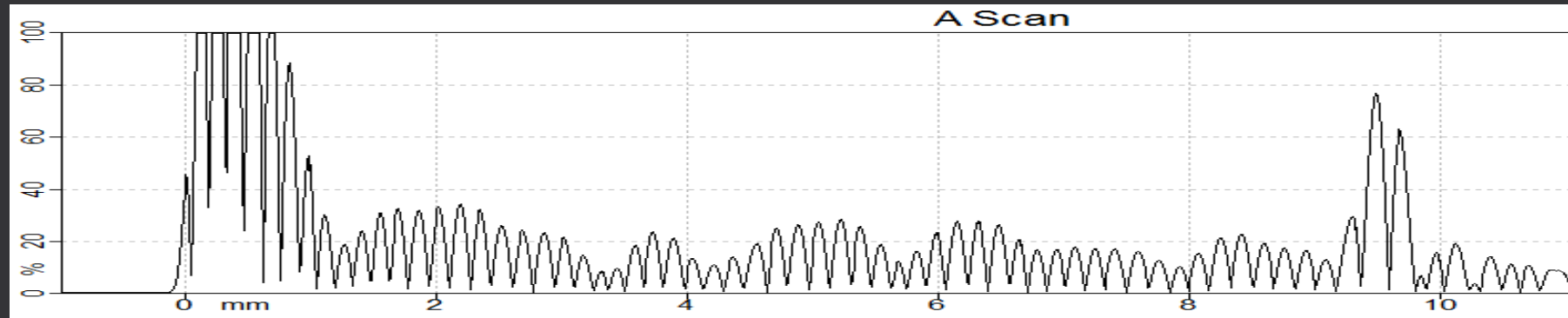
Ultrasound in medicine

- Ultrasound works well in the body for medicine because a large percentage of the body is water and surrounding tissues and organs have a similar density and sound speed
  - No multiple reverberations
  - Low attenuation
  - Single echo from each interface

Ultrasound and composites

- Ultrasound also works well in the composites because a large percentage of the laminate is resin and the composite plies and resin layers have a similar density and sound speed
  - No multiple reverberations
  - Low attenuation
  - Single echo from each interface





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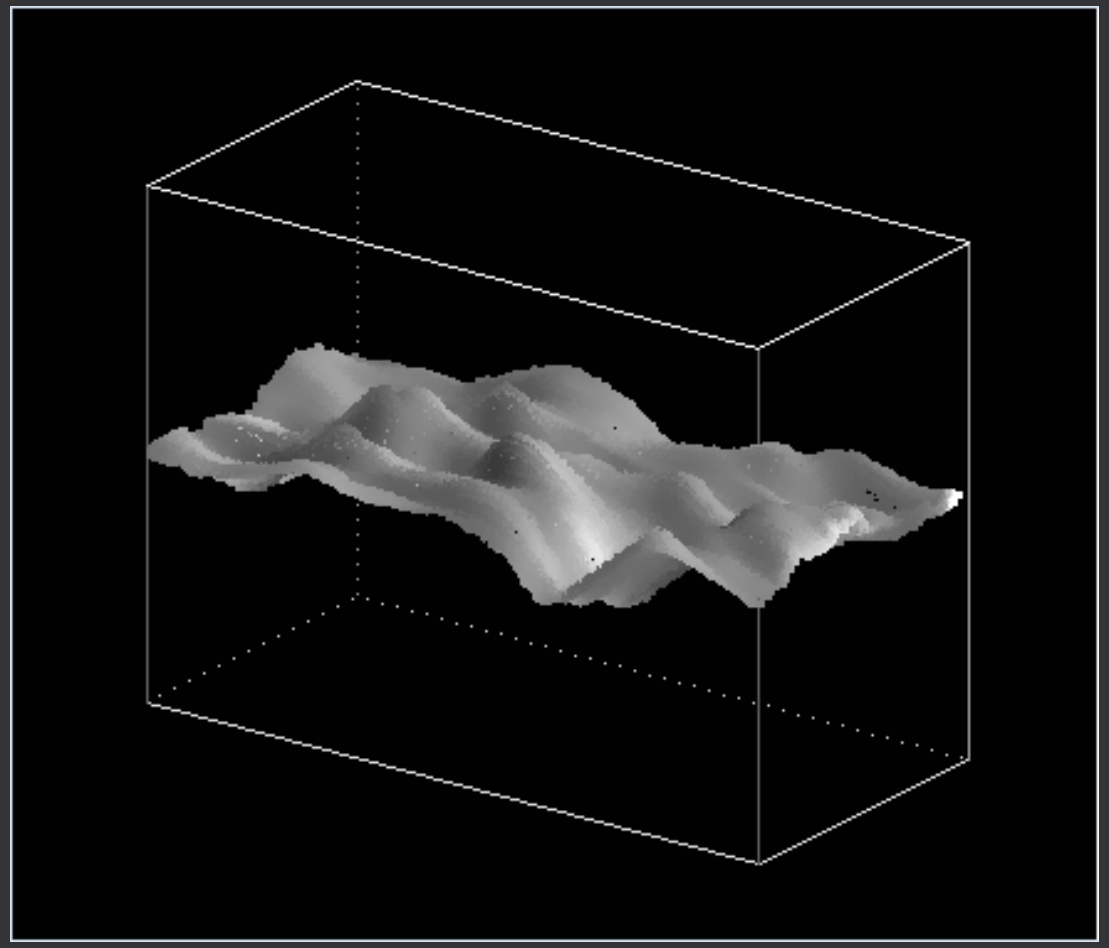
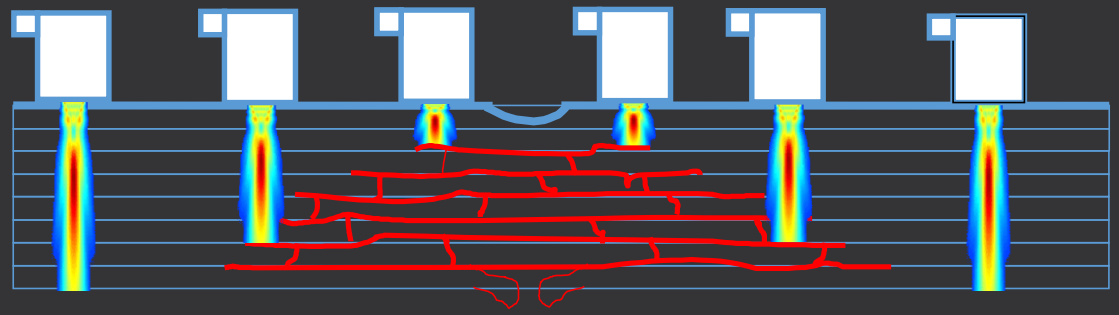
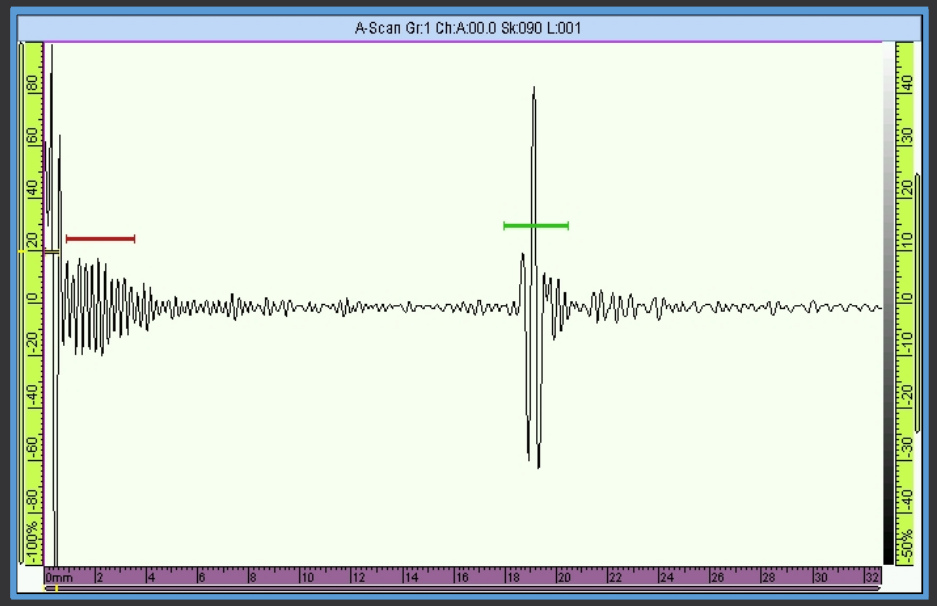
3D ultrasound imaging in composites

