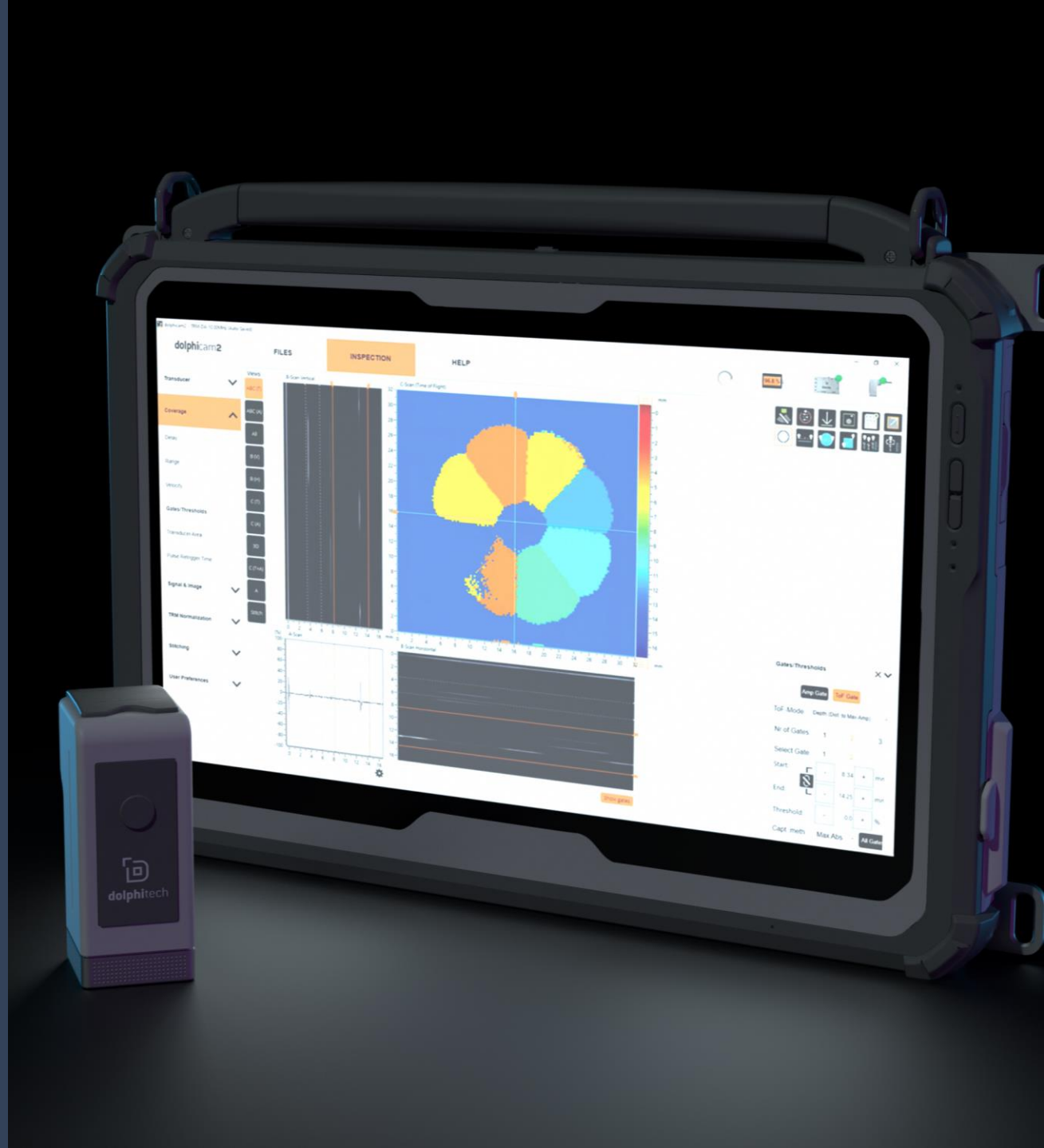
dolphitech

Advanced ultrasonic inspection with the dolphicam2

Meeting name – Meeting date

Dolphitech rep name – Dolphitech rep title



Who are we?

- Established in 2009 in Gjøvik, Norway we now have offices in the UK and USA.
- Since then, we have grown to become an established solution provider in industrial ultrasonic imaging.
- Our mission is to deliver a cutting-edge inspection platform that can provide measurable improvements in NDT performance.

Where to find us?

TOTAL DEFENCE GROUP

FSi

CenSec
CENTER FOR DEFENCE, SPACE & SECURITY

COFREND
Confédération Française pour les Essais Non Destructifs

ASNT

BINDT
THE BRITISH INSTITUTE OF NON-DESTRUCTIVE TESTING
CORPORATE MEMBER

ASTM INTERNATIONAL

RCNDE
UK Research Centre in NDE

Who uses us?

BOEING

SPIRIT AEROSYSTEMS

IRISNDT

GALACTIC

UNITED

TEAM

jetBlue

SOLVAY

NASA

What sets us apart?

Fast
Out-of-the-box to inspection in 60 seconds

Easy to use
Simple interface and intuitive layout provide a shallow learning curve

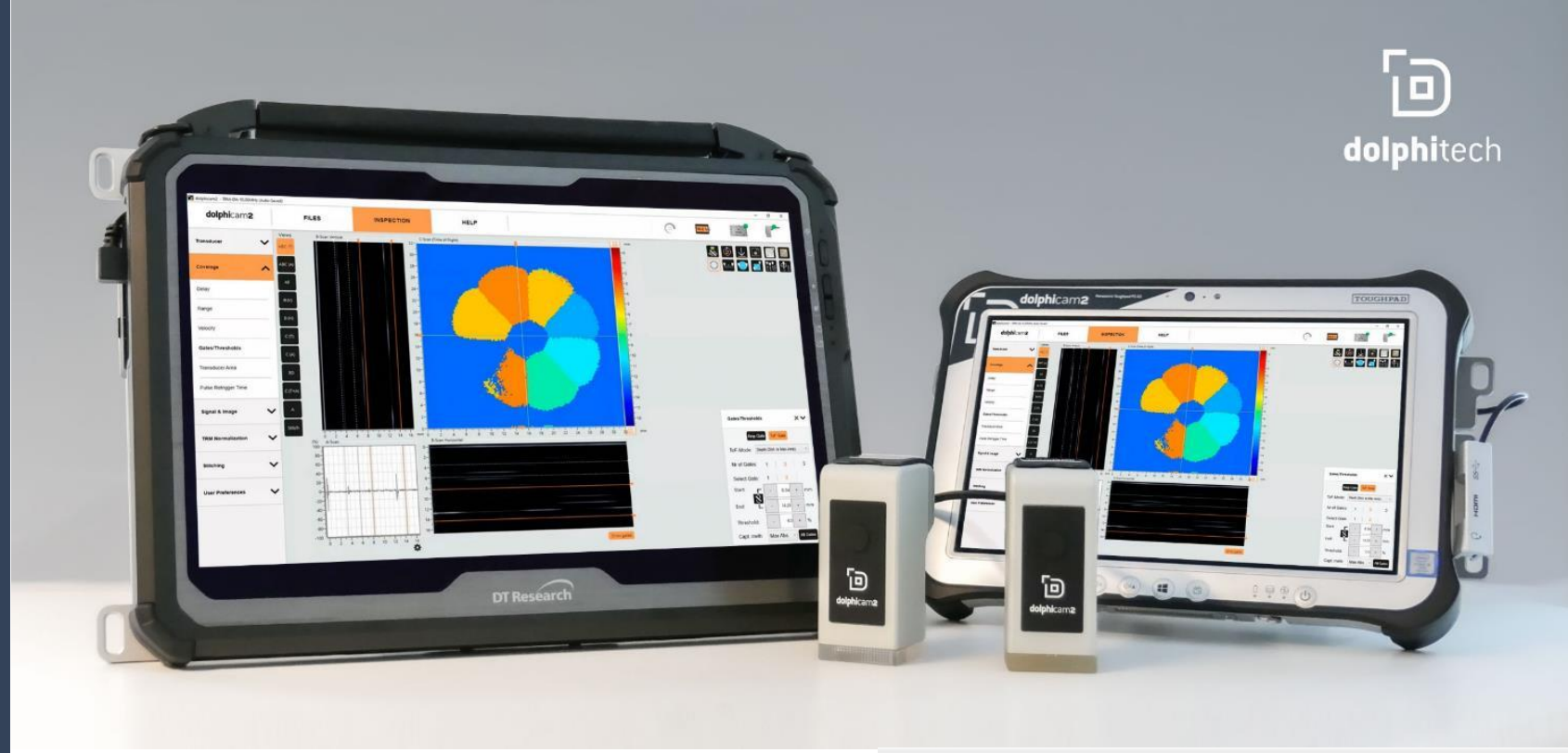
Data Rich
Permanent digital records of all data with the press of a button

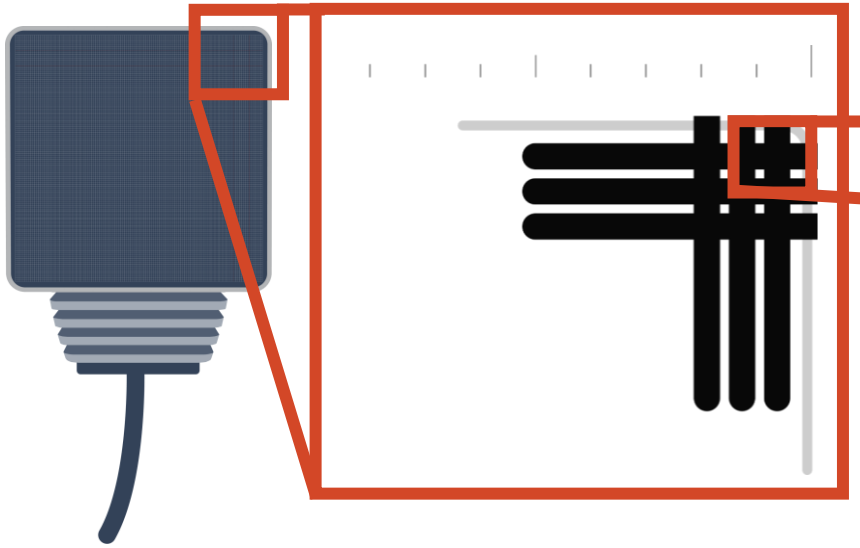
Highly cost-effective
simplified training and maintenance procedures

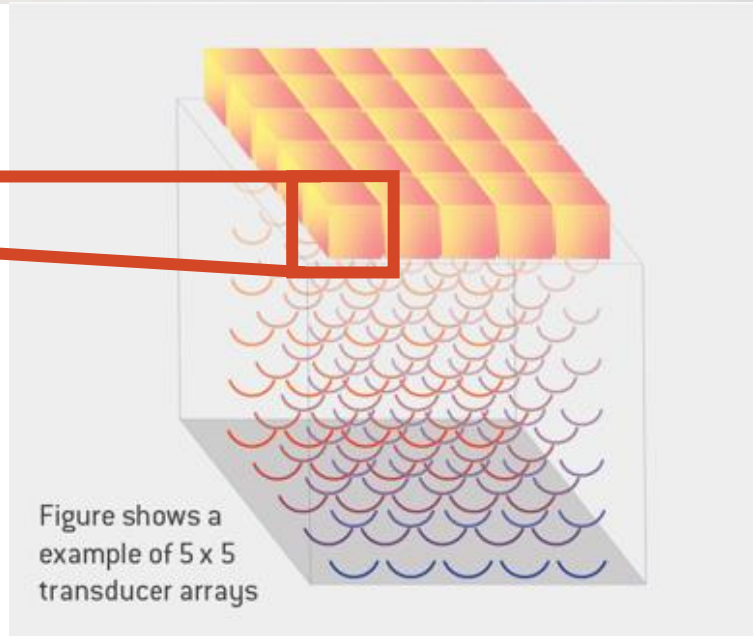
Portable
3kg combined system weight for comfortable on-site working

What is the dolphicam2?

- Unique 2D matrix array transducer platform
- Live data capture in 3-dimensions and high level of detail
- Transducer frequencies from 0.7 – 10MHz
- Inspection of CFRP, GFRP, metals, bonds and coatings





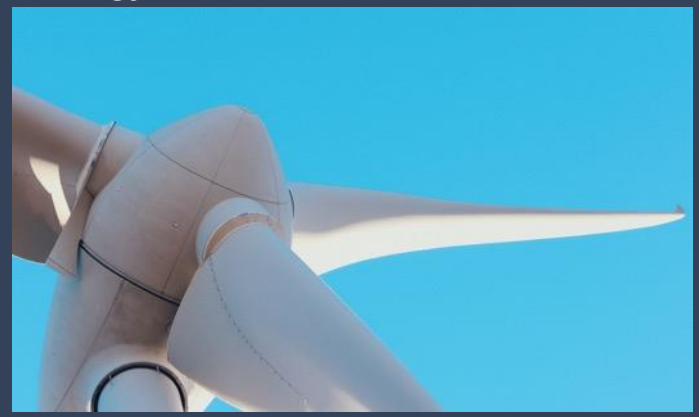


What markets do we serve?

Aerospace

Space Tech

Energy



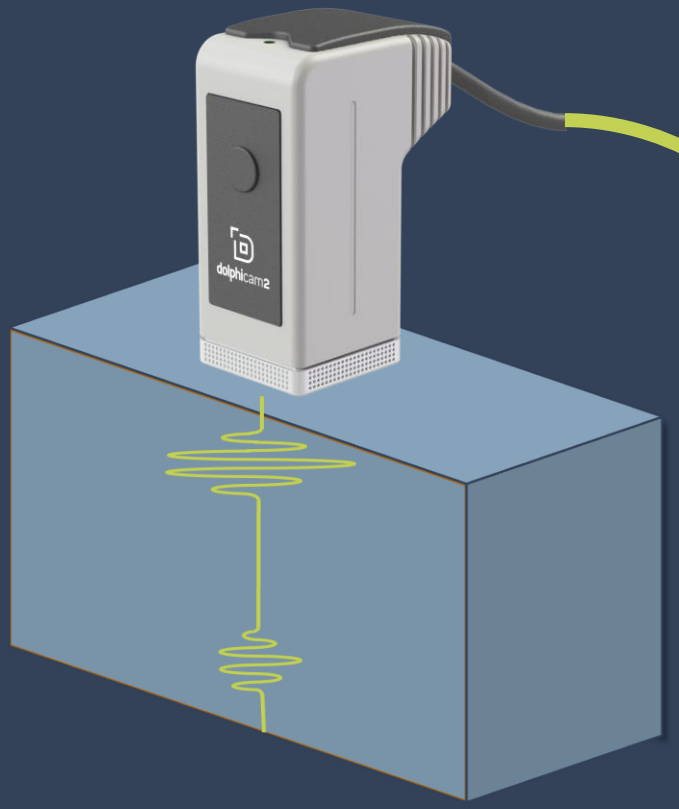
Defense

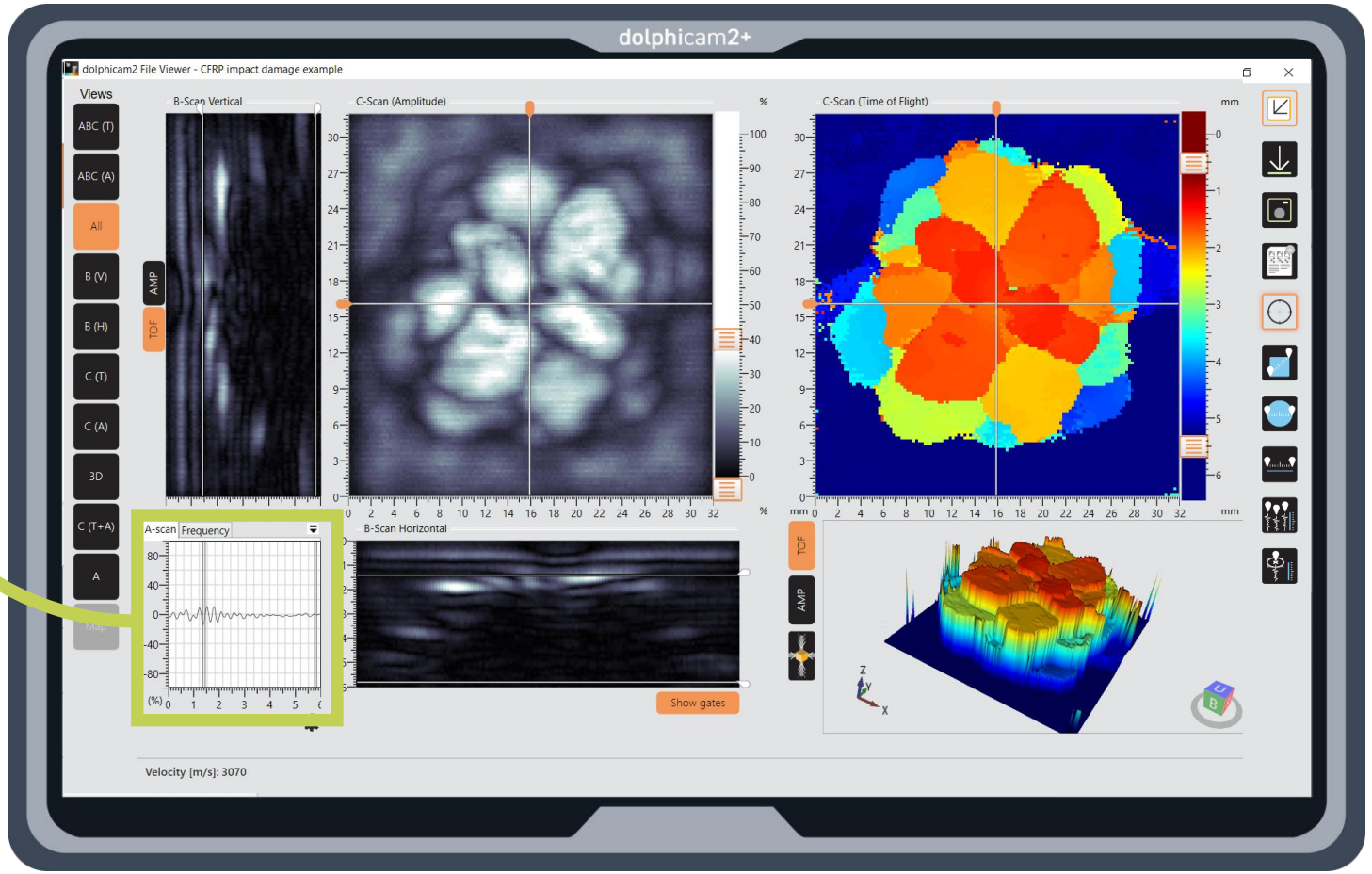
Marine

Automotive

How do we display this unique data?