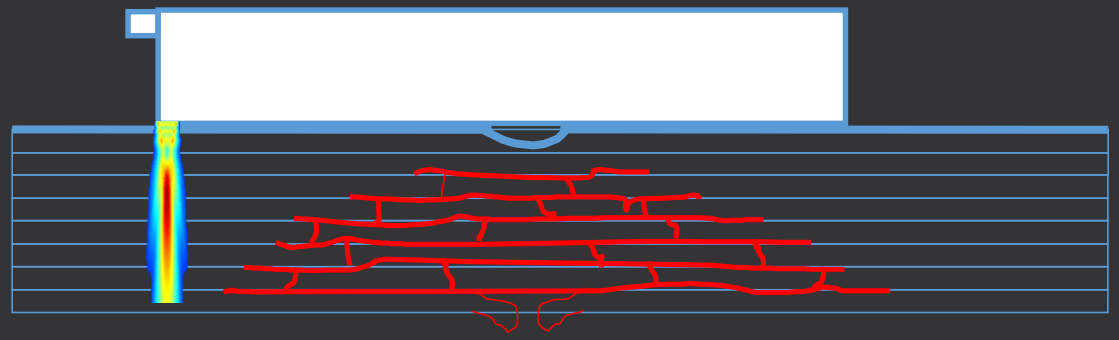


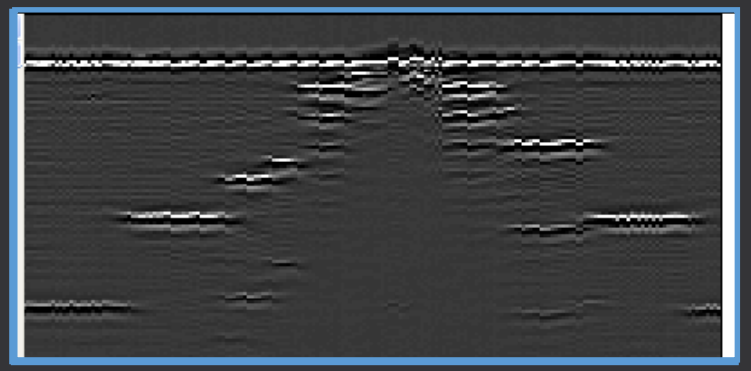
Basic: A-scan

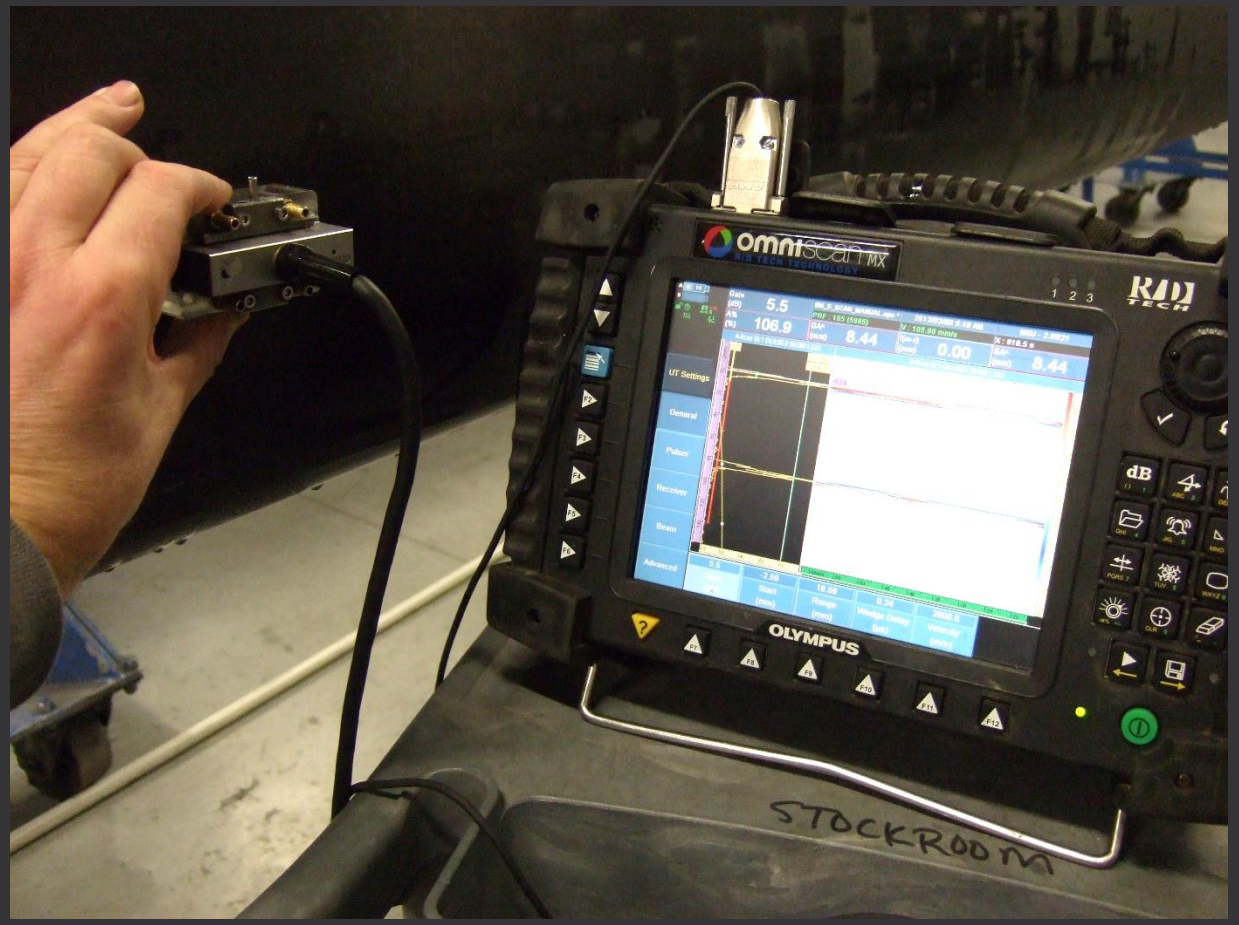




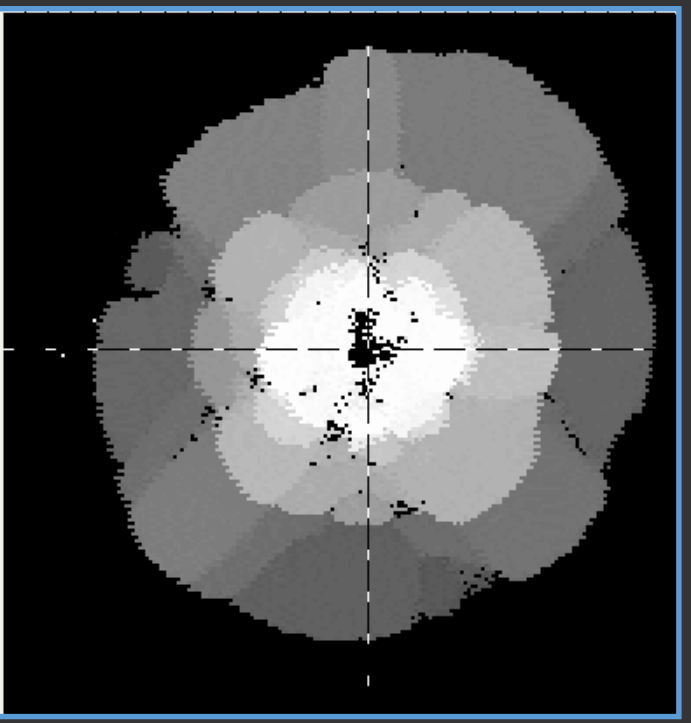
Cross section – B-scan

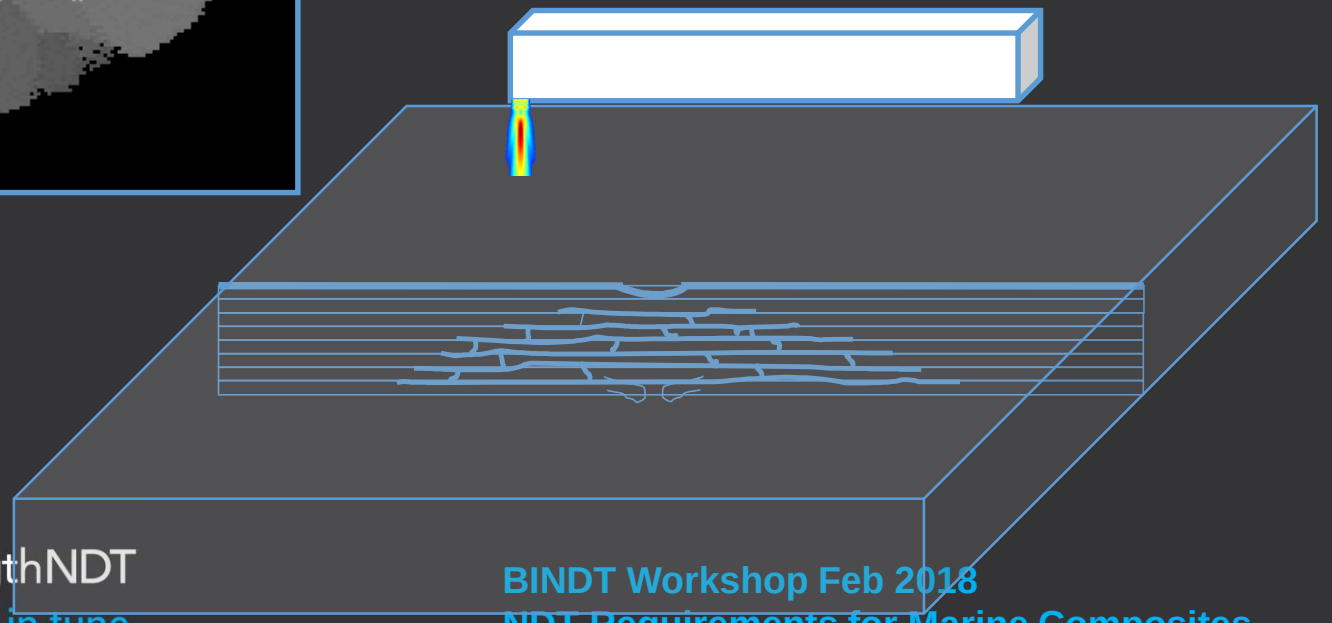




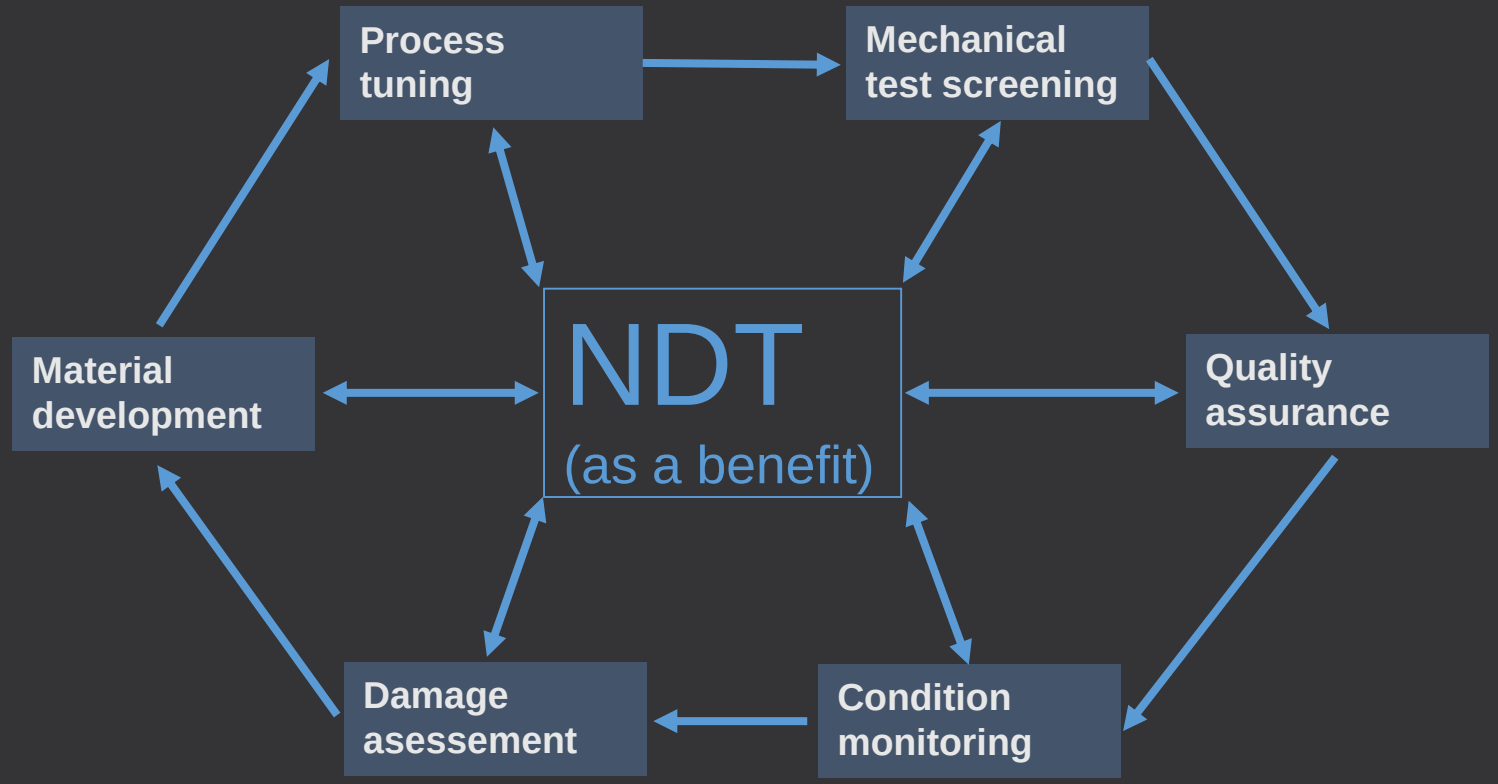


Plan view - C-scan

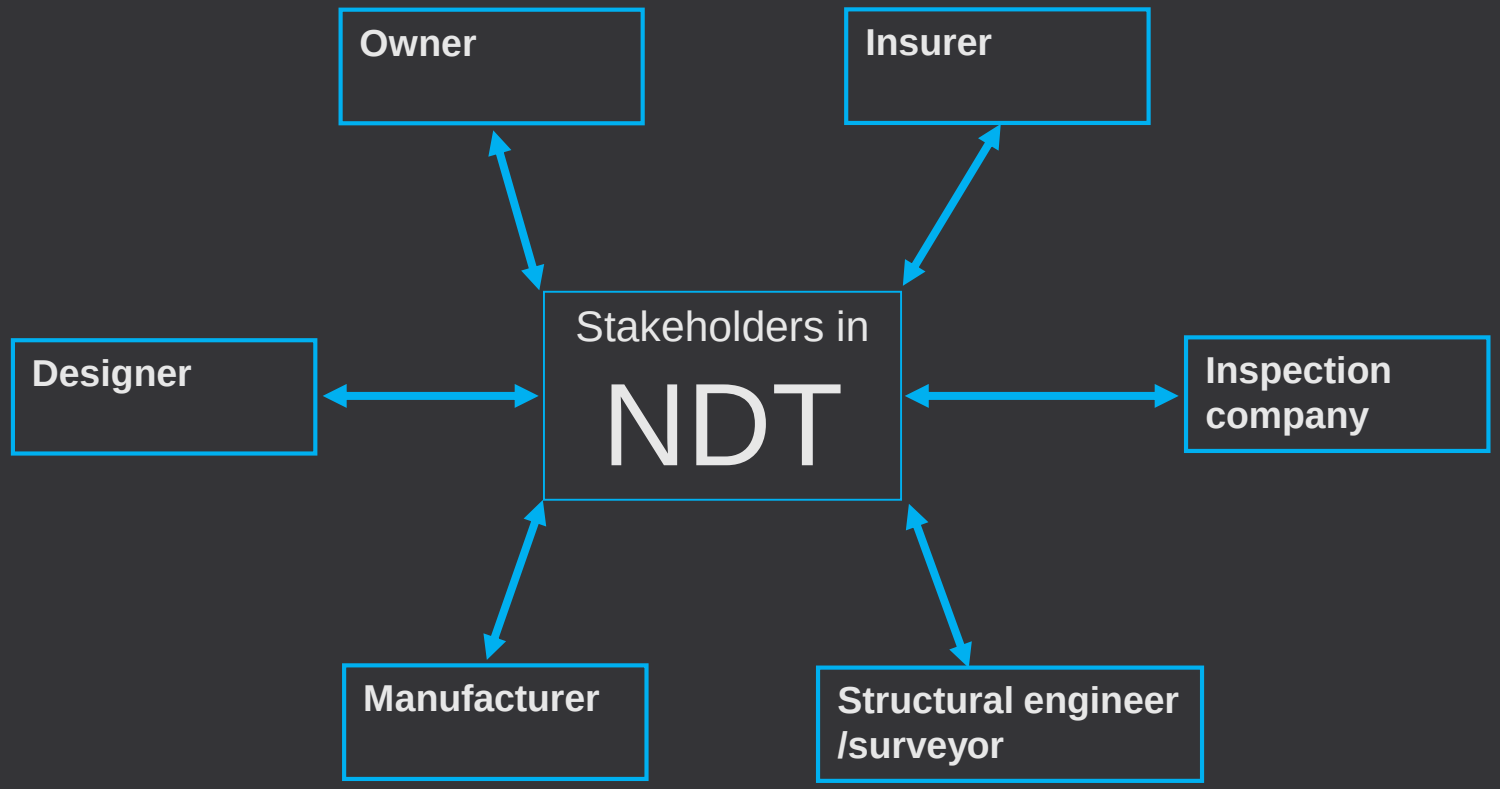




NDT in composite processes (ideal)



Diverse requirements for NDT



Maritime and Coastguard Agency

MARINE INFORMATION NOTE

MIN 417 (M)

Large Yachts: Examination and Inspection of Carbon Fibre Masts and Spars
Survey of Composite Masts and Spars Used on Large Yachts

Notice to all designers, builders, owners, masters, skippers, surveyors and Classification Societies of large sailing yachts

Areas where new guidance is needed

- Third party oversight (independent level 3)
- Inspector training (level 2, composites)
- Procedures (documented and approved)
- Techniques (documented and verified)
- Reporting (results can be traced/reproduced)
- Acting on findings (sign off by designer/OEM)

- Much of what is required exists in other industries such as Aerospace and can be adapted to the Marine Industry