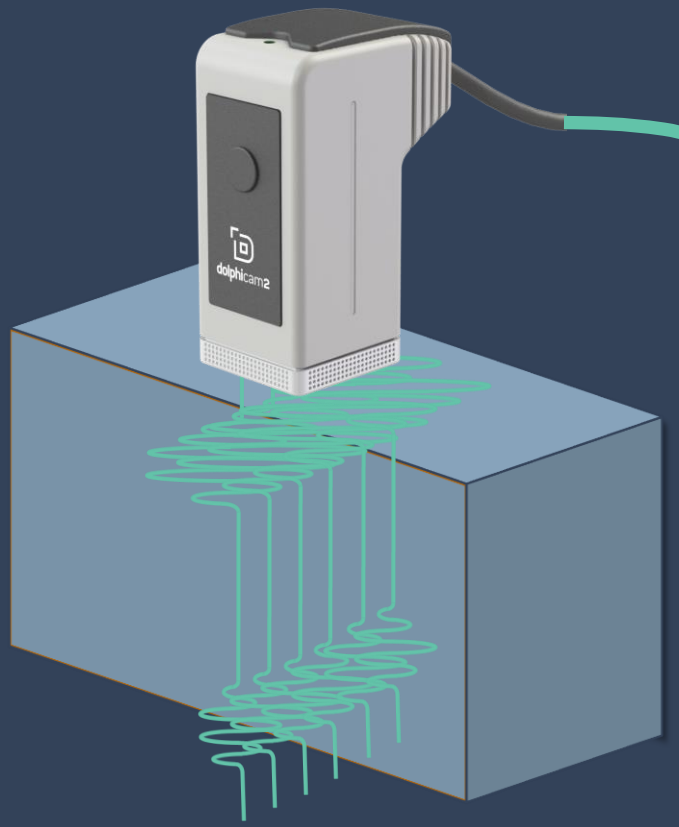
A-scans

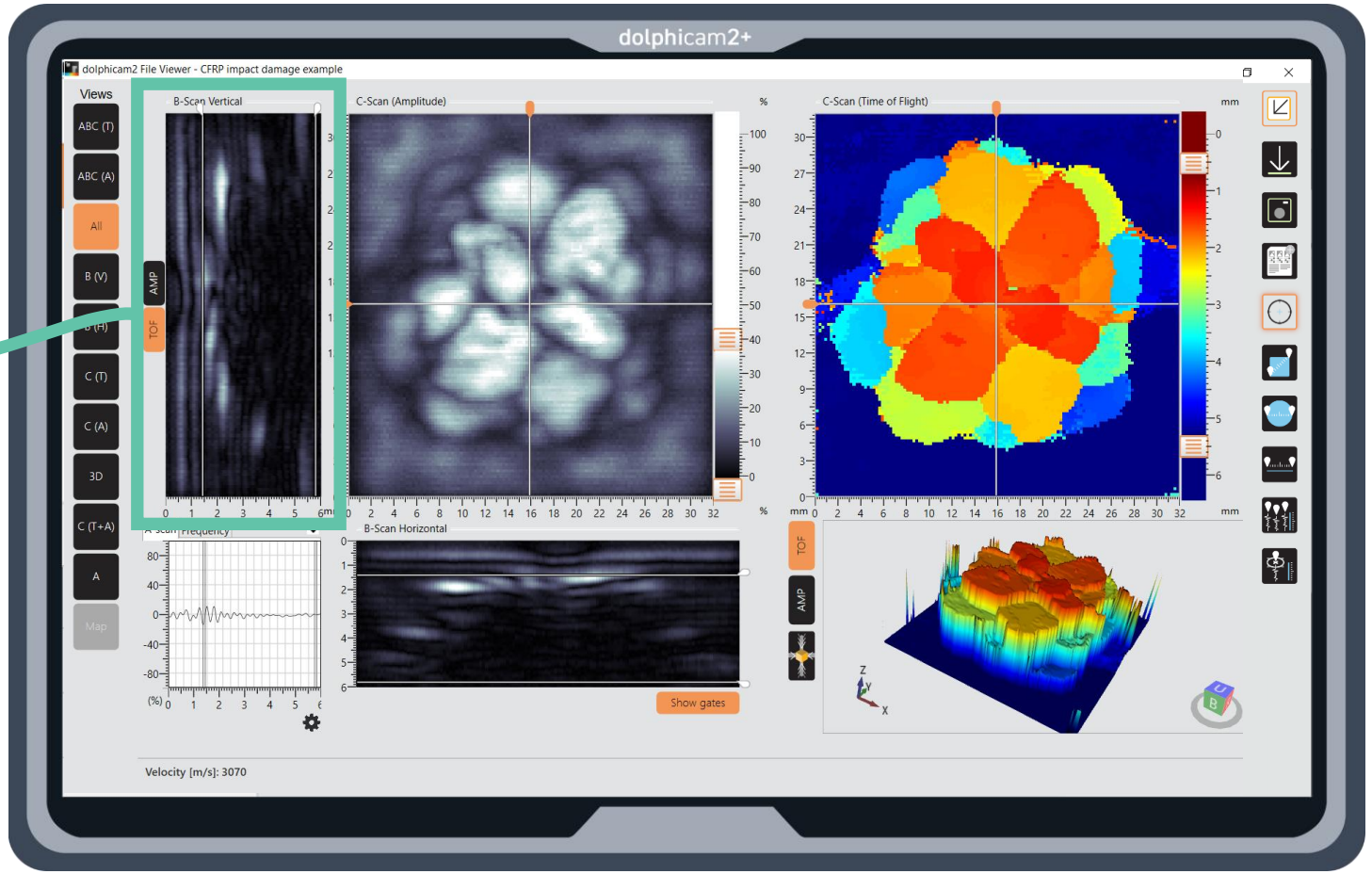




How do we display this unique data?

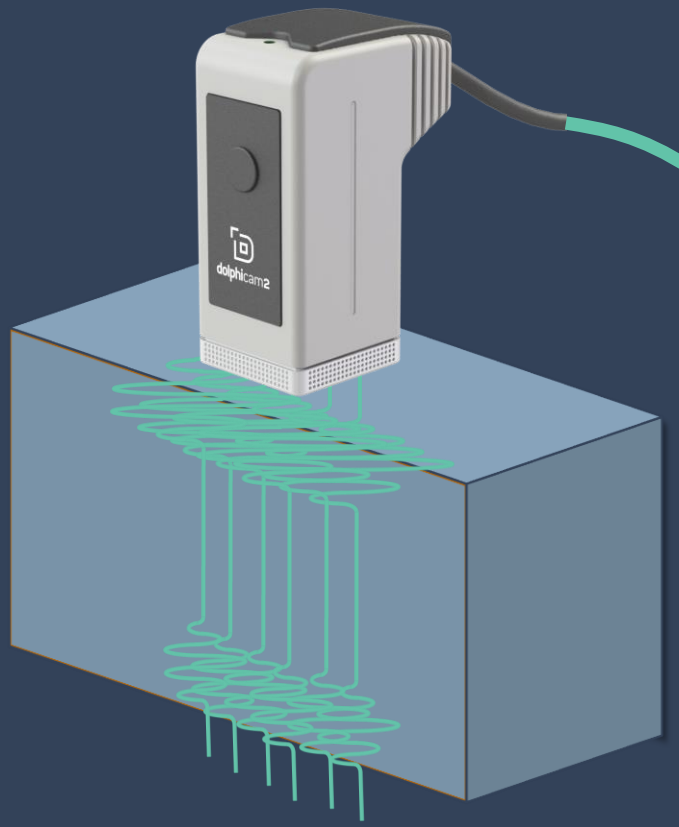
Vertical B-scan

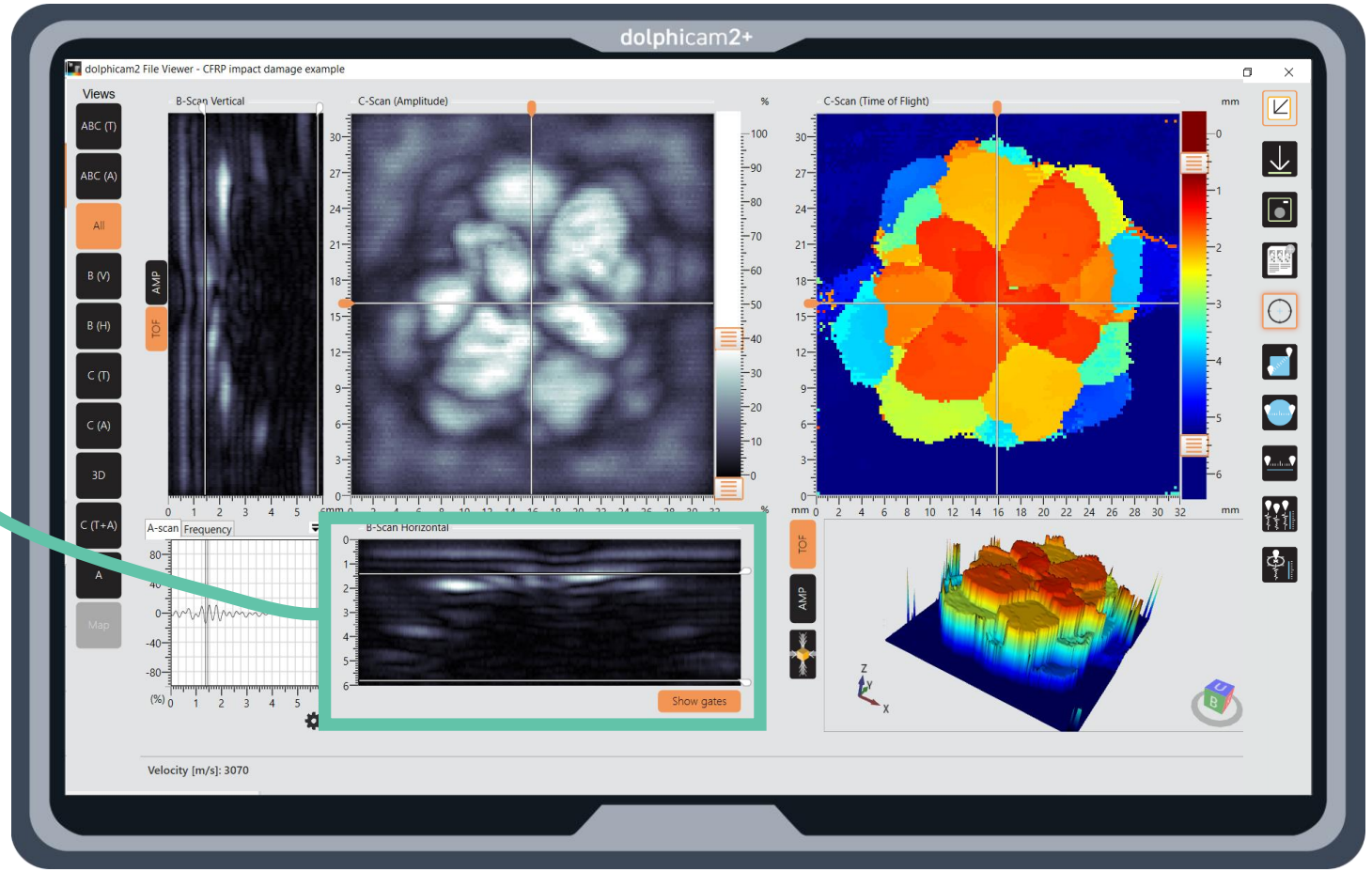




How do we display this unique data?

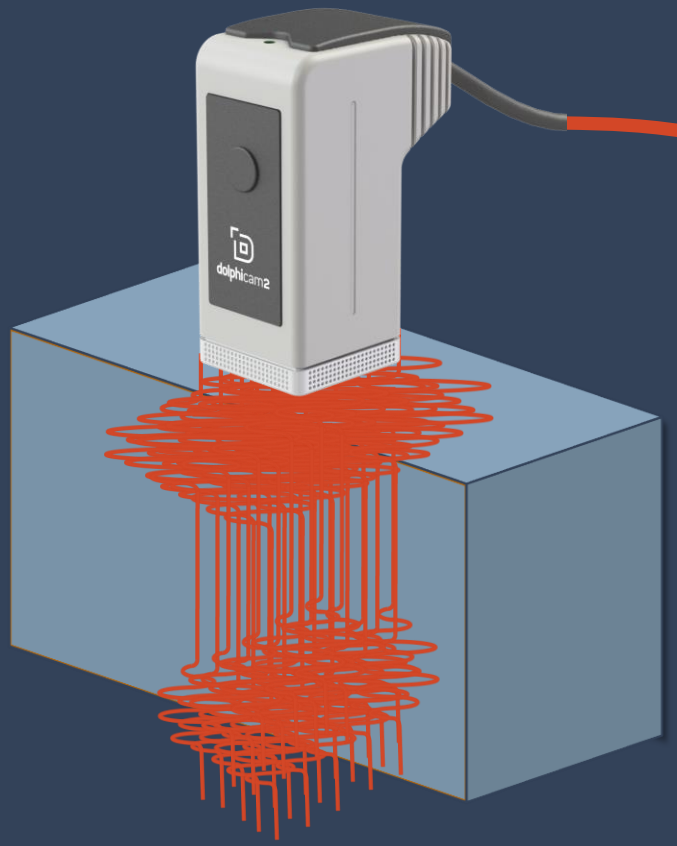
Horizontal B-scan

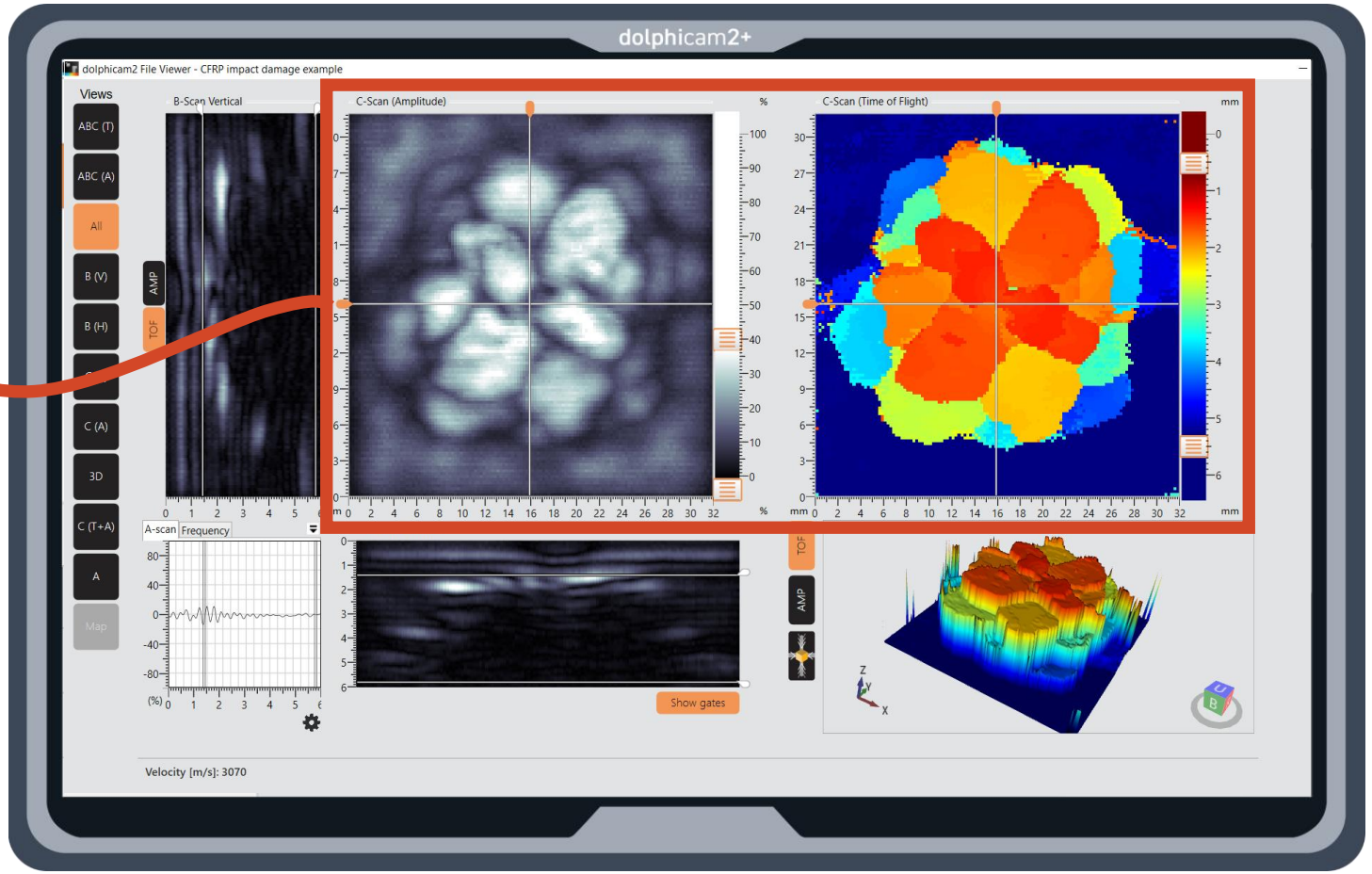




How do we display this unique data?

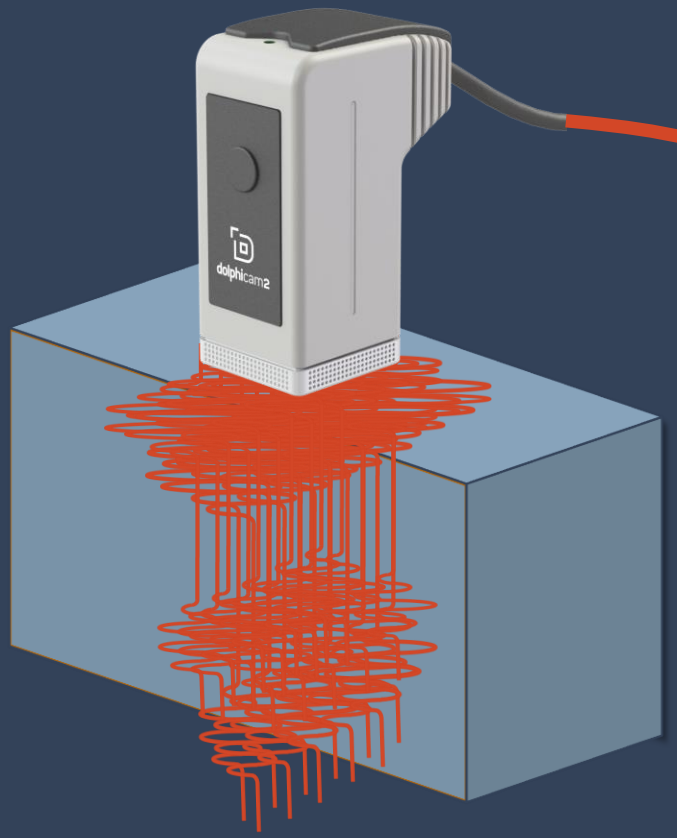
C-scans

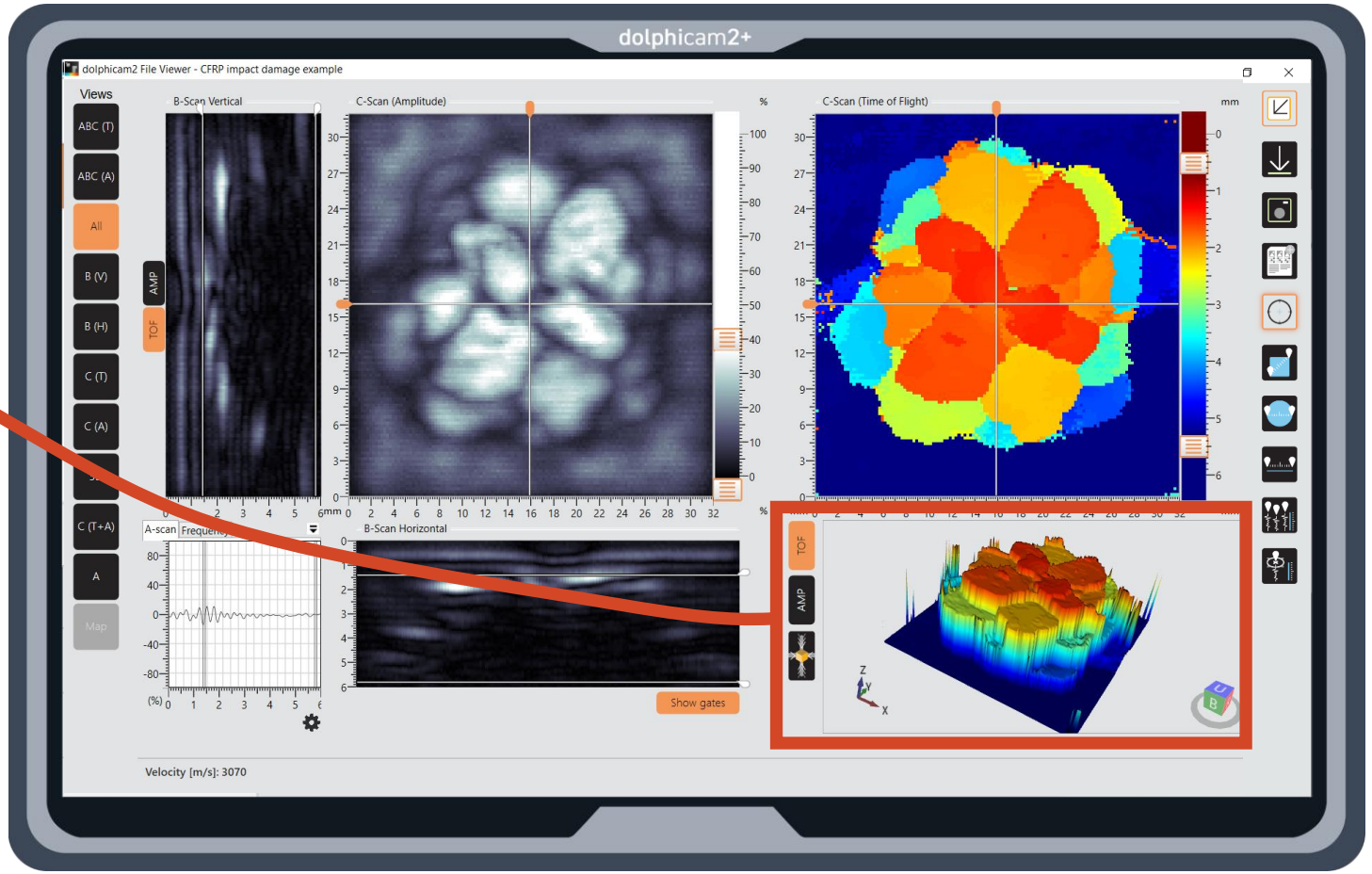




How do we display this unique data?

3D View





Summary of key benefits

- **Only system with Live C-scan capability:**

  Enables instant visualisation of the internal volume

- **Smaller and lighter than competitors:**

  Reach more confined spaces and inspect with reduced operator fatigue

- **Only system with full analysis toolkit onboard:**

  Save time by performing analysis at the point of inspection: no need to transfer to a separate workstation and use separate software

- **Easiest system to use:**

  As the dolphicam2 uses only straight beam ultrasound, the equipment set-up and data interpretation are easier than competitors

Carbon fibre composites

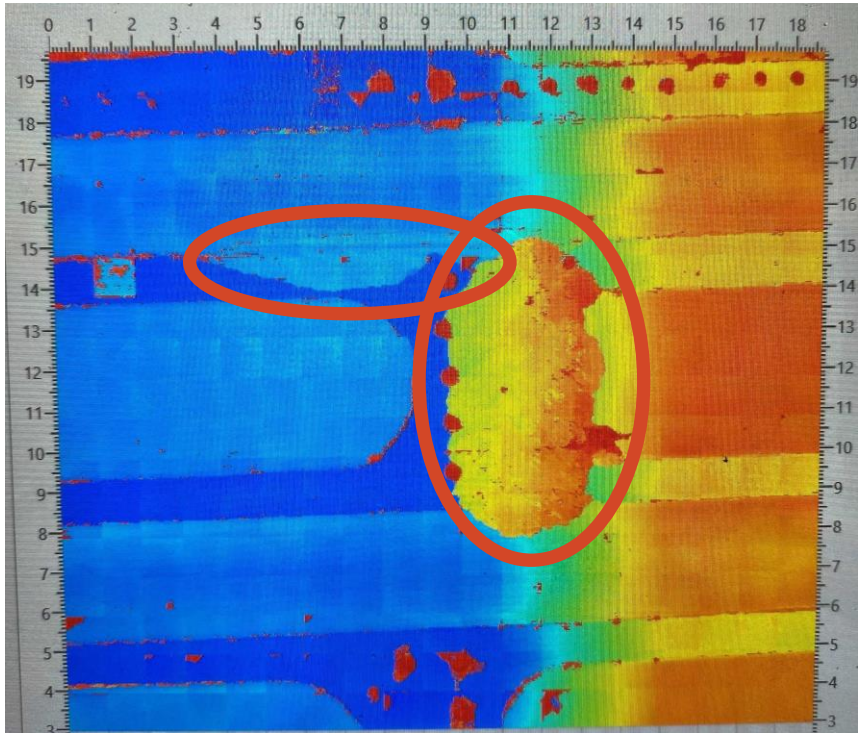
787 impact damage

- Impact event on the fuselage of a Boeing 787 Dreamliner
- 480x480mm area mapped with the dolphicam2
- Main impact zone and disbonded stringer clearly visible

- Aircraft photograph

- Amplitude C-scan

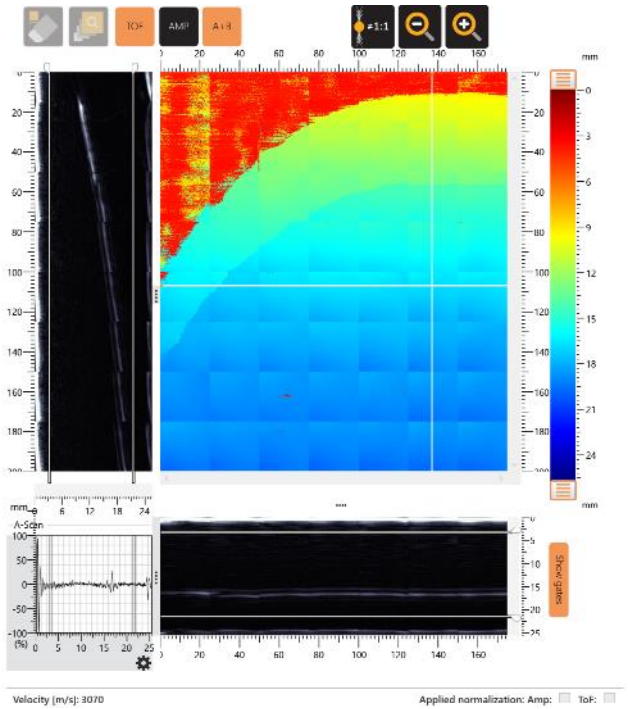
- ToF (Depth) C-scan



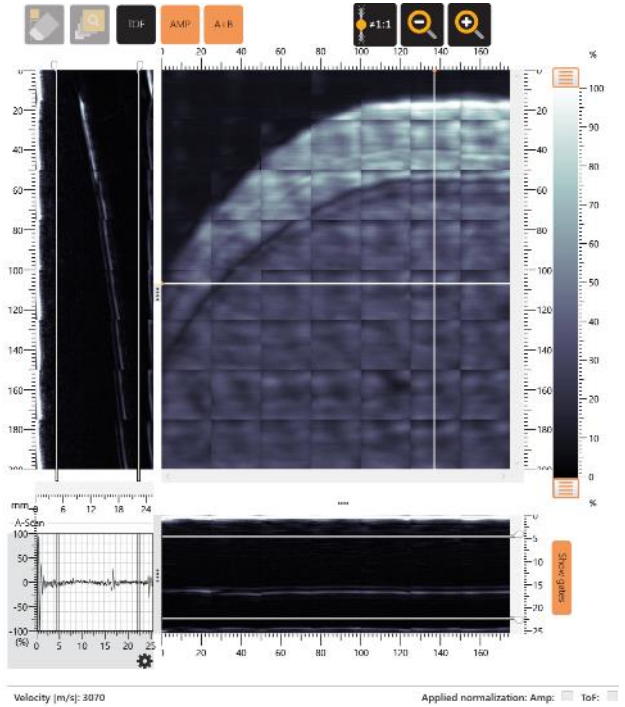
GE90 Composite Fan Blade Inspection

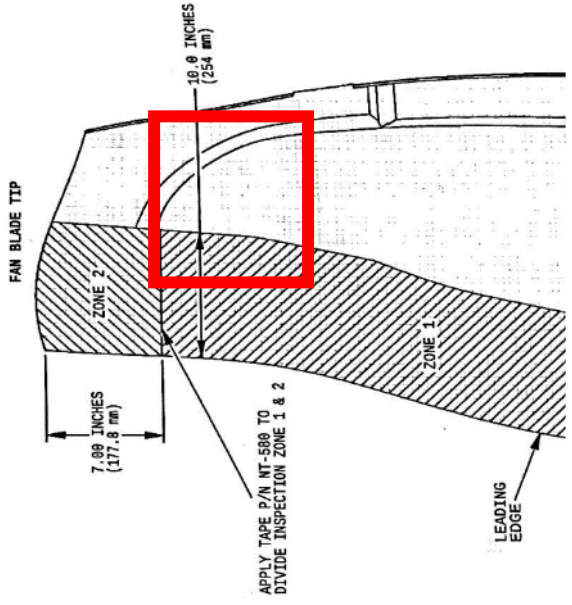
- Manually-stitched 5” x 8” area of a GE90 Composite Fan Blade
- Reduction in thickness visible towards trailing edge of blade
- Step change in thickness visible, corresponding to technical drawing

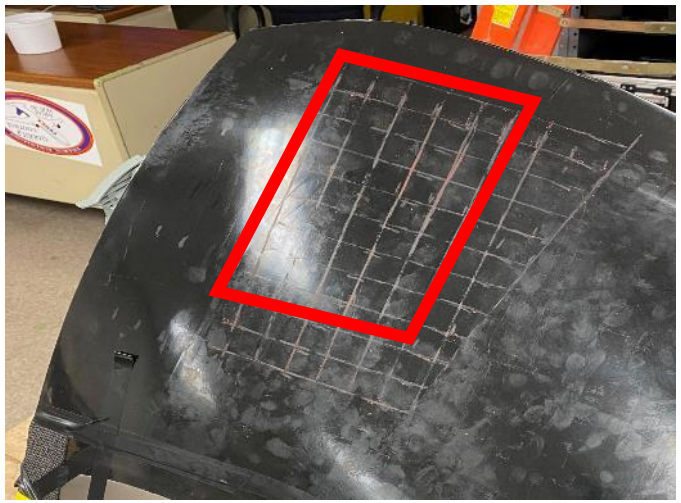
- ToF (Depth) C-scan



- Amplitude C-scan



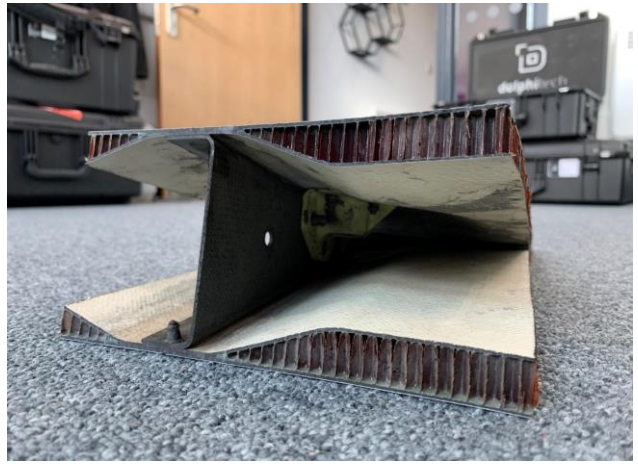




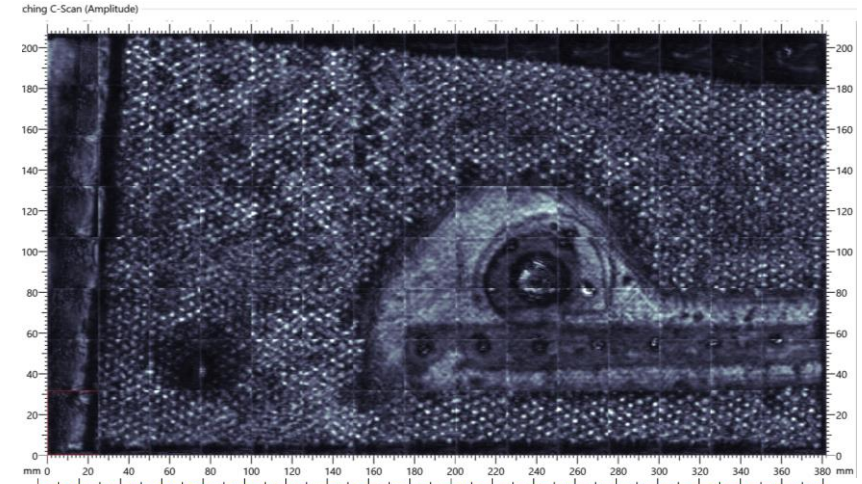
A330/A340 elevator trailing edge

- CFRP to Nomex core
- Monolithic CFRP stiffener rib

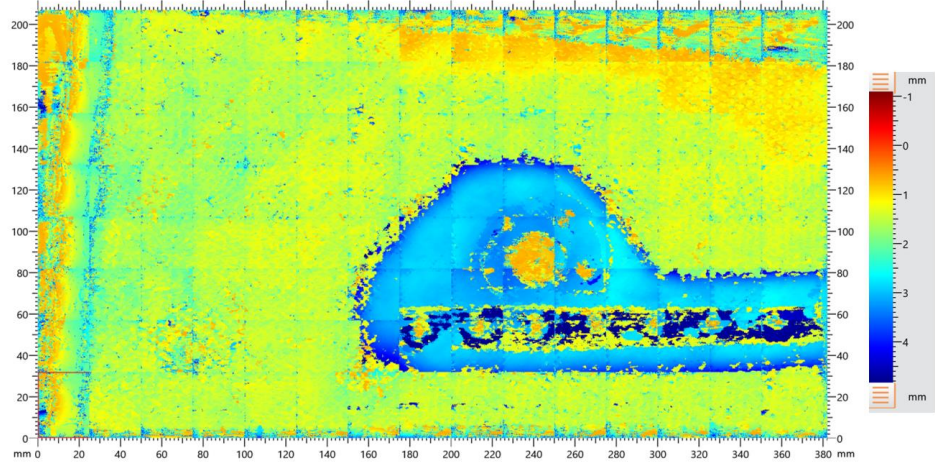
- Sample photograph



- Amplitude C-scan



- ToF (Depth) C-scan



CFRP delamination from holes

- 5mm thick monolithic UD CFRP with 6mm thru holes
- 3mm semicircle milled from back surface to 1mm depth from back surface