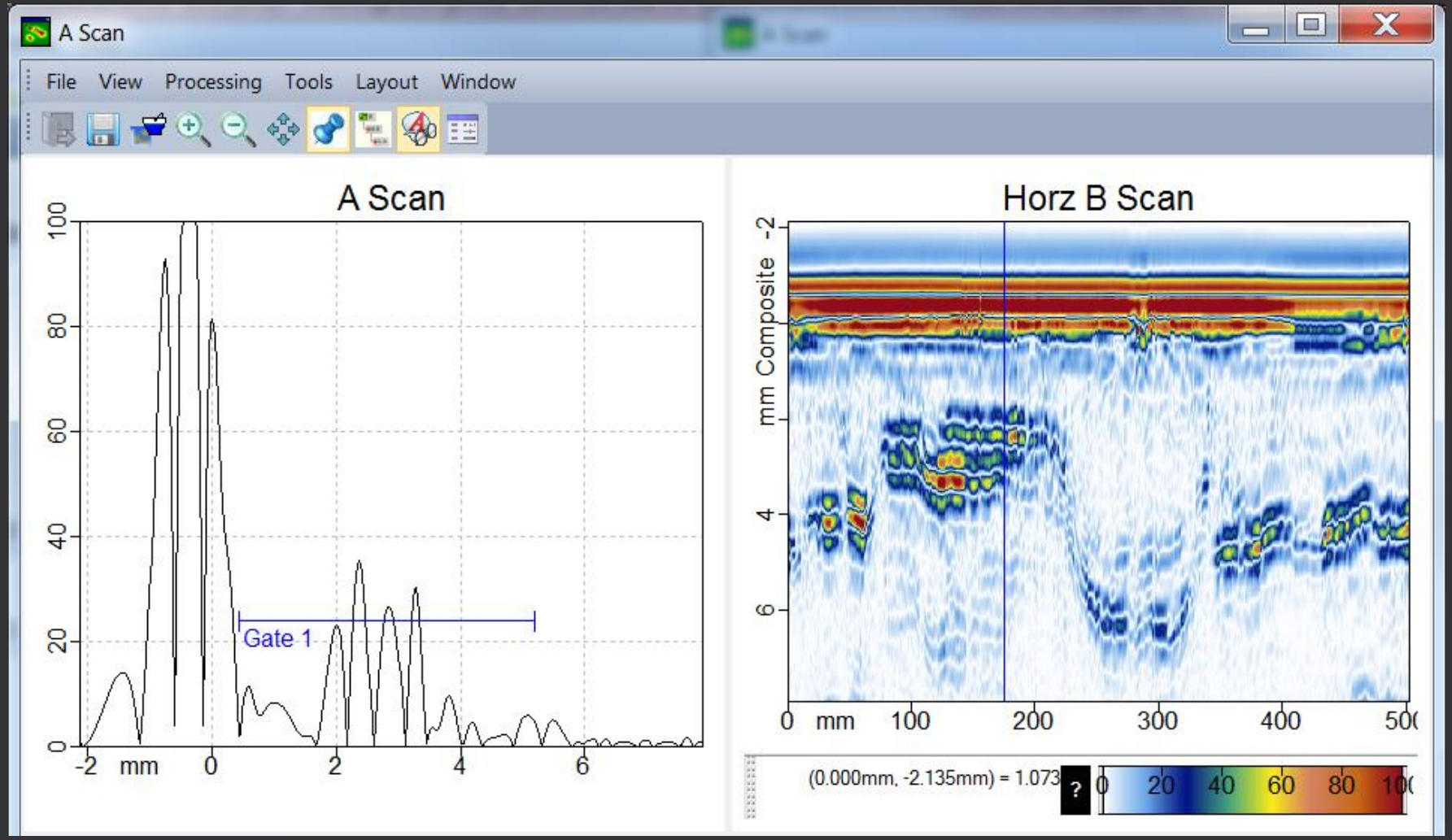
Case 1: Mast laminate inspection - voids

- **Position** of ultrasound signal ***can*** be used to find voids
  - Highest possible frequency possible should be used
  - What happens if the wrong frequency is used ?
    - Defects are missed
  - Ability to resolve thickness and sensitivity to things like voids/pores are dependant on the ultrasound wavelength