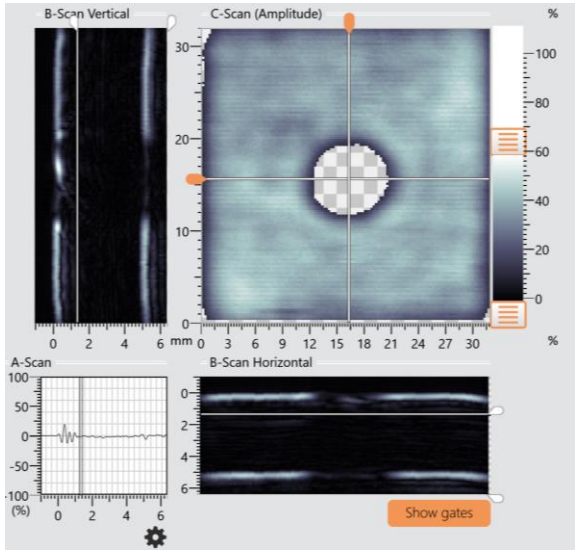
Inspection surface

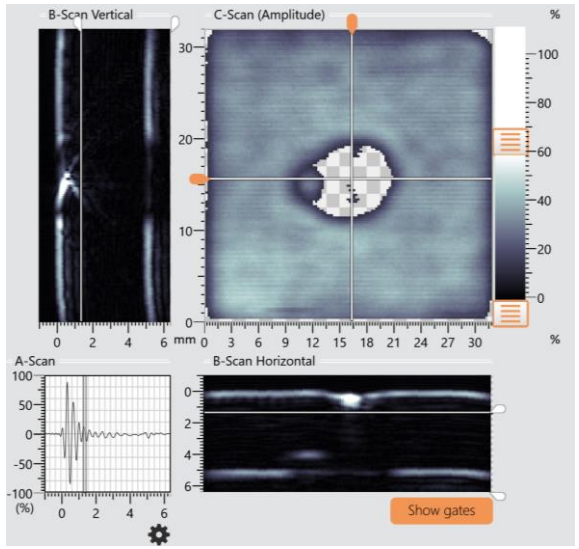
Back surface

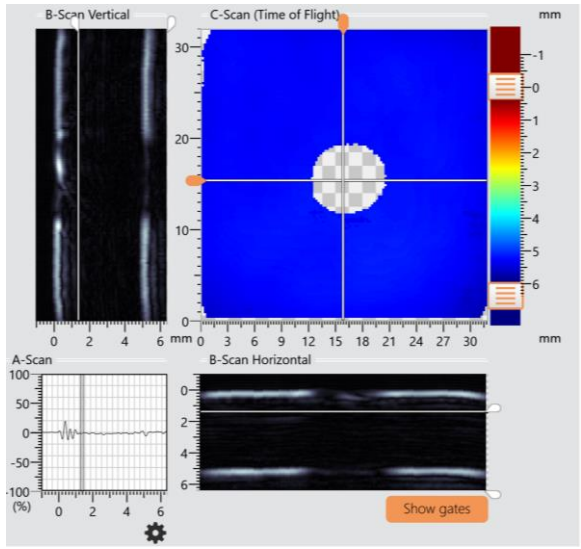
- Amplitude C-scan
- ToF (Depth) C-scan

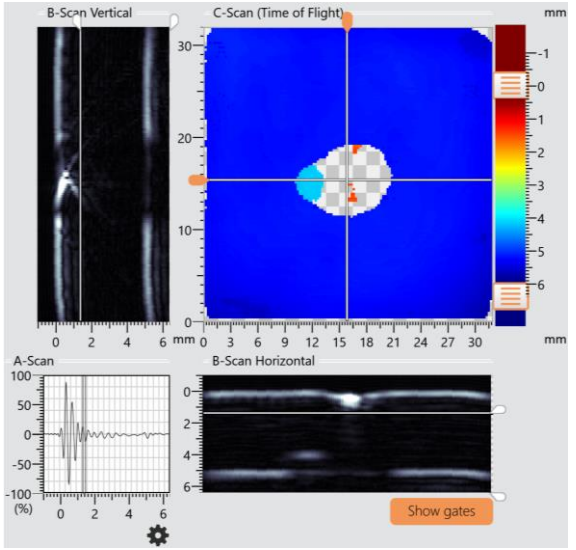
– Control

– Delamination





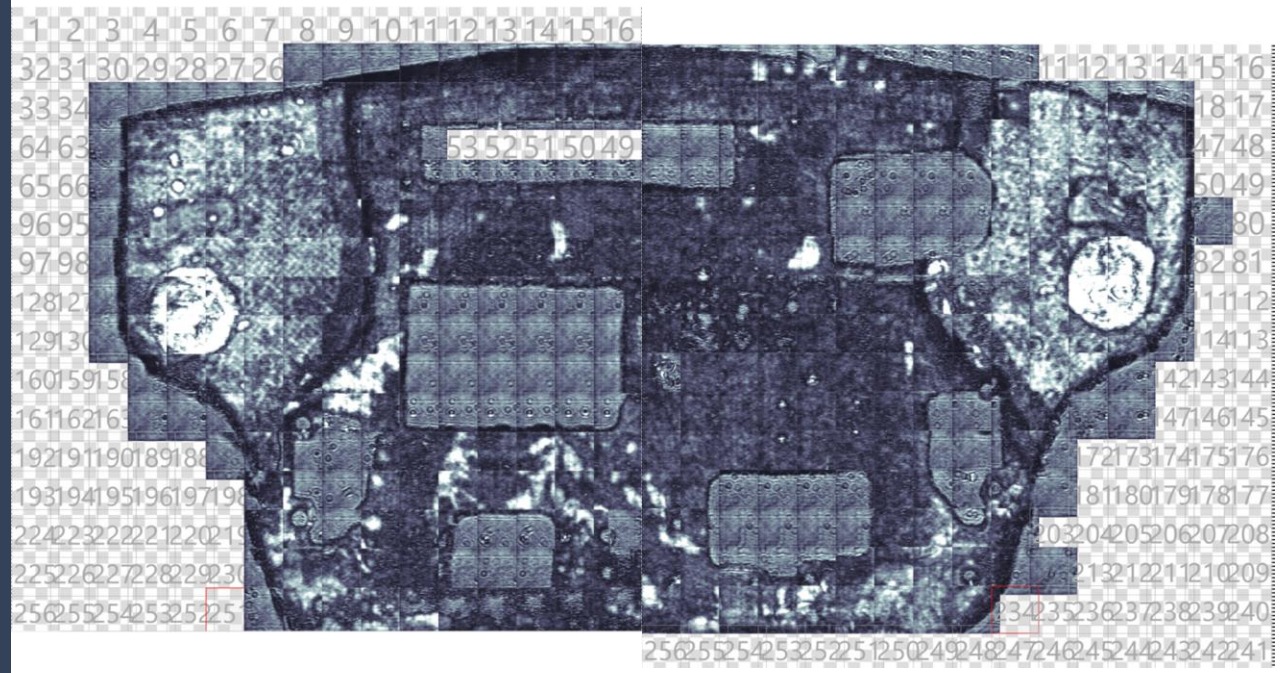




CFRP military ground vehicles

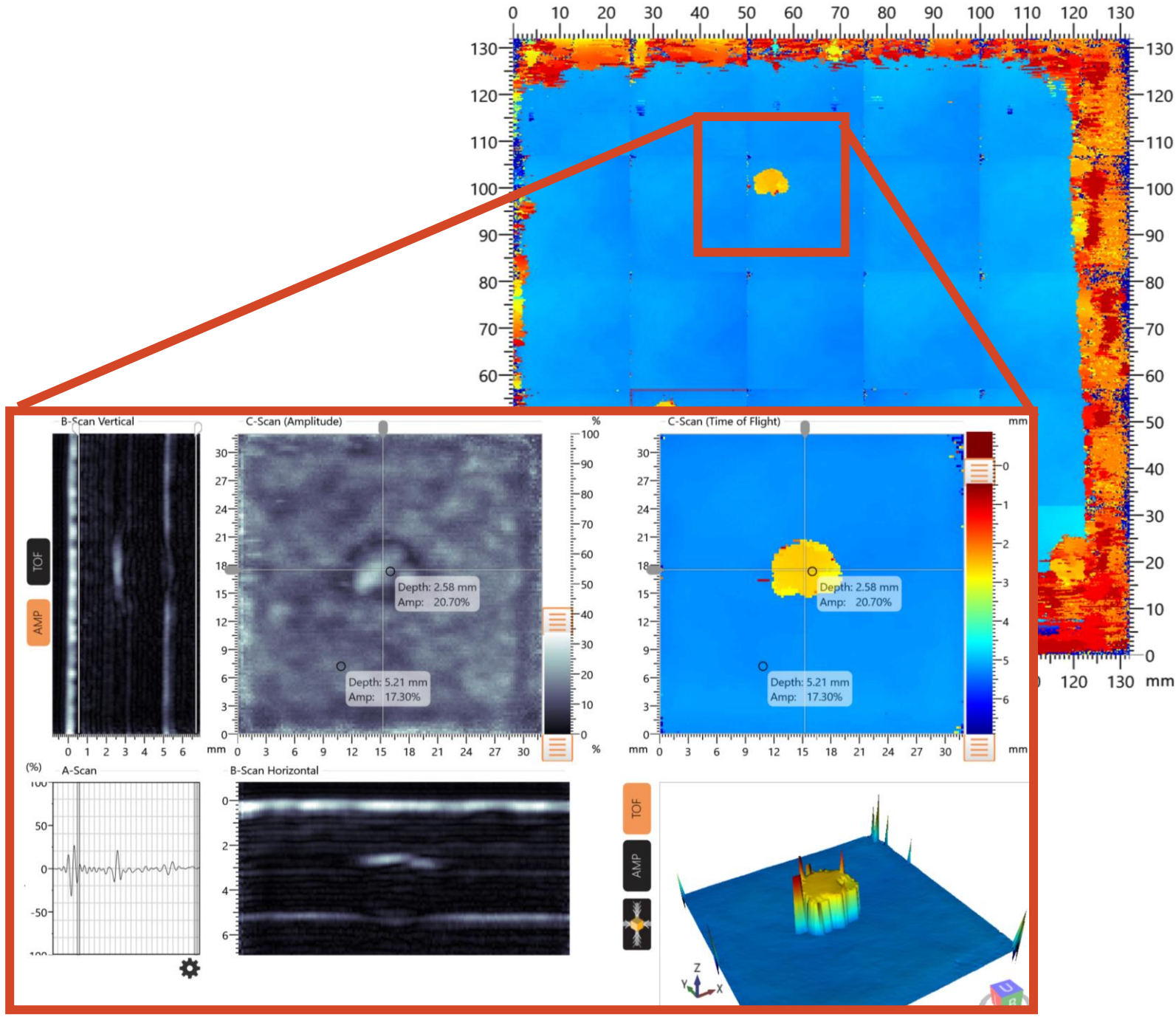
- Vendor-supplied CFRP chassis for Personnel Carrier with unknown damage.
- The dolphicam2 was able to detect area which contained voids around the engine mounts and other critical stress areas.
- Large area has been covered on-site, with standard dolphicam2 platform with no peripherals or scanners required.
- This was achieved with no latency in results – the dolphicam2 can be used for live screening to provide the engineering team with data to make proper improvements and repairs.

- Amplitude C-scan with voids identified



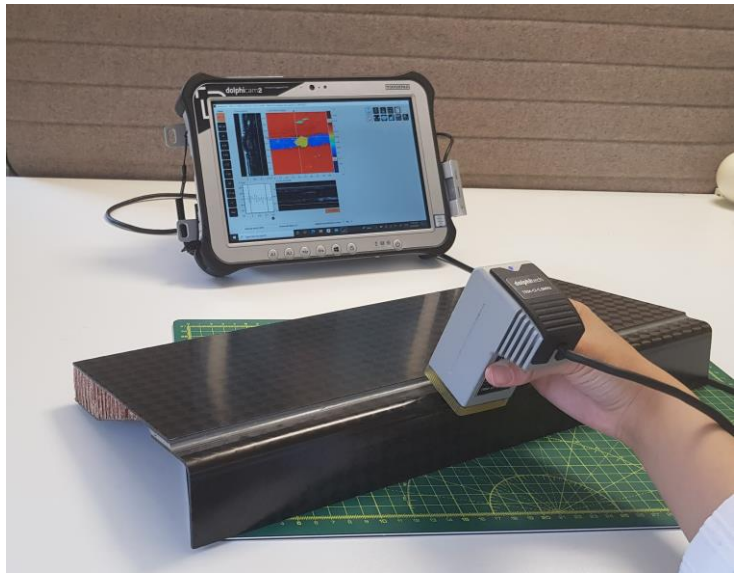
CFRP adhesive bondline defects

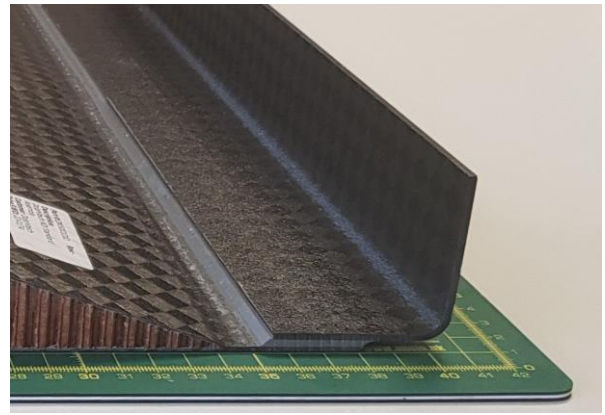
- 5mm thick adhesively bonded CFRP sample (2x 2.5mm) plates
- Embedded reflectors at bondline

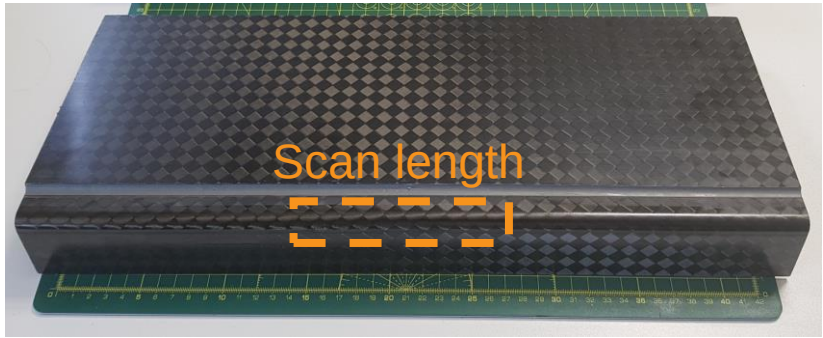


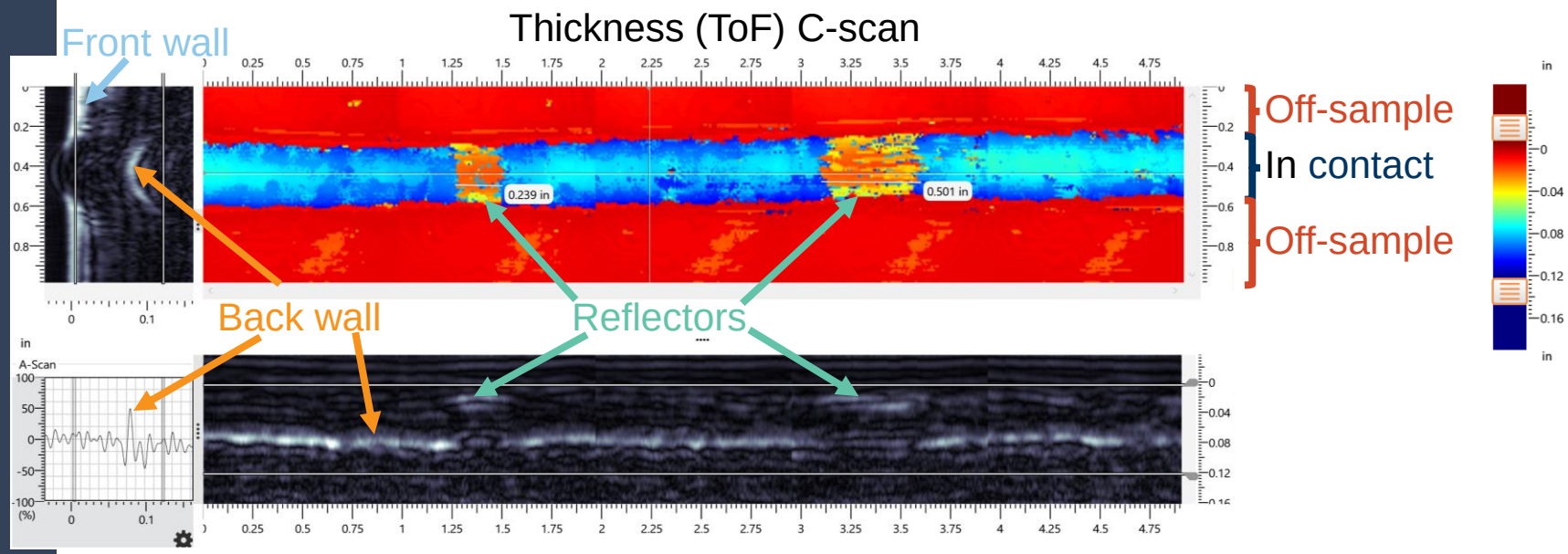
CFRP radii

- Tight corner radius of 0.09″ thick carbon fiber laminate.
- Nominal radius of curvature is 0.3125″ (~8mm).
- Circular reflectors are embedded, which are nominally 0.25″ and 0.5″ in diameter.



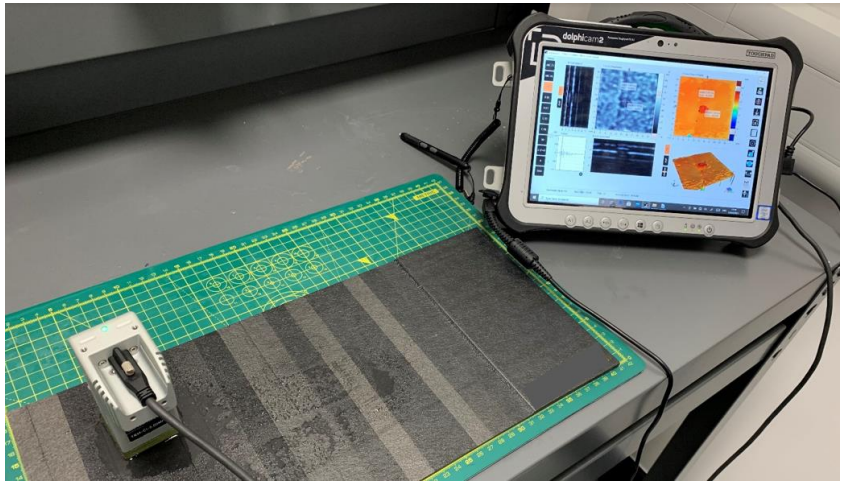




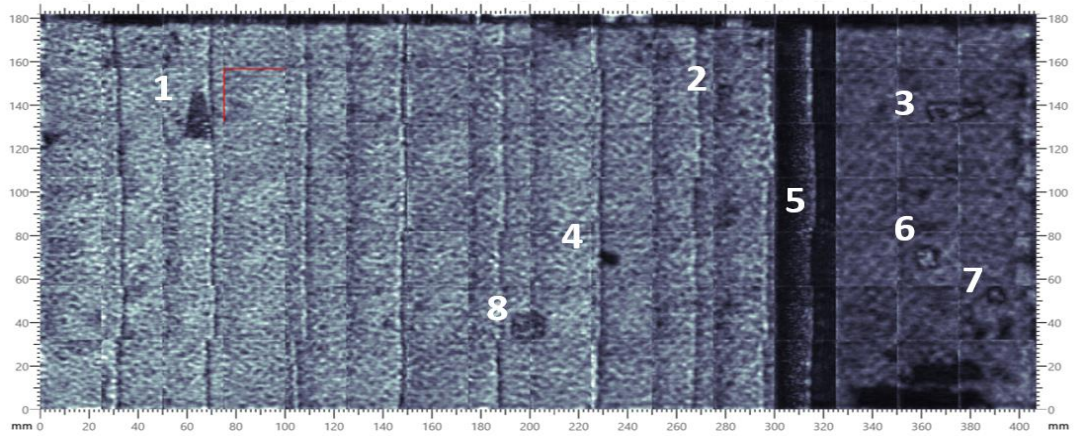


CFRP ply drops

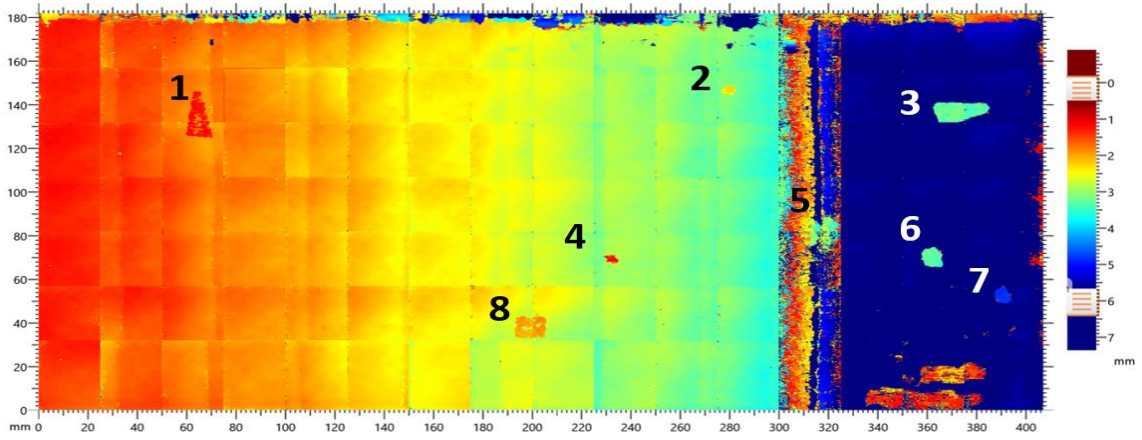
- 1-6mm thickness, discrete ply drops
- Inspection from stepped, non-mould side
- Various shape and size reflectors embedded in laminate



- Amplitude C-scan

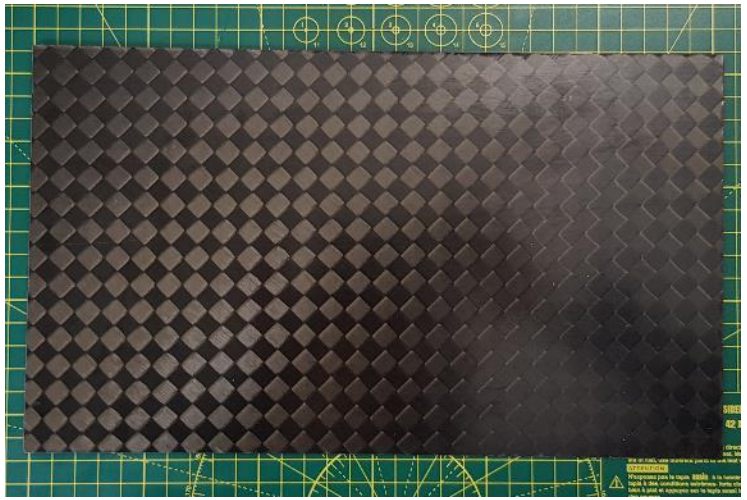


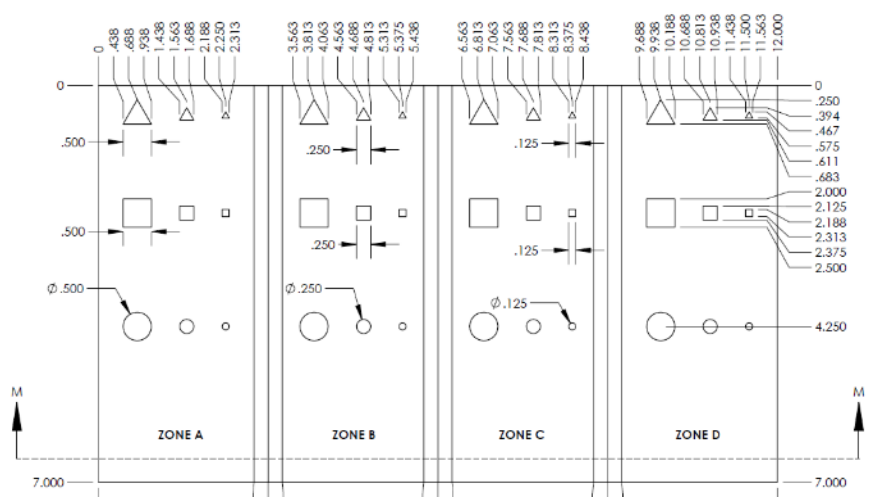
- ToF (Depth) C-scan

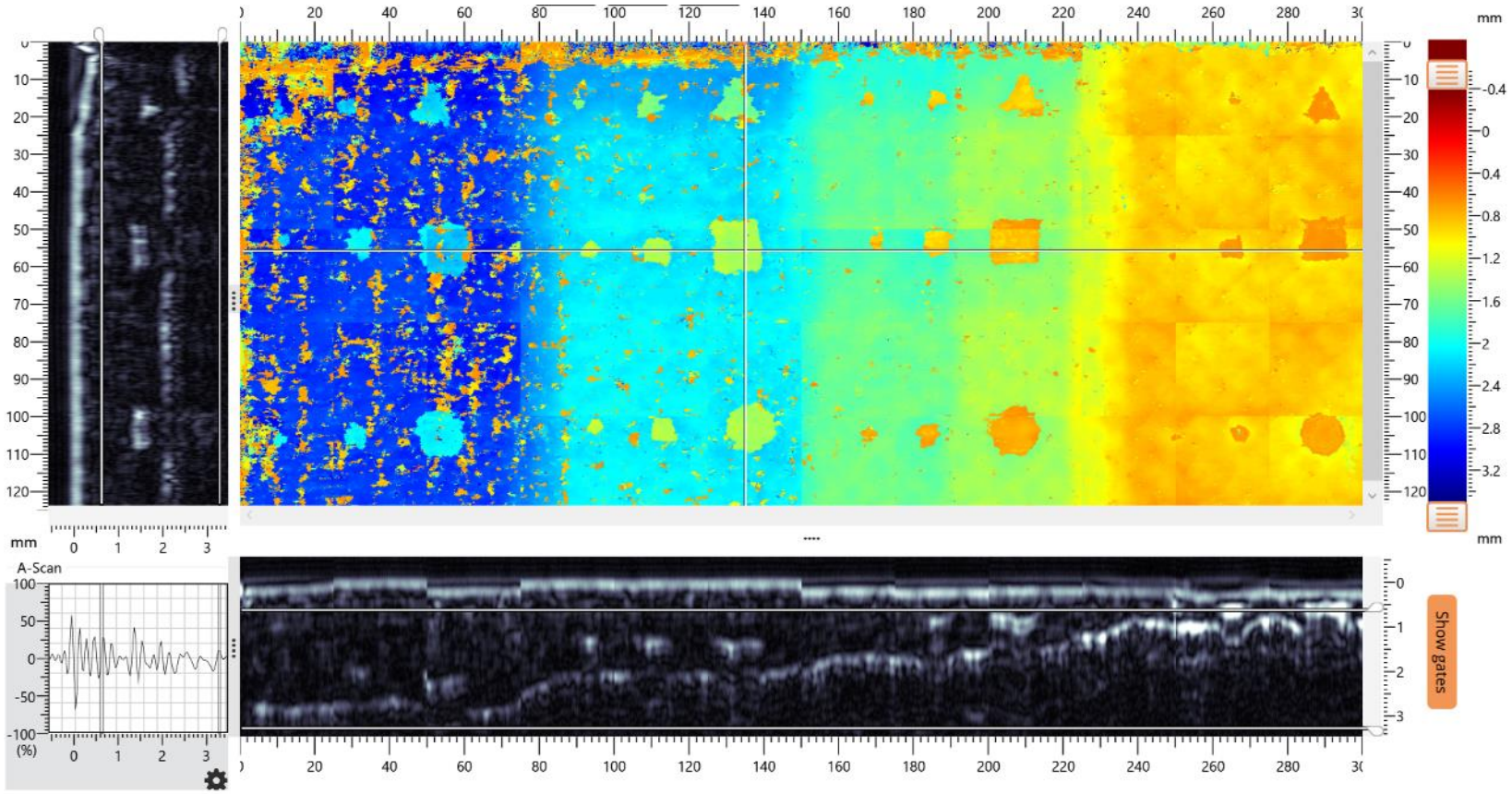


Spread tow CFRP laminate ply drops

- 0.5-2.5mm thickness with four different zones
- Various shape and size reflectors embedded in laminate
- All 36 reflectors detected
- All A-scan and B-scan information recorded