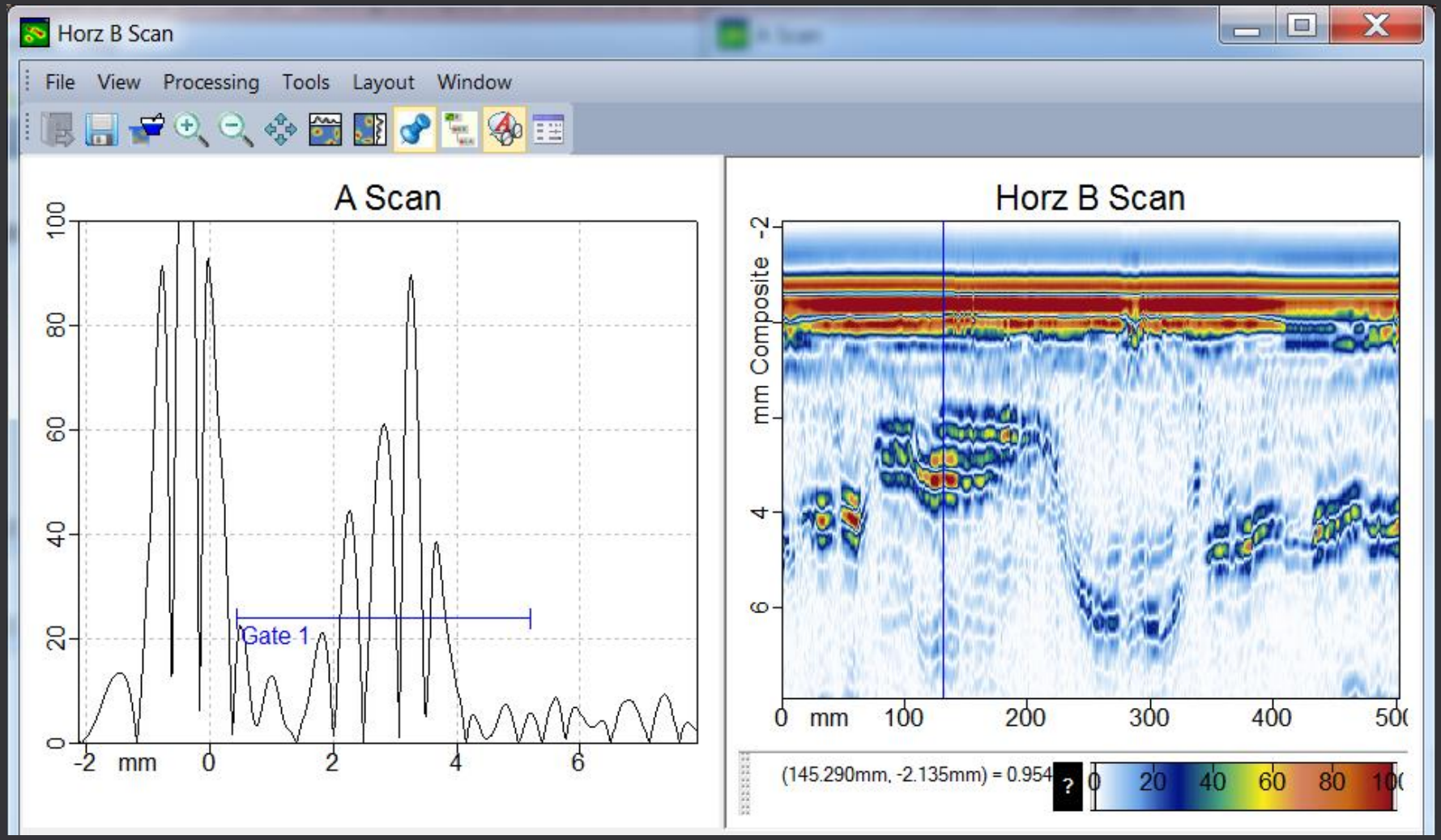
Laminate inspection - voids

- 3.5 mm laminate thickness, ply thickness 0.3 mm
- Inspection at 2 MHz (incorrect)
  - Wavelength: 1.4 mm
  - Thickness resolution 0.7 mm
- Inspection at 5 MHz (correct)
  - Wavelength: 0.6 mm
  - Thickness resolution 0.3 mm