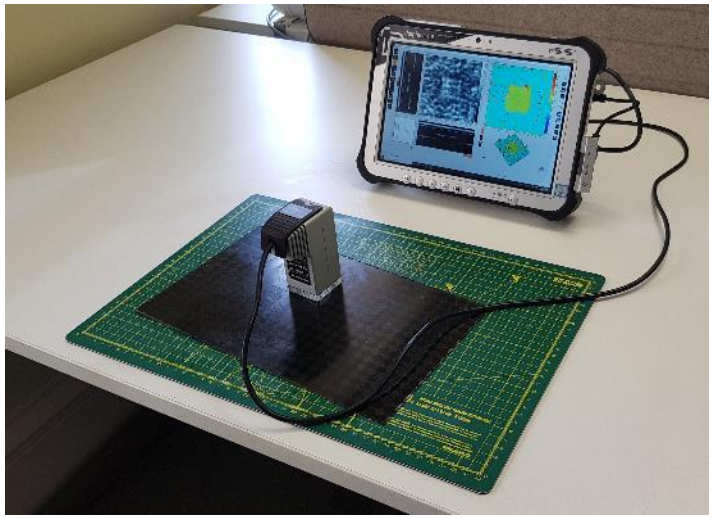


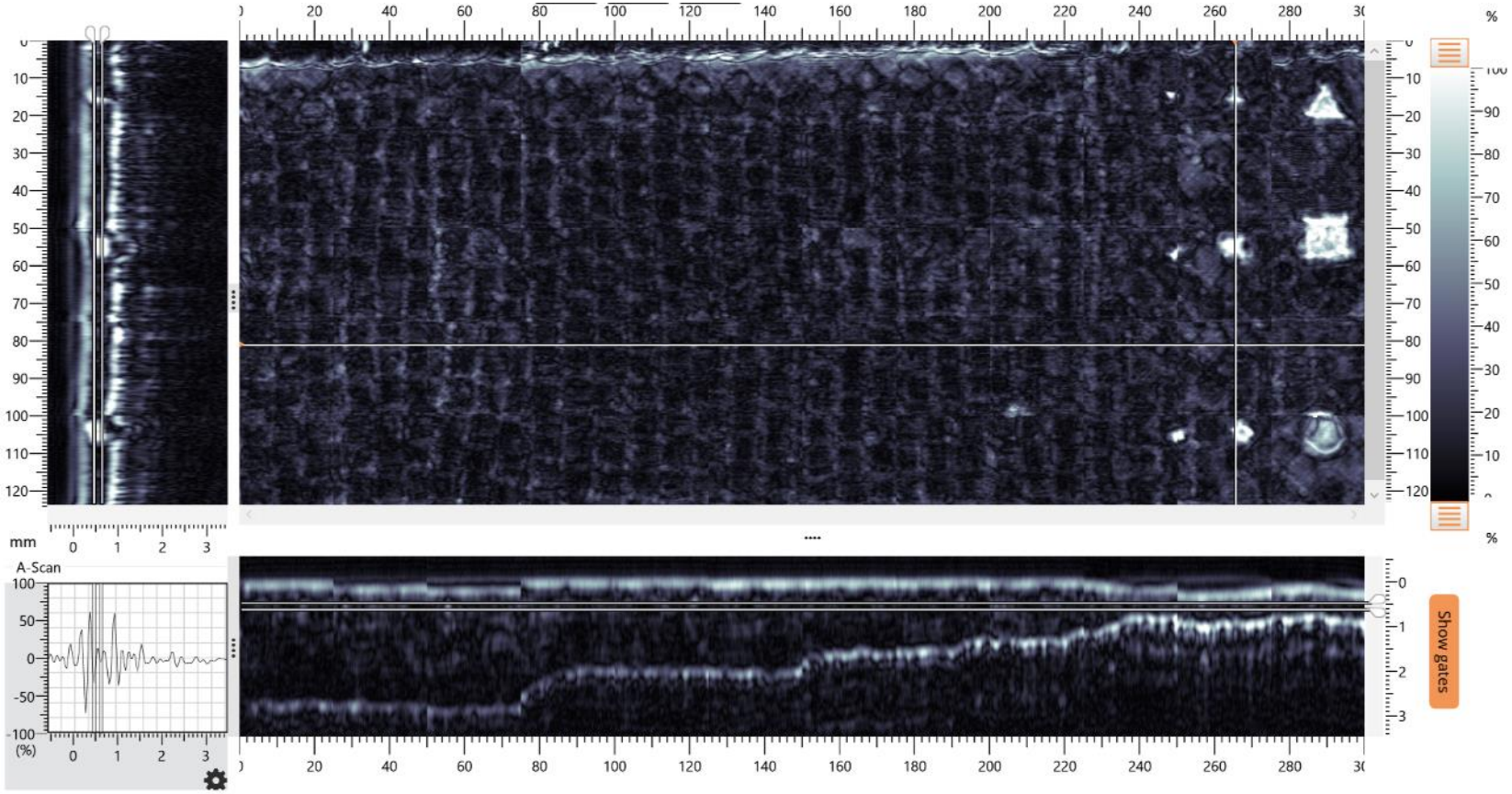




Spread tow CFRP laminate ply drops

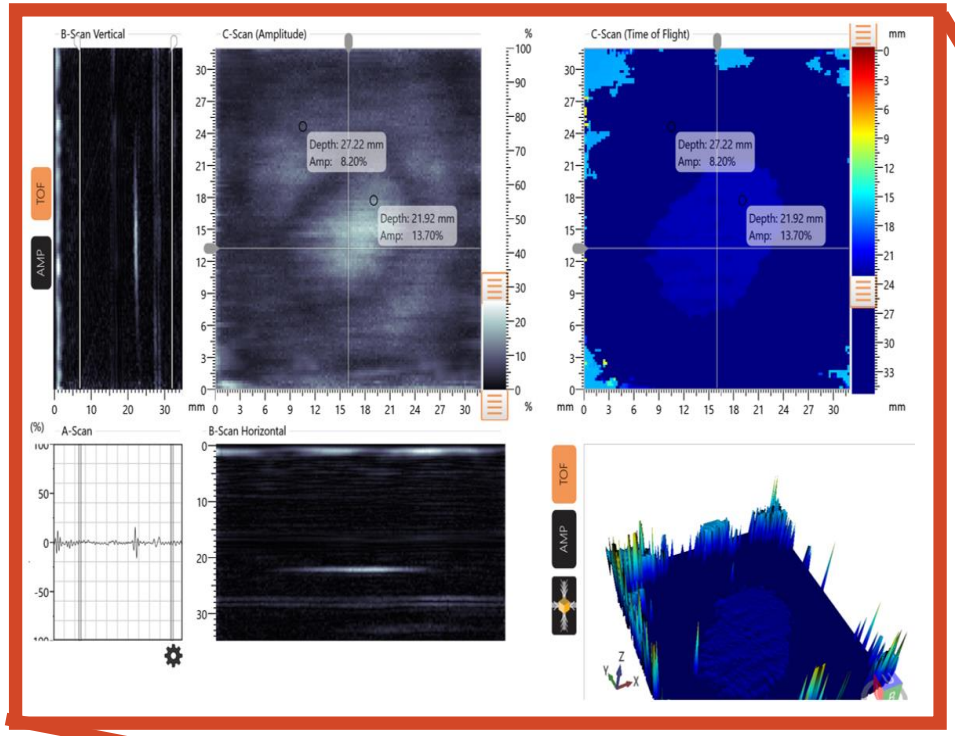
- Internal gating possible to highlight the flaws from each thickness step
- In the image on the right, flaws in Zone A (~0.5mm) are highlighted



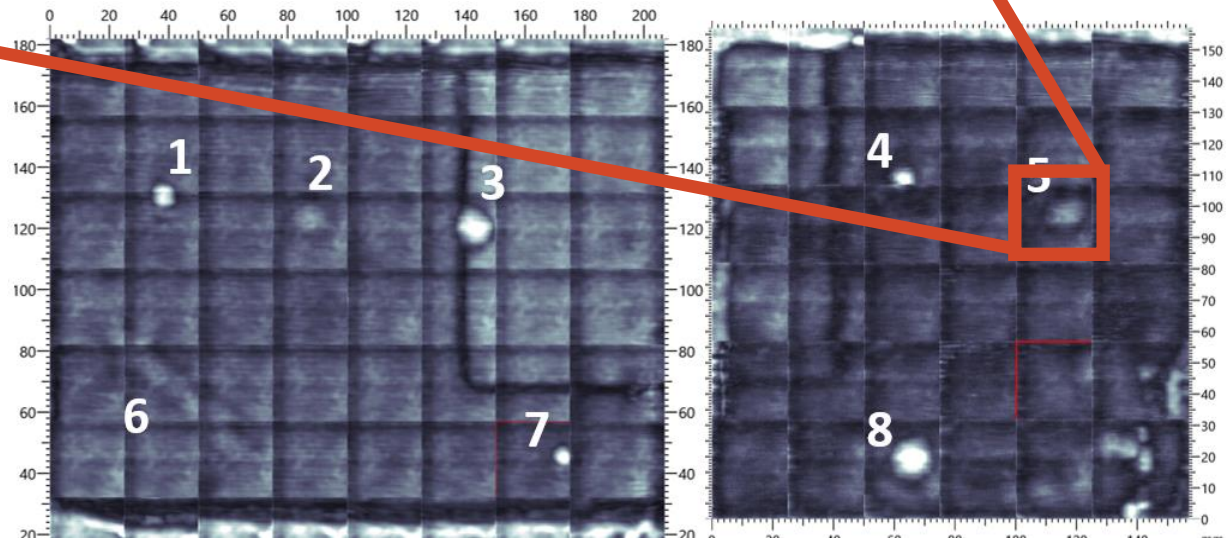


CFRP with backing panel

- 17mm and 27mm thick monolithic CFRP with aluminium backing panel bonded to bottom
- Difference between backed and unbacked regions
- Reflectors embedded in laminate and at bonded interface both resolved

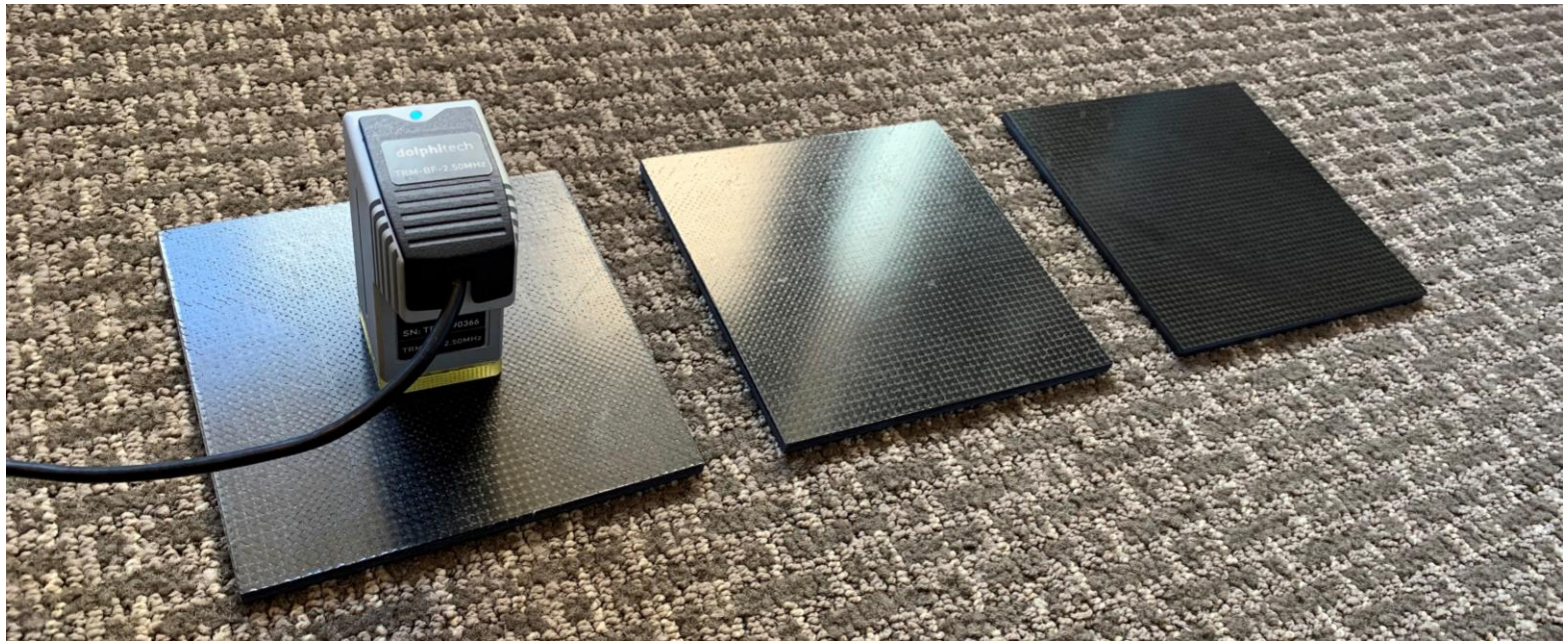


- Amplitude C-scan



CFRP porosity detection

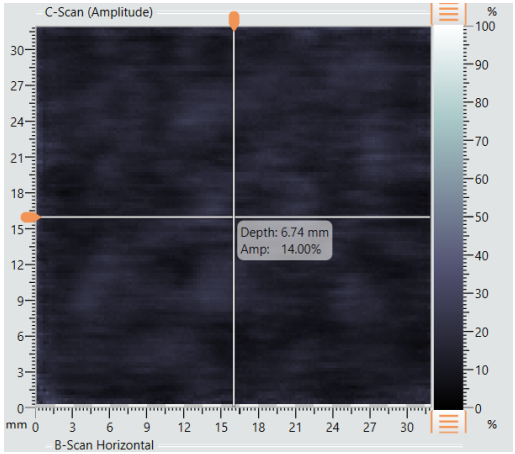
- 3x reference porosity standards were manufactured for dolphitech by Flying S Inc.
- Panels are 1/4” thick monolithic woven CFRP laminates
- To produce different porosity levels, one panel was cured at 50% vacuum, one at 75% vacuum, and one at 100% vacuum
- Back wall echo was gated and max amplitudes compared to assess porosity level



CFRP porosity detection

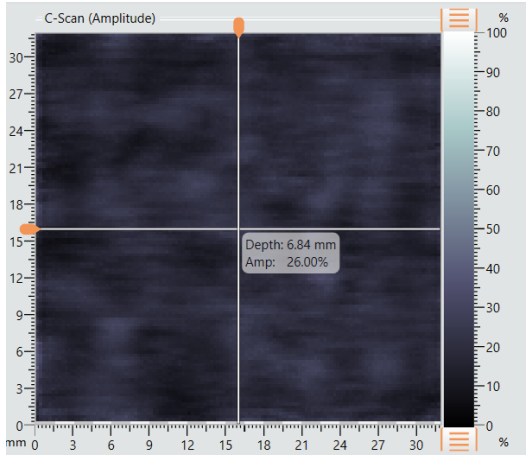
- Most basic level of analysis:
  - Qualitative evaluation of image colour
- Next level of analysis:
  - Single point amplitude measurement using crosshair marker

50% vacuum



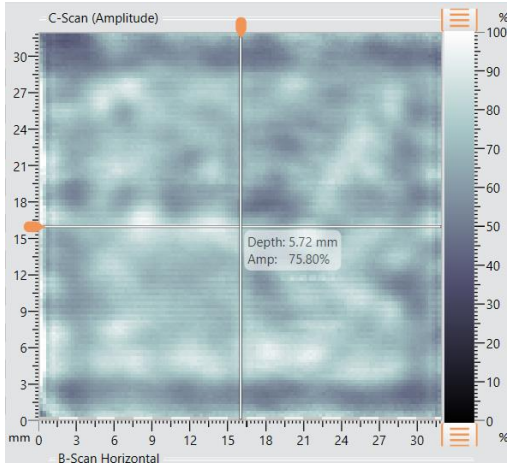
14.0% amplitude

75% vacuum



26.0% amplitude

100% vacuum

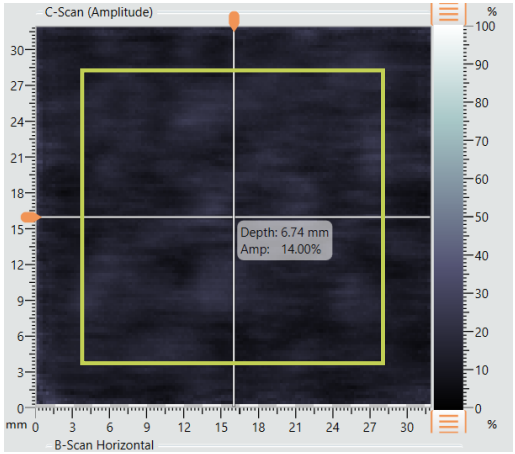


75.8% amplitude

CFRP porosity detection

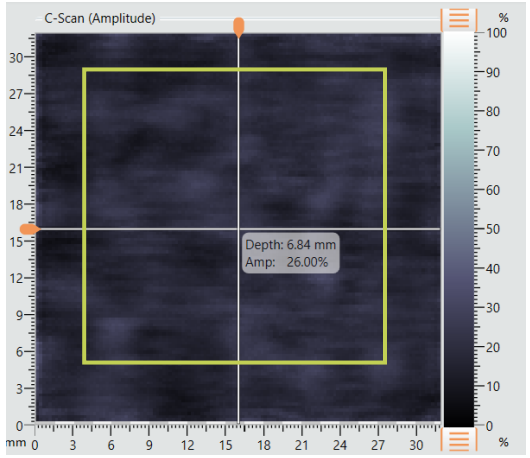
- Next level of analysis:
  - Statistical measurement over region of interest
  - This represents values from 10,000 A-scan (25 x 25mm measurement square)

50% vacuum



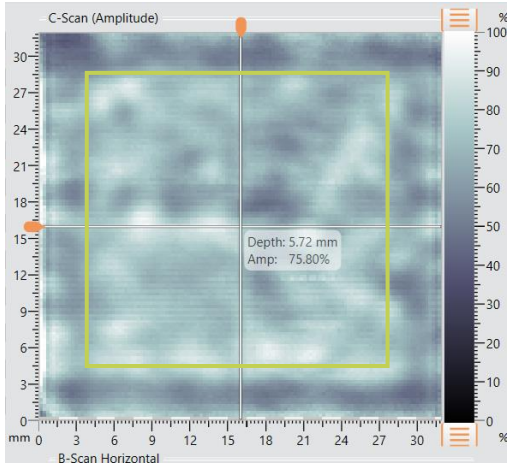
Statistics		
Mean	Median	Mode
16.12 %	16.10 %	16.50 %
Std. Deviation	Maximum	Minimum
3.53 %	28.90 %	6.07 %

75% vacuum



Statistics		
Mean	Median	Mode
19.77 %	19.70 %	19.70 %
Std. Deviation	Maximum	Minimum
3.80 %	34.04 %	8.51 %

100% vacuum

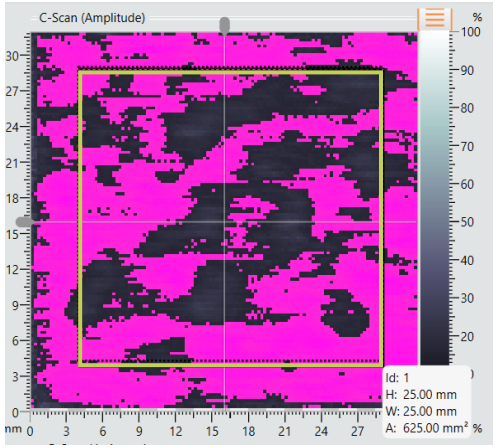


Statistics		
Mean	Median	Mode
72.86 %	72.70 %	71.90 %
Std. Deviation	Maximum	Minimum
7.64 %	98.49 %	45.81 %

CFRP porosity detection

- Final level of analysis:
  - Defect detection tool used over measurement square
  - This applies a threshold amplitude value to the scan data

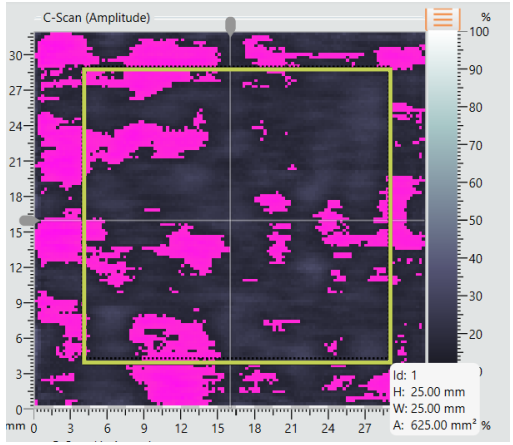
50% vacuum



Statistics		
Mean	Median	Mode
16.12 %	16.10 %	16.50 %
Std. Deviation	Maximum	Minimum
3.53 %	28.90 %	6.07 %

Defect		
Height	Width	Area
24.50 mm	24.75 mm	315.25 mm²
Mean	Median	Mode
13.36 %	13.70 %	15.50 %
Std. Deviation	Maximum	Minimum
2.02 %	16.20 %	6.07 %

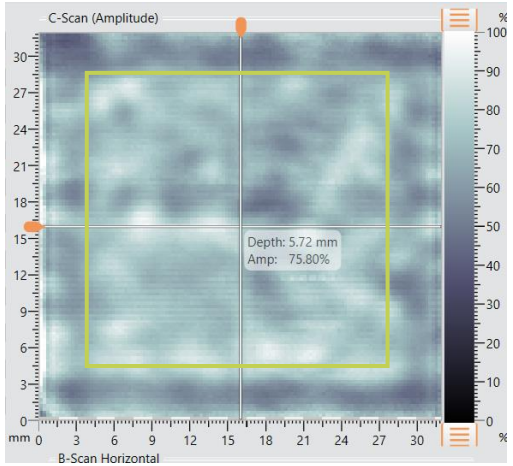
75% vacuum



Statistics		
Mean	Median	Mode
19.77 %	19.70 %	19.70 %
Std. Deviation	Maximum	Minimum
3.80 %	34.04 %	8.51 %

Defect		
Height	Width	Area
24.50 mm	24.75 mm	114.25 mm²
Mean	Median	Mode
14.29 %	14.70 %	15.30 %
Std. Deviation	Maximum	Minimum
1.48 %	16.20 %	8.51 %

100% vacuum



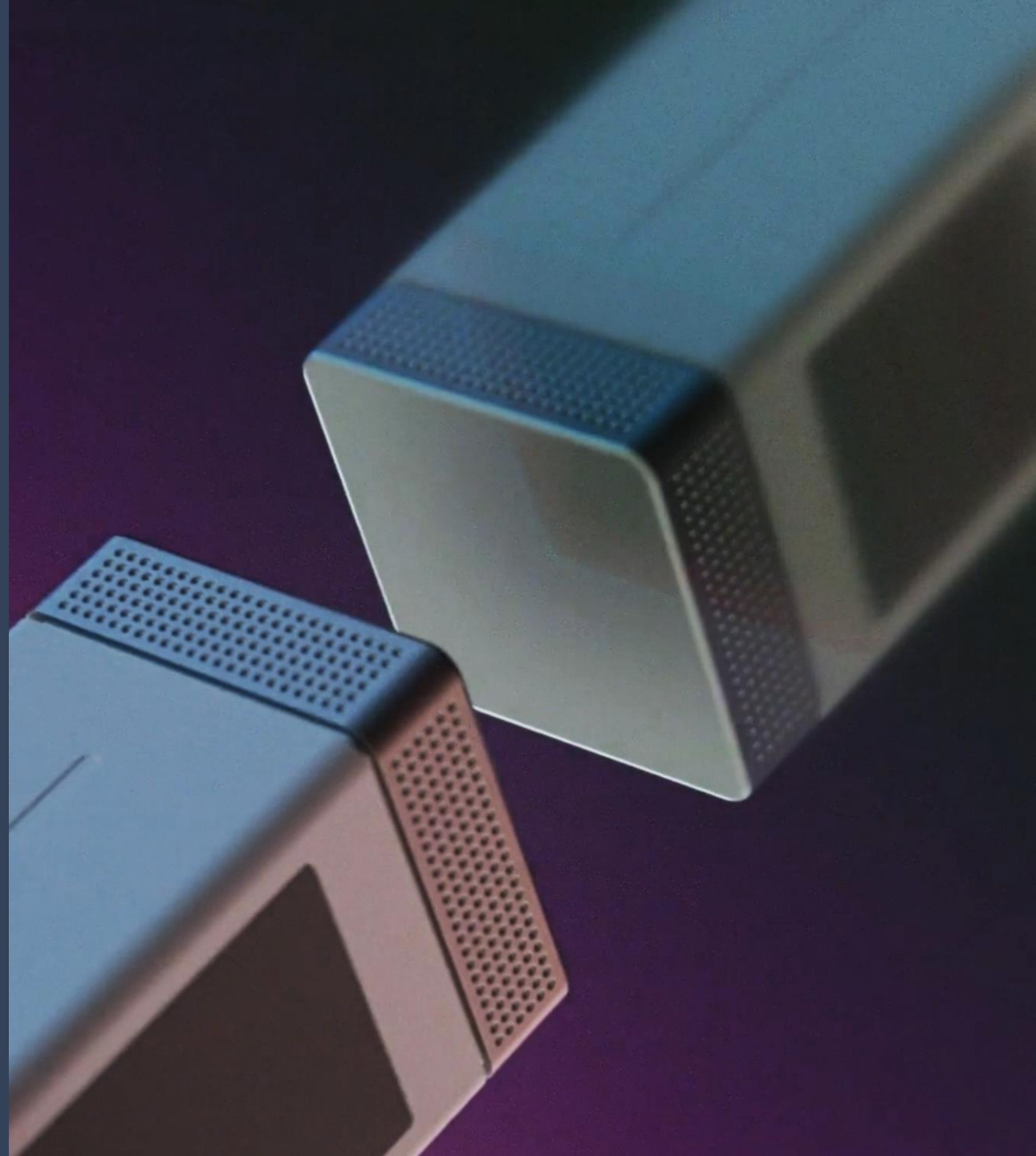
Statistics		
Mean	Median	Mode
72.86 %	72.70 %	71.90 %
Std. Deviation	Maximum	Minimum
7.64 %	98.49 %	45.81 %

Defect		
Height	Width	Area
0.00 mm	0.00 mm	0.00 mm²
Mean	Median	Mode
NaN %	NaN %	NaN %
Std. Deviation	Maximum	Minimum
NaN %	NaN %	NaN %

Introducing Matrix Through Transmission Ultrasound

MxTTU

- Our unique transducer technology now harnessed in through-transmission mode
- This enables inspection of challenging composite structures including multiple bond layers and core samples
- Improved alignment capacity provided by the matrix array
- Ability to toggle between TTU and pulse echo for in-line defect sentencing

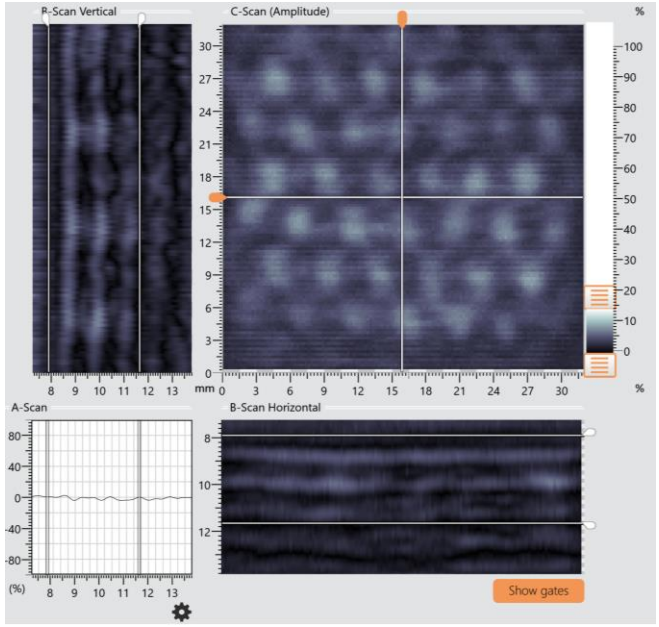


MxTTU

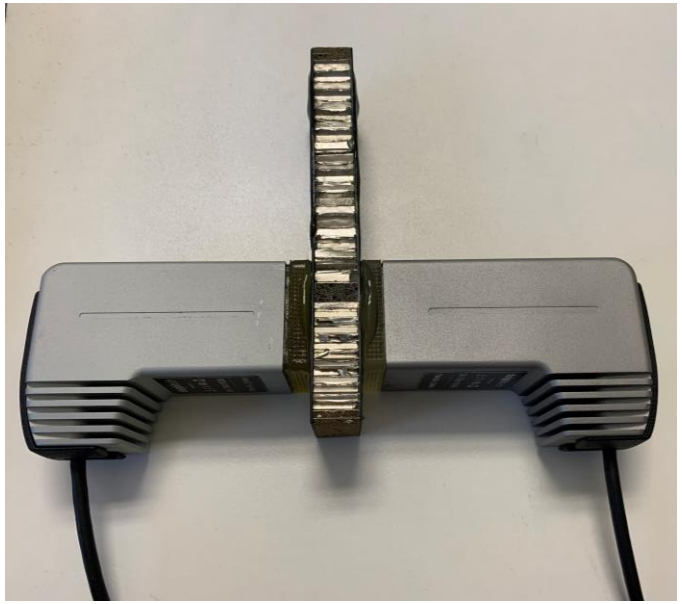
Aluminium core

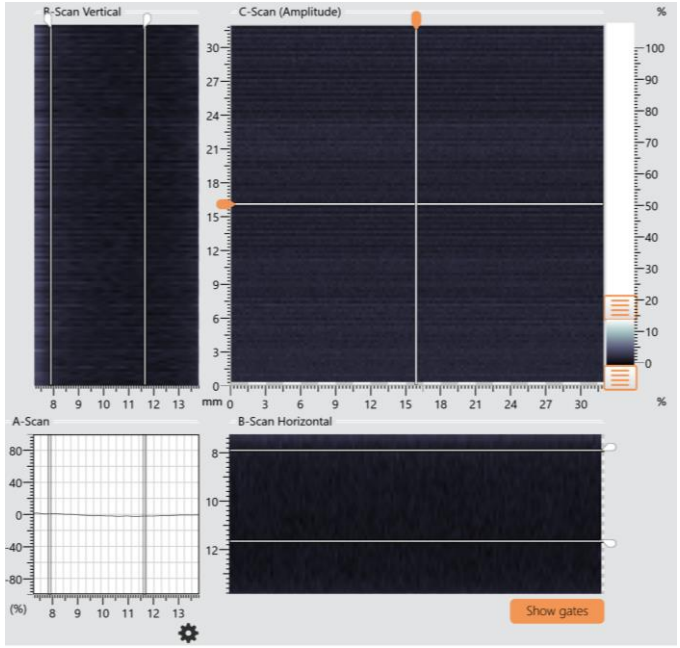
- 1mm thick unidirectional CFRP skins
- 14mm aluminium honeycomb core
- One half of the sample bonded, the other half unbonded
- 2.5MHz MxTTU can readily distinguish between them

- Bonded structure



- Unbonded structure

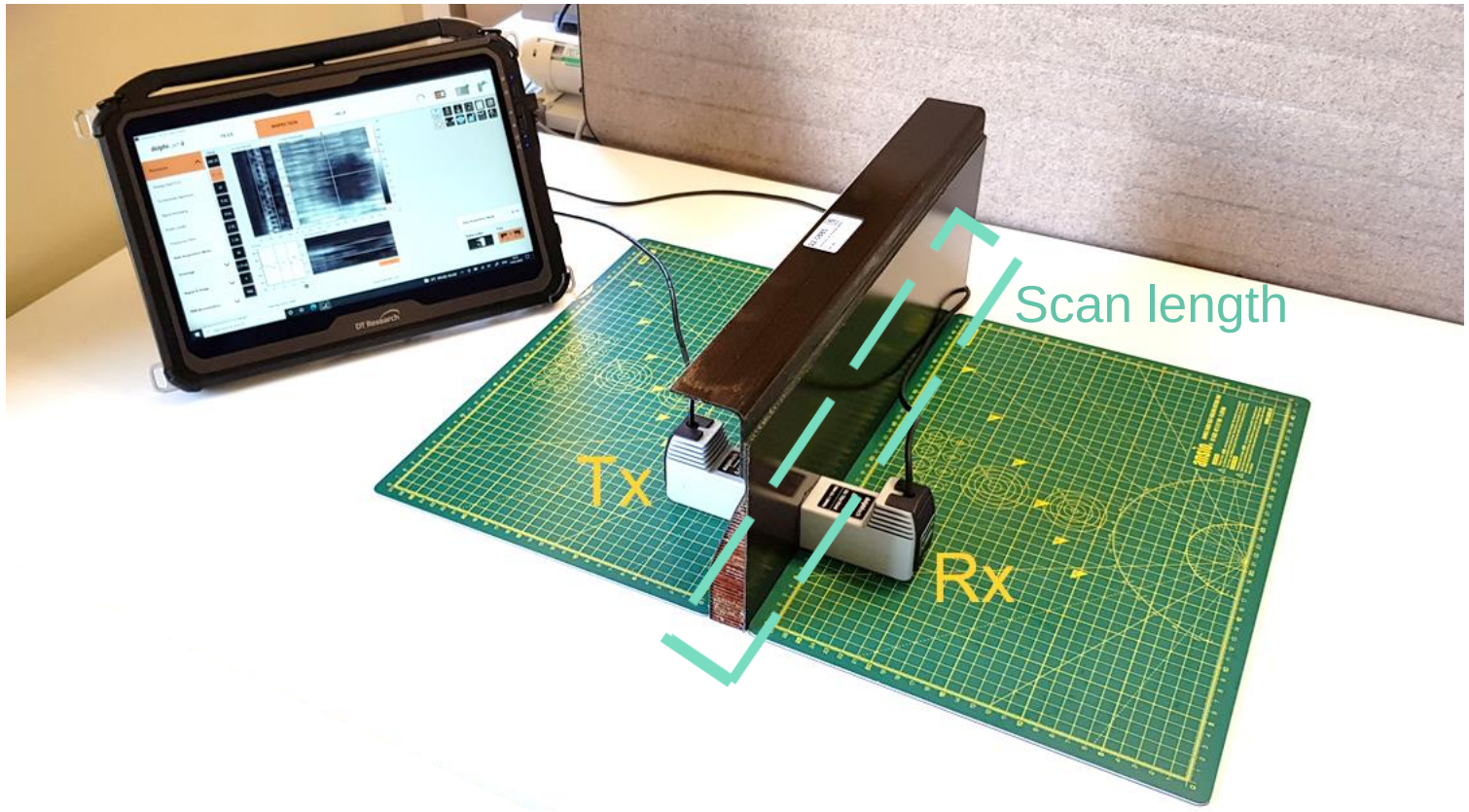


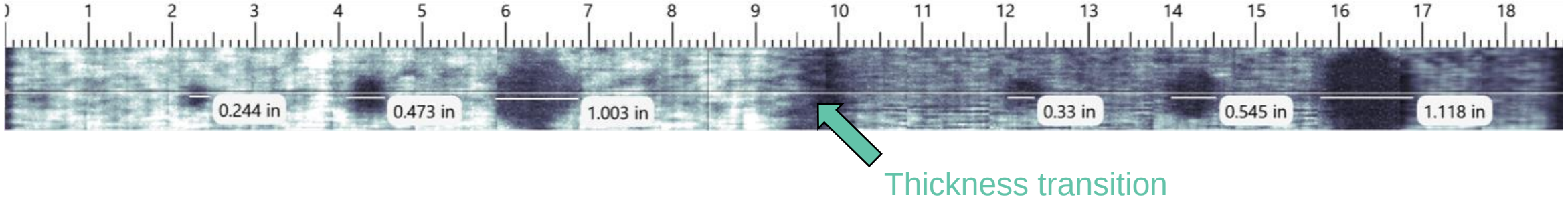


MxTTU

Nomex core

- 1.7mm thick woven CFRP skins
- 25mm thick Nomex core
- 3x circular reflectors on each side of the skin-to-core interface
- 1.5MHz MxTTU with EA transducers (no delay line)