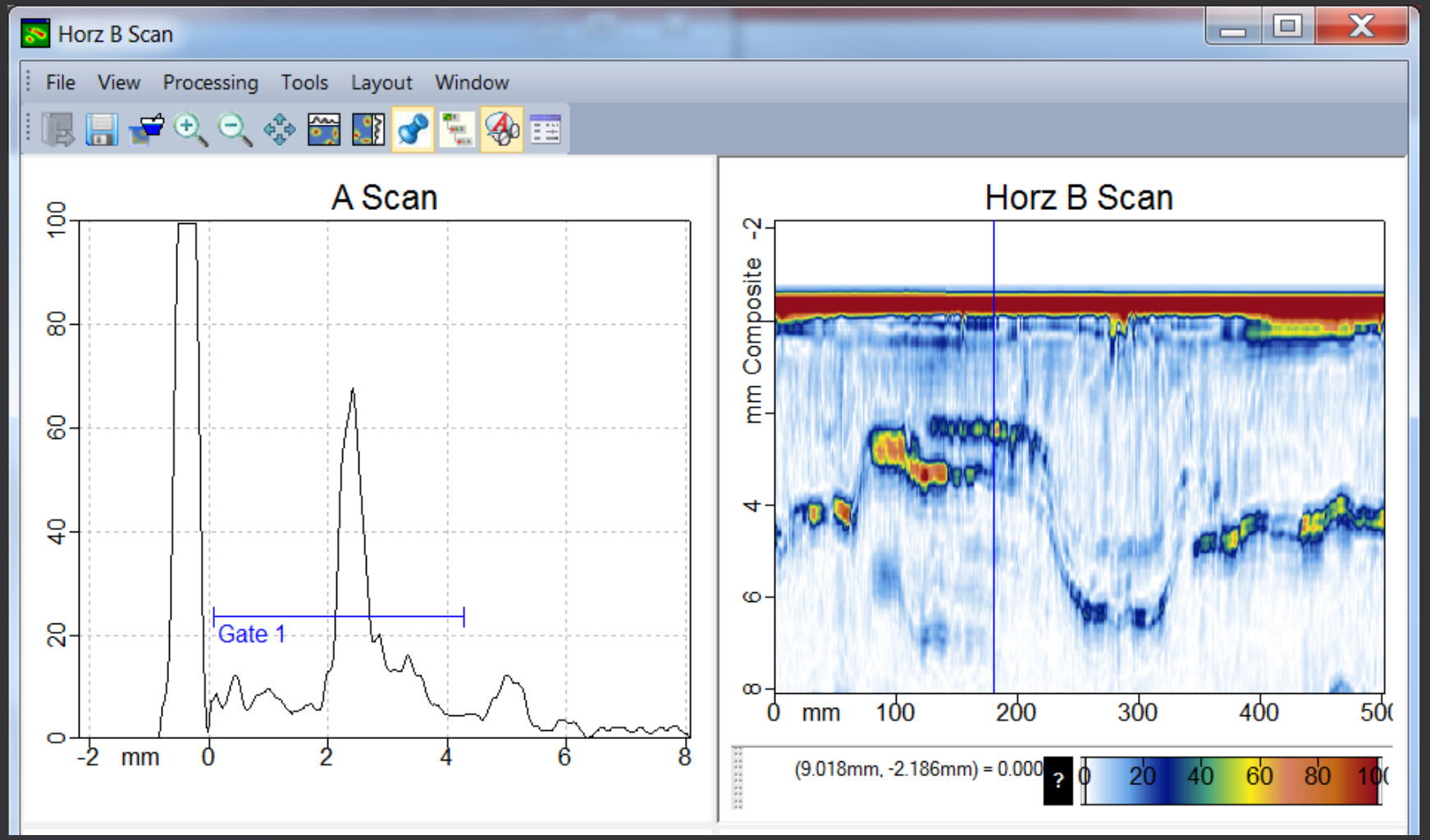
Layer porosity measurement at 2 MHz



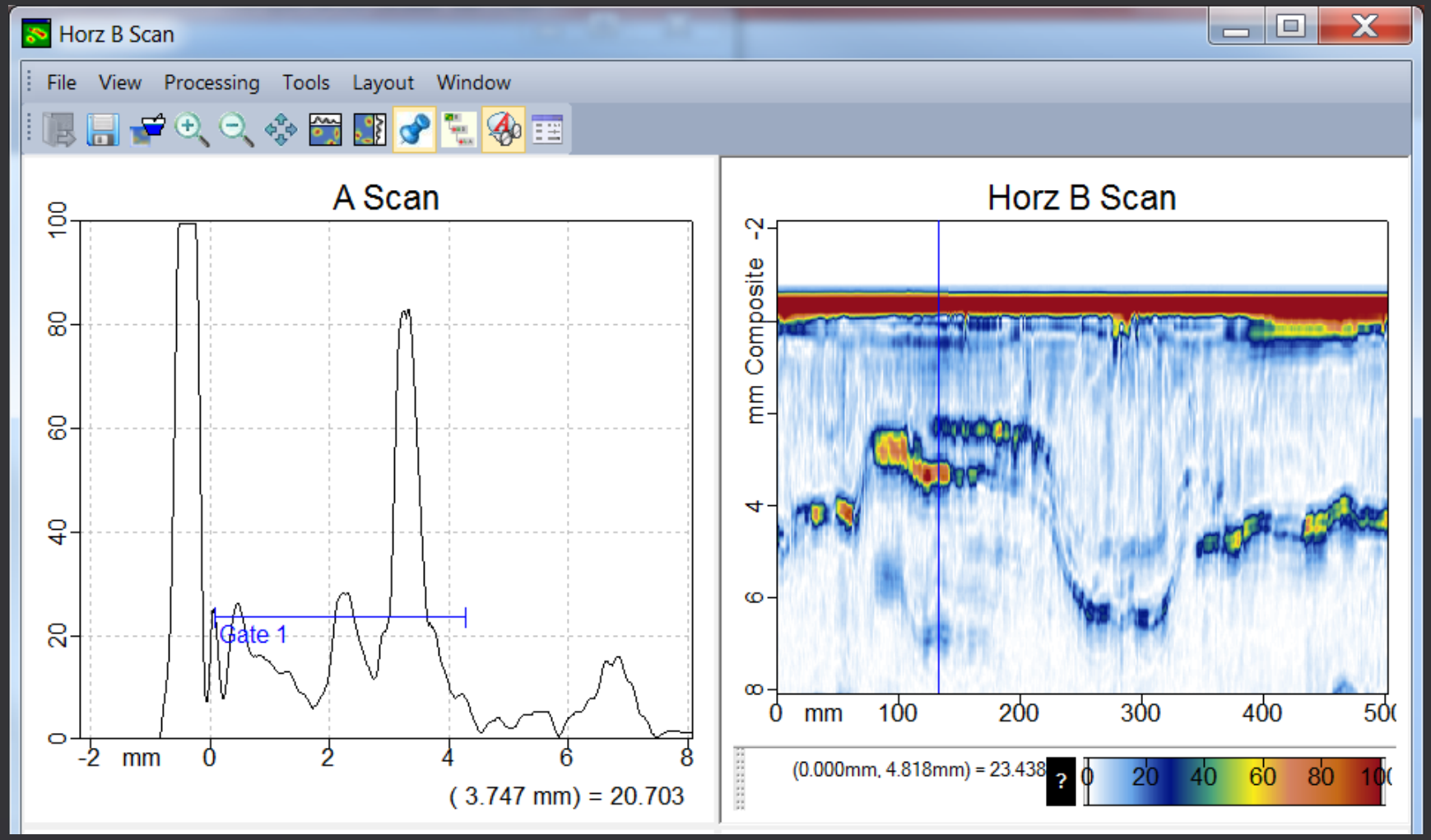
Layer porosity measurement at 2 MHz



Layer porosity measurement at 5 MHz



Layer porosity measurement at 5 MHz



Case 1 conclusion

- Sample taken from area where cut-out would be made
  - Independent micrograph analysis showed extensive layer porosity and the laminate/component was rejected by the designer and end customer
- At 2 MHz the mast was ***incorrectly*** deemed ok with minor porosity ***by the inspector***
- At 5 MHz the mast was ***correctly*** deemed not ok with extensive layer porosity ***by the designer***

Destructive analysis brings certainty

- Core samples
- Cut outs
- End cuts
- Good repair process and expertise already exists
- With correct ultrasound frequency issues with the laminate can be found and reported to the manufacturer/designer and acted upon

Conclusions for requirements

- Current NDT technologies are well placed to serve this diverse sector
  - Materials and good practice available from Aerospace sector
- High level guidance and regulations sorely needed
  - ISO, BSI, EN
  - NDT organisations, certification schemes
  - Classification bodies
- Composites certification will help but
- Needs to be detailed to cope with diverse materials and techniques
  - Training schools are key – training and services understanding requirements and interpreting standards/guidance
  - Composites technology centres – product/materials technology