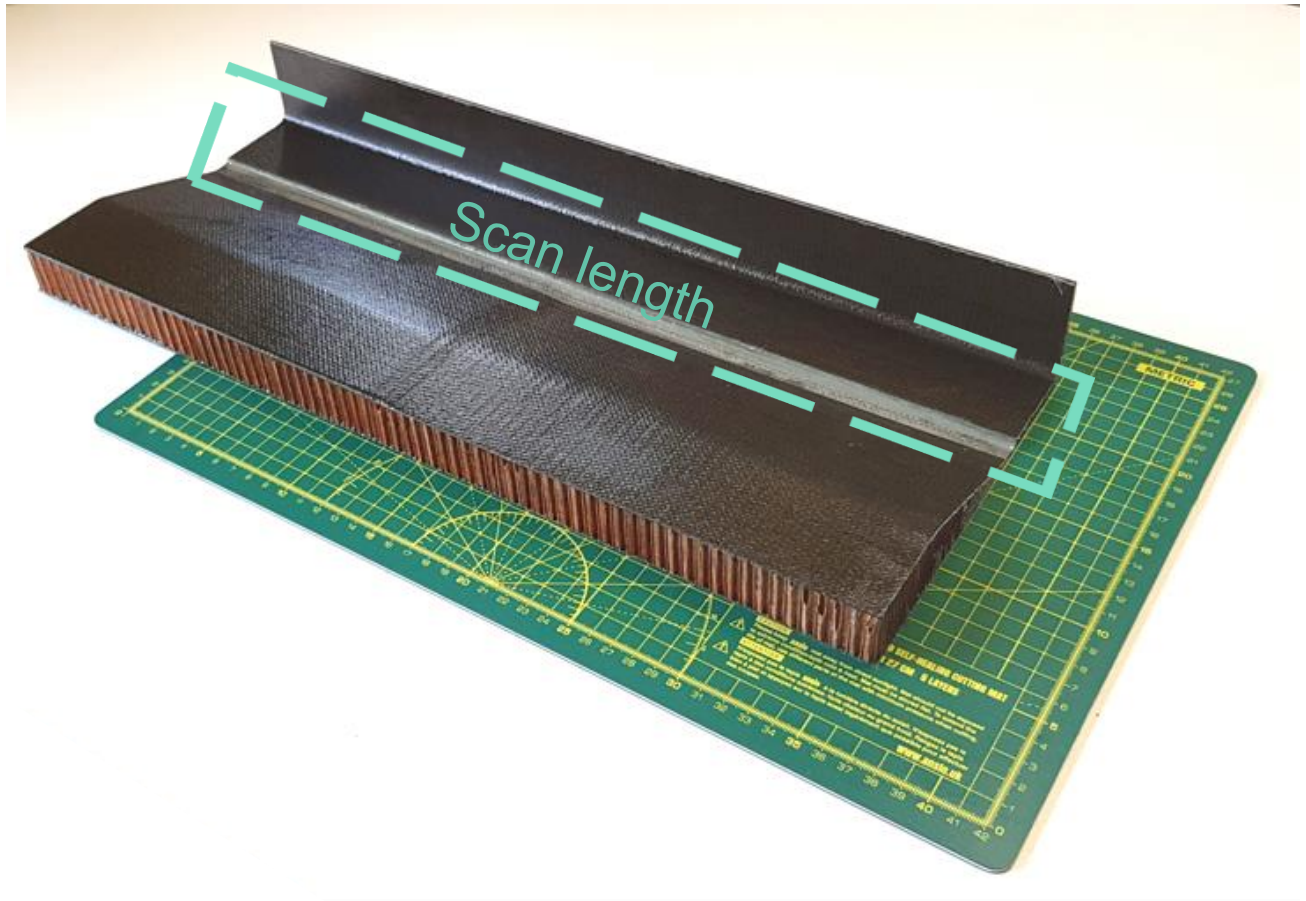


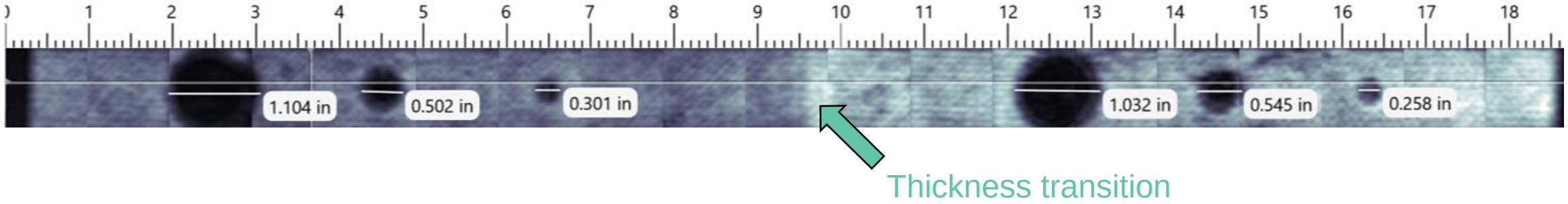


MxTTU

Adhesive bondline

- 6mm total thickness woven CFRP
- Epoxy adhesive layer thickness varies from 0.7mm to 2mm
- 3x circular reflectors on each side of the adhesive bond interface
- 3.5MHz MxTTU with AF TRMs (8mm Aqualene delay line)

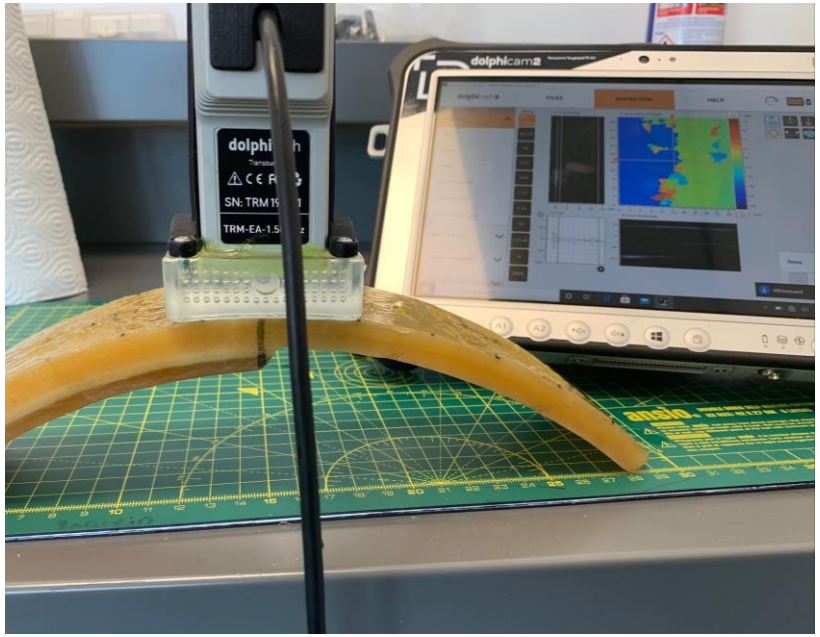


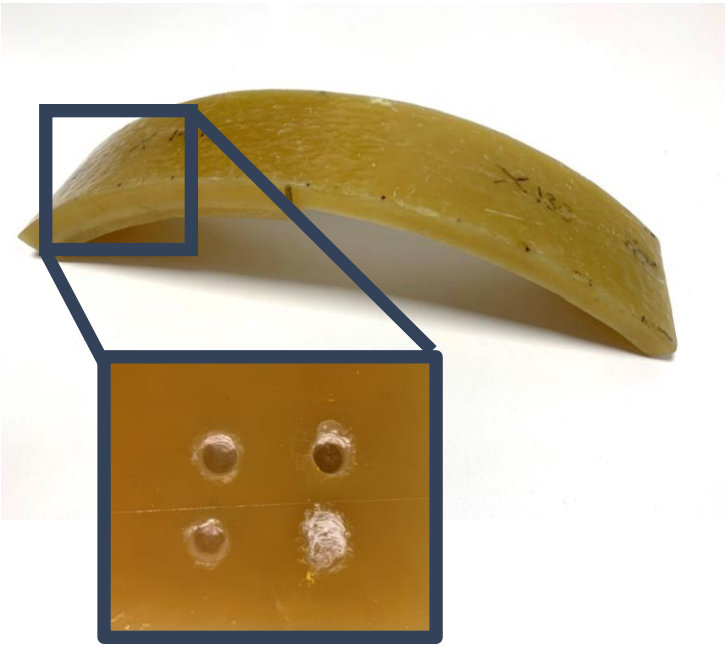


Glass fibre composites and plastics

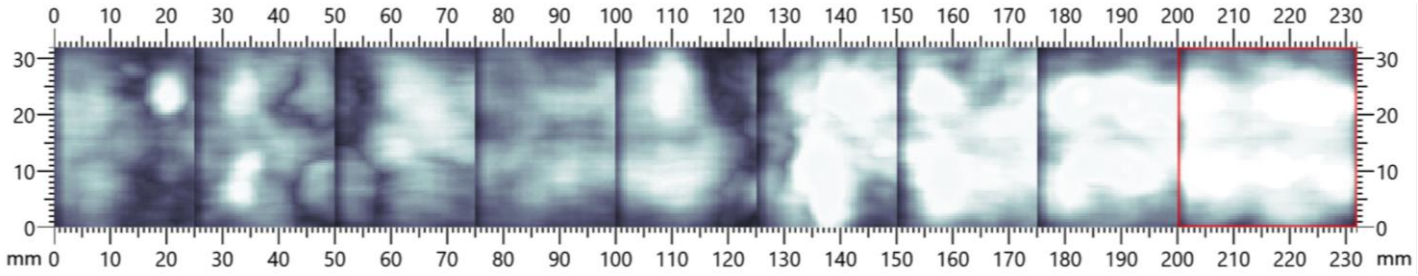
Fibre Reinforced Plastic (FRP) piping

- 1.5MHz transducer with 600mm pipe shoe attached
- Pipe sample with thickness transition from 13 to 19mm
- Holes milled into inner surface

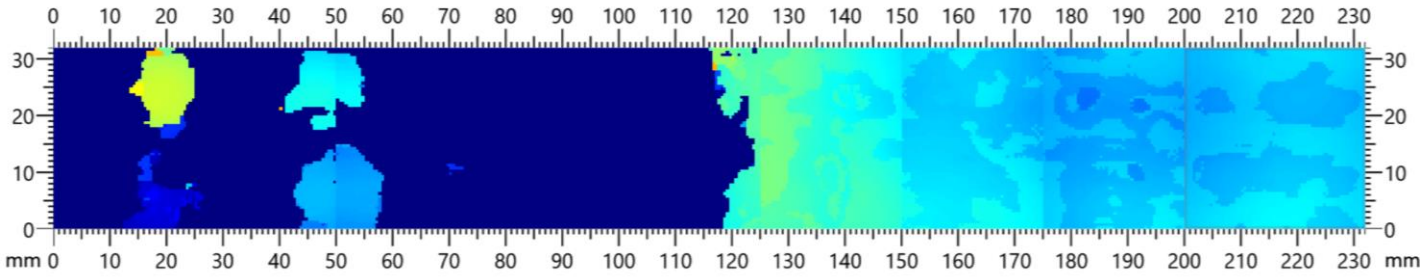




- Amplitude C-scan



- ToF (Depth) C-scan

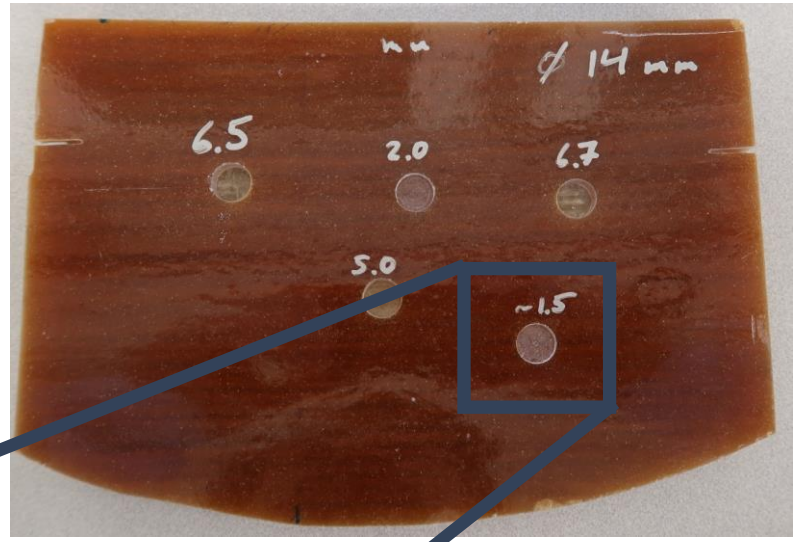


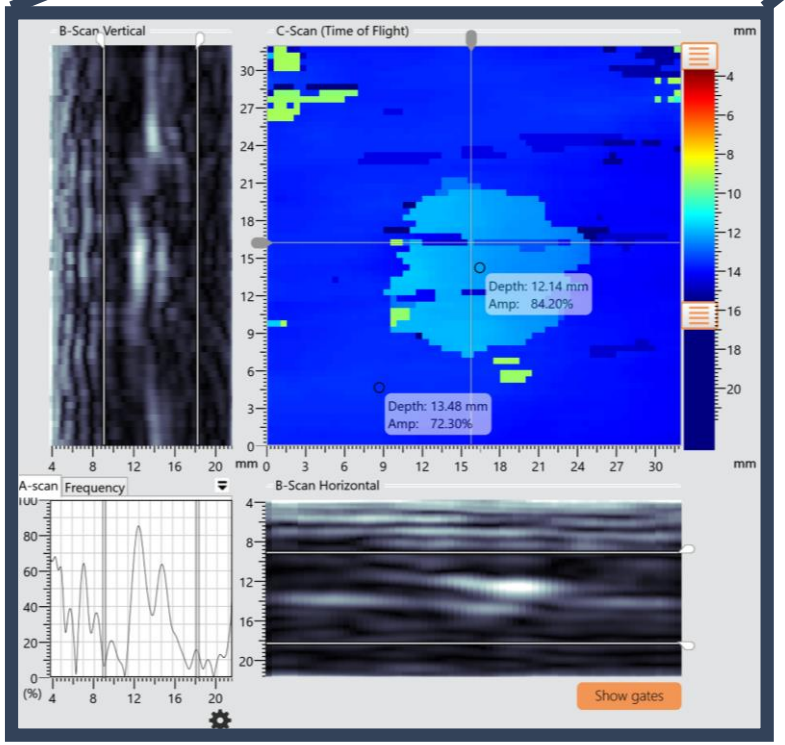
FRP piping

- Flue gas stack sample
- 13.5mm thickness
- Outer surface is 70% fibre volume fraction
- Inner surface is 30% fibre volume fraction
- Inspection to inner surface possible
- Images courtesy of Research Institutes of Sweden

– Inspection surface

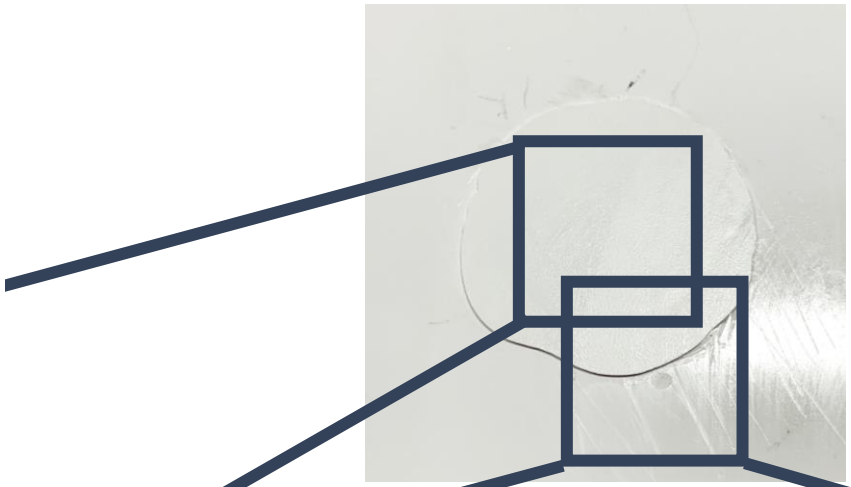
– Back surface

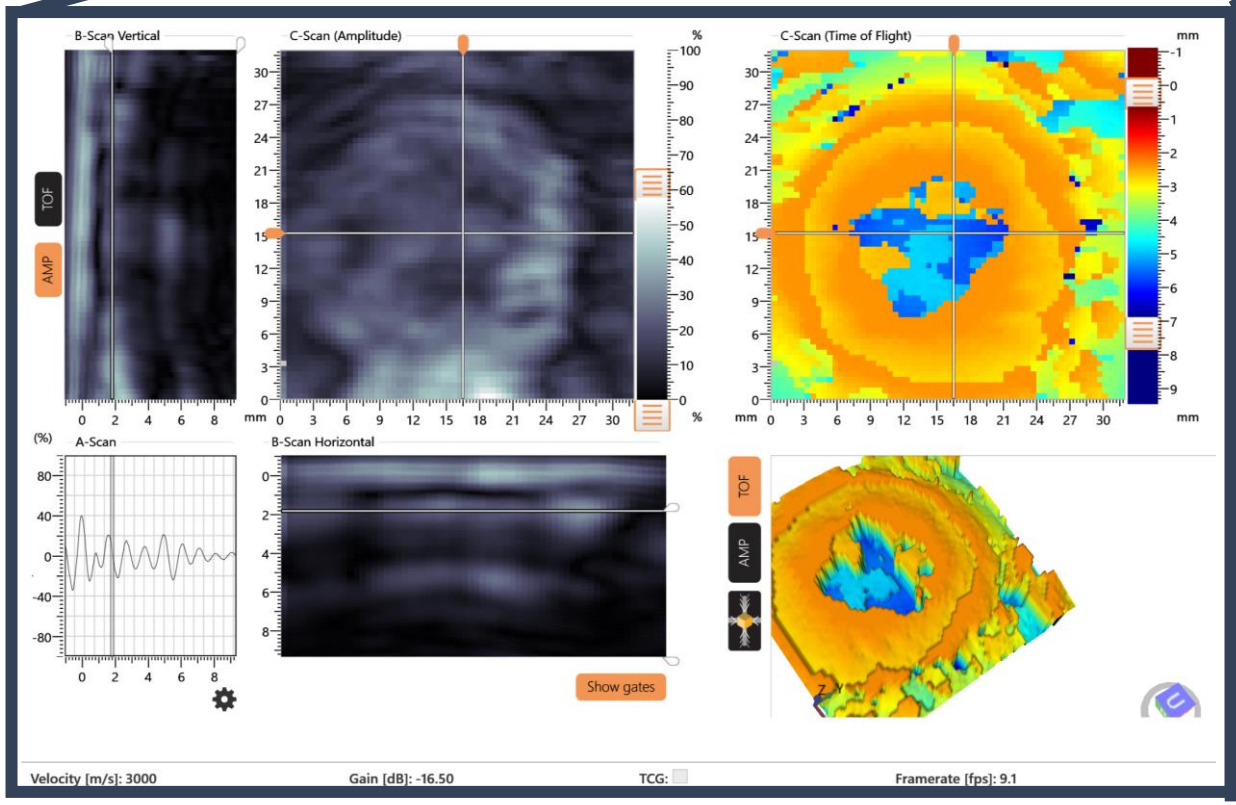


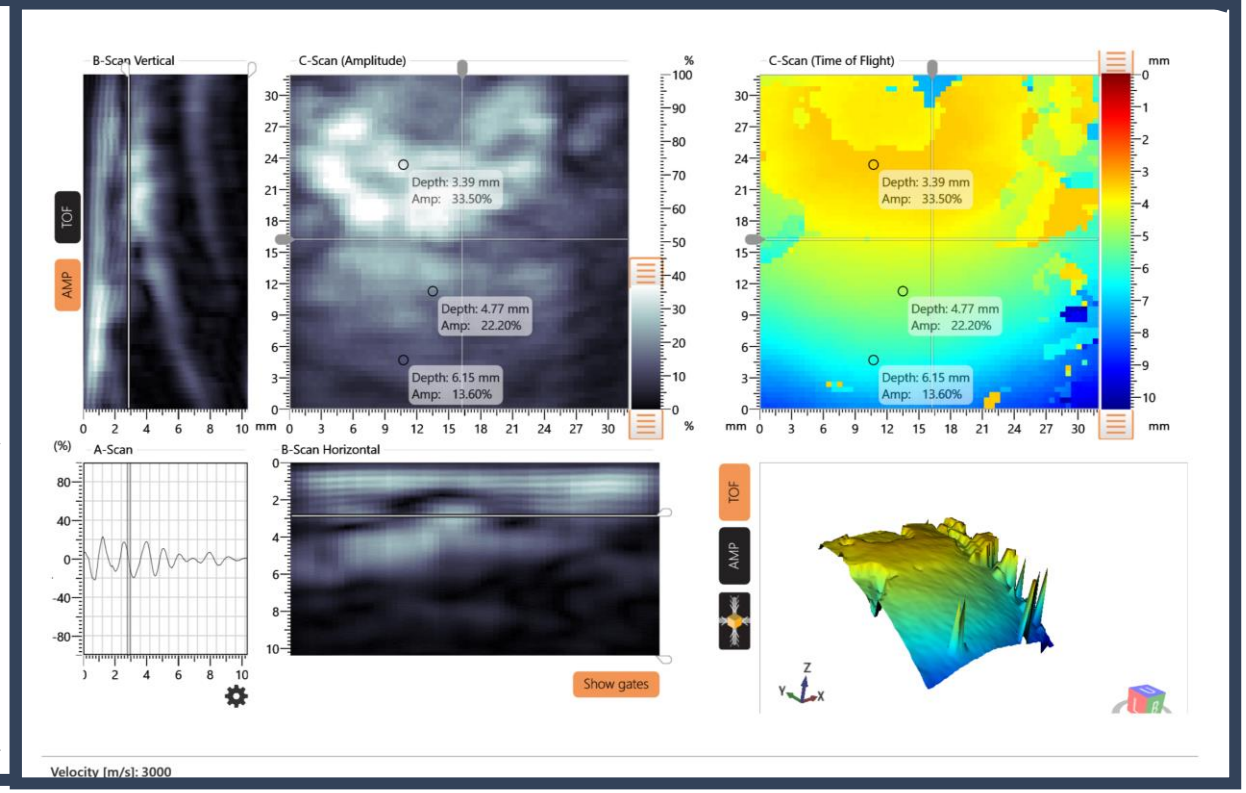


Yacht hull repair region

- Glass fibre hull of a large motor yacht
- Repair plug region
- Scarf angle slope visible at edge of repair



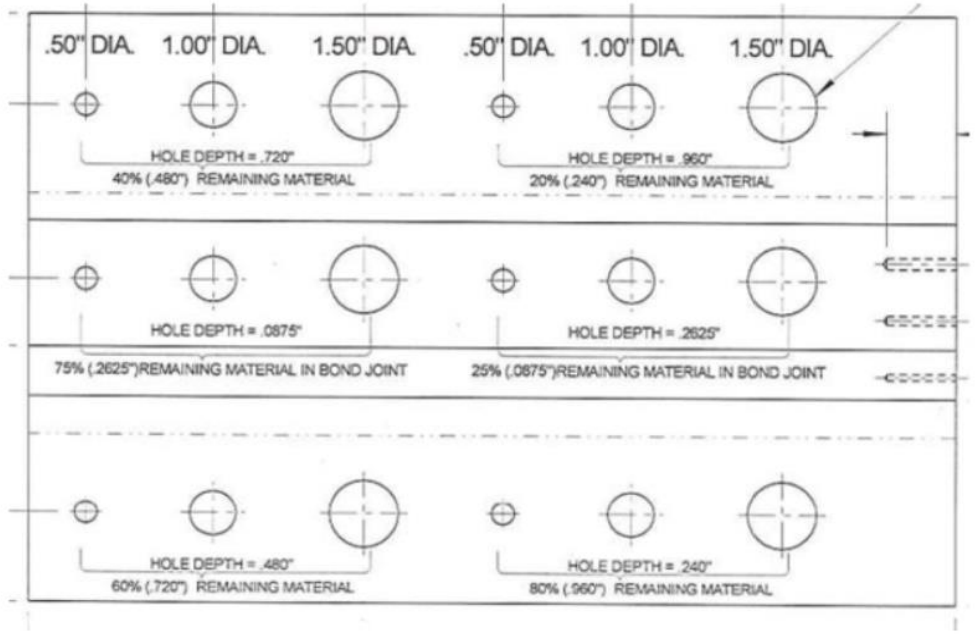




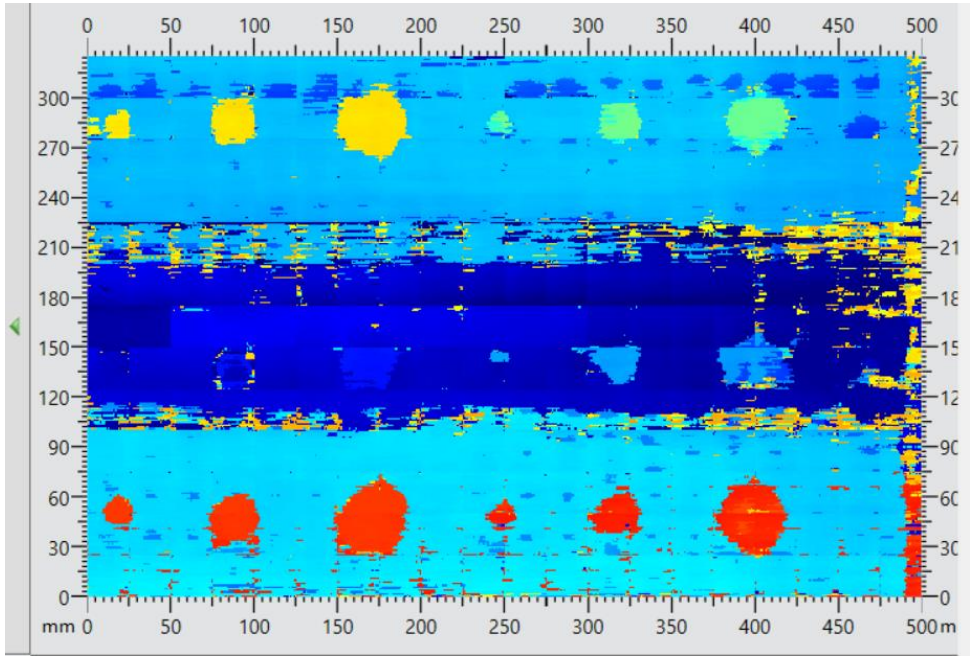
Wind blade GFRP

- Sample is part of a round robin trial with SANDIA Labs in the US
- 30mm thick with additional adhesive strip across centre
- Representative of blade skin with thick bondline underneath
- Reflectors are flat bottomed holes

- Technical drawing



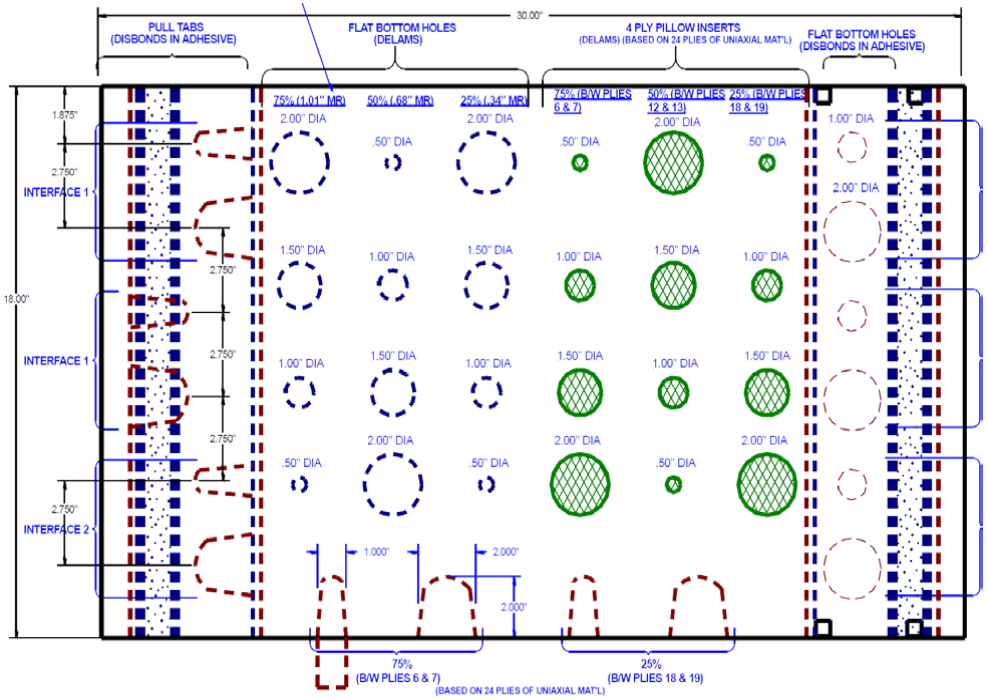
- ToF (Depth) C-scan



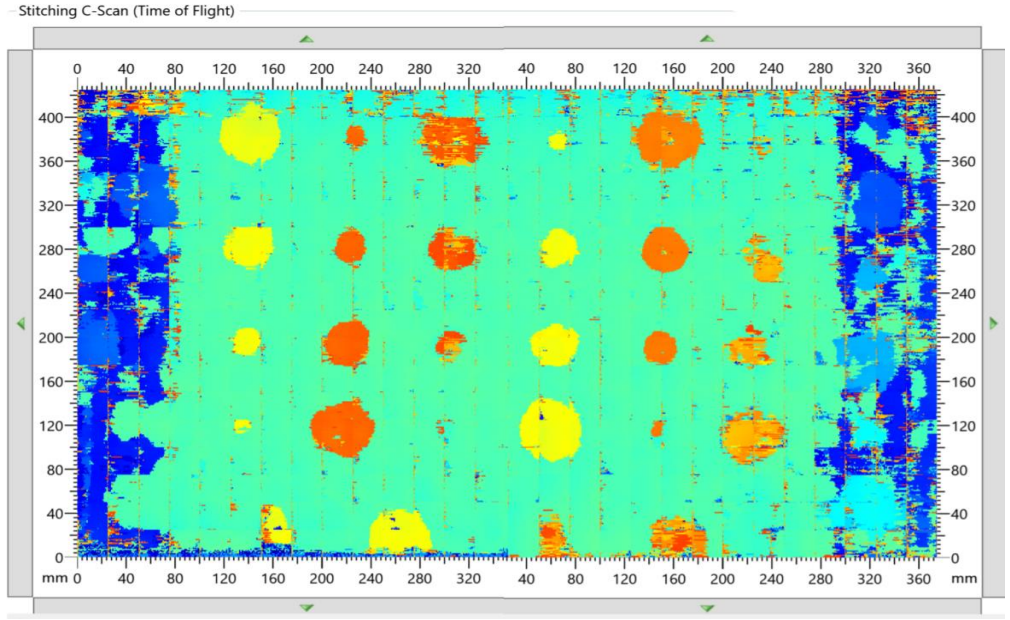
Wind blade GFRP

- Sample is part of a round robin trial with SANDIA Labs in the US
- 32mm thick with additional adhesive strip along edges
- Representative of blade skin with thick bondline underneath
- Reflectors are flat bottomed holes, pillow insert and disbonds

– Technical drawing

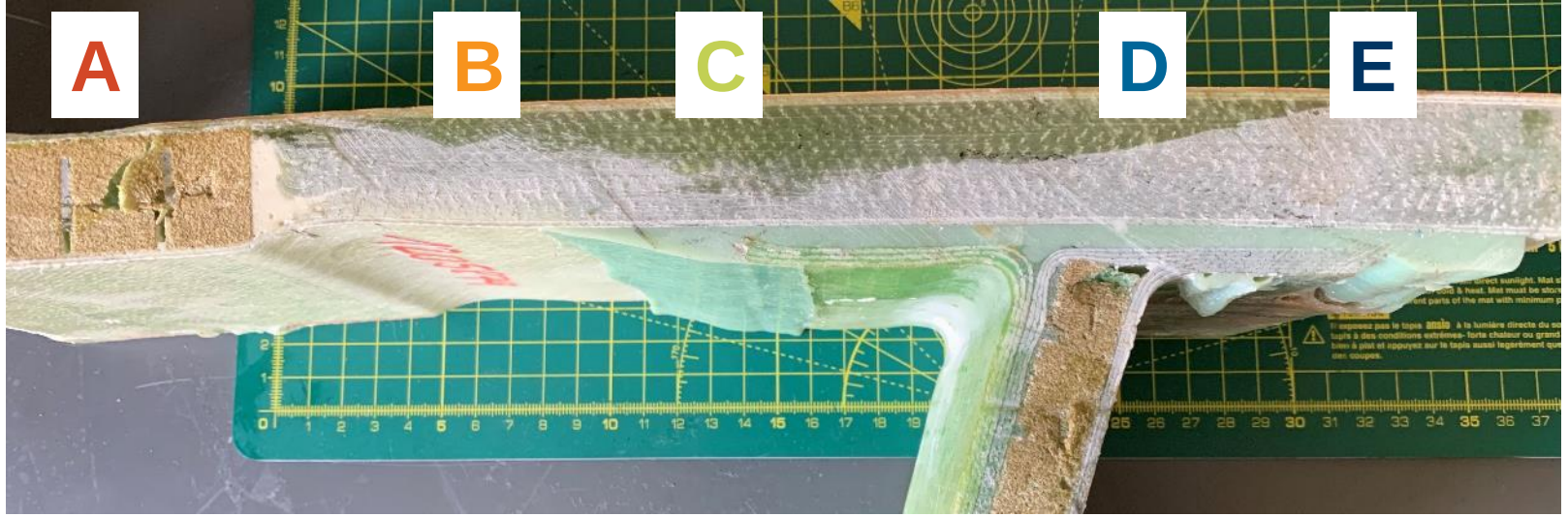


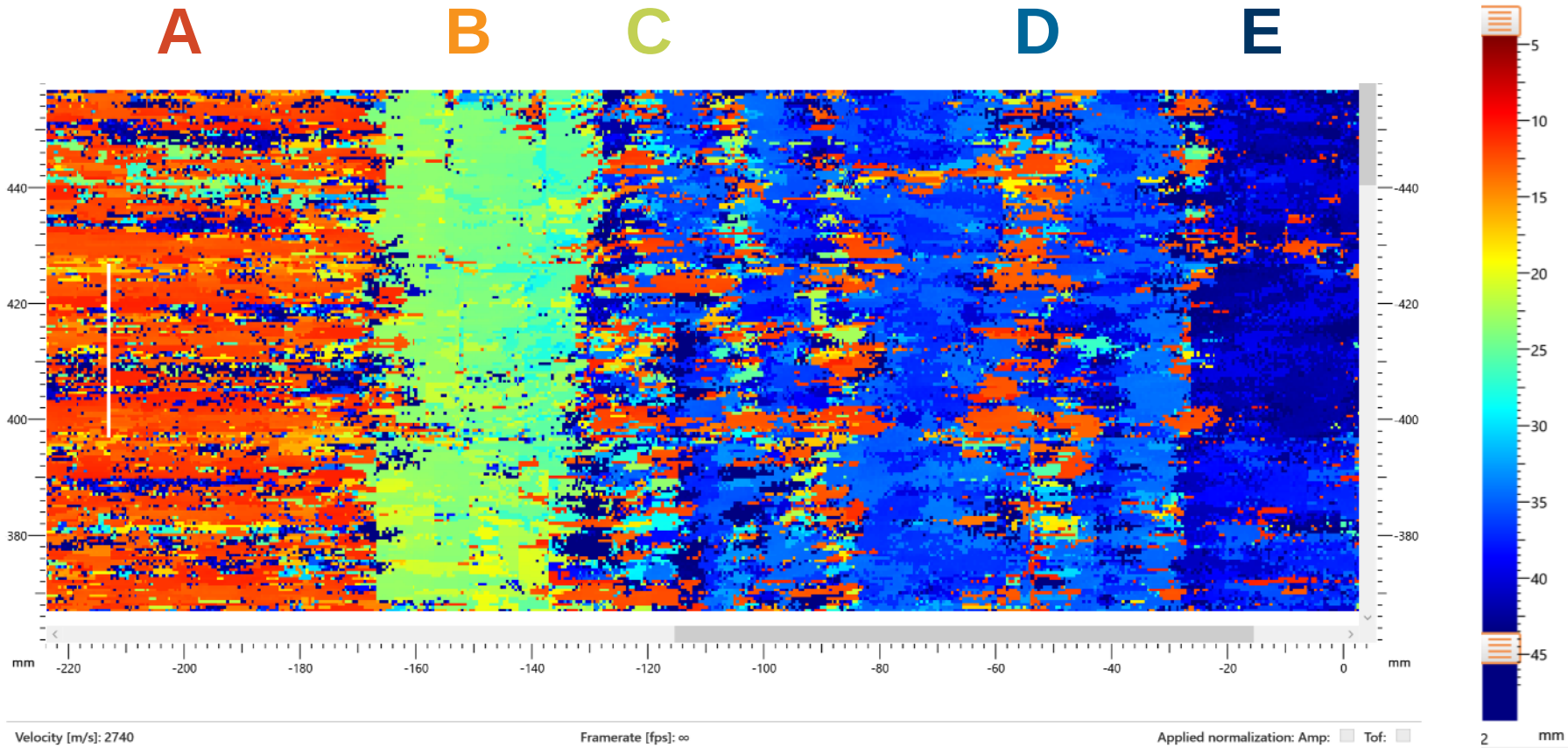
– ToF (Depth) C-scan



Inspection in service

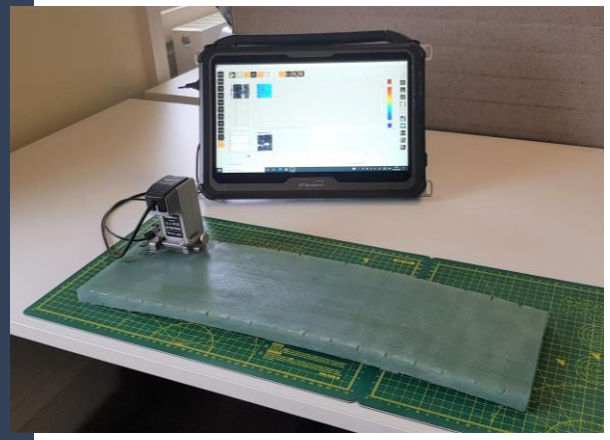
- 38mm thick spar cap to shear web bonded piece from real wind blade
- Data acquired with a 1.5MHz TRM in direct contact with the part
- Three distinct thickness regions observed:
  A) Thin skin to foam core
  B) Back surface of spar cap
  E) Back surface of shear web flange
- Loss of backwall echo observed on
  C) adhesive slope
  D) Location where the shear web extends downward through the blade
- Watch the video **here**



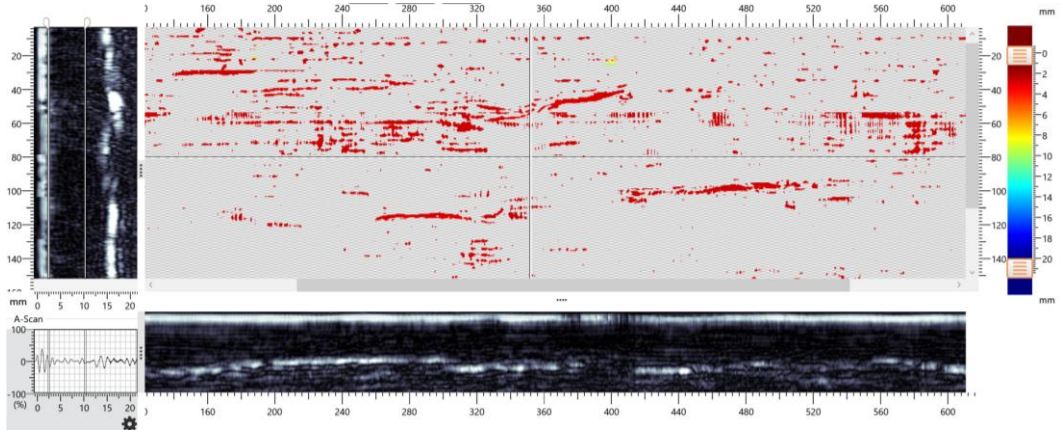


Wrinkles in GFRP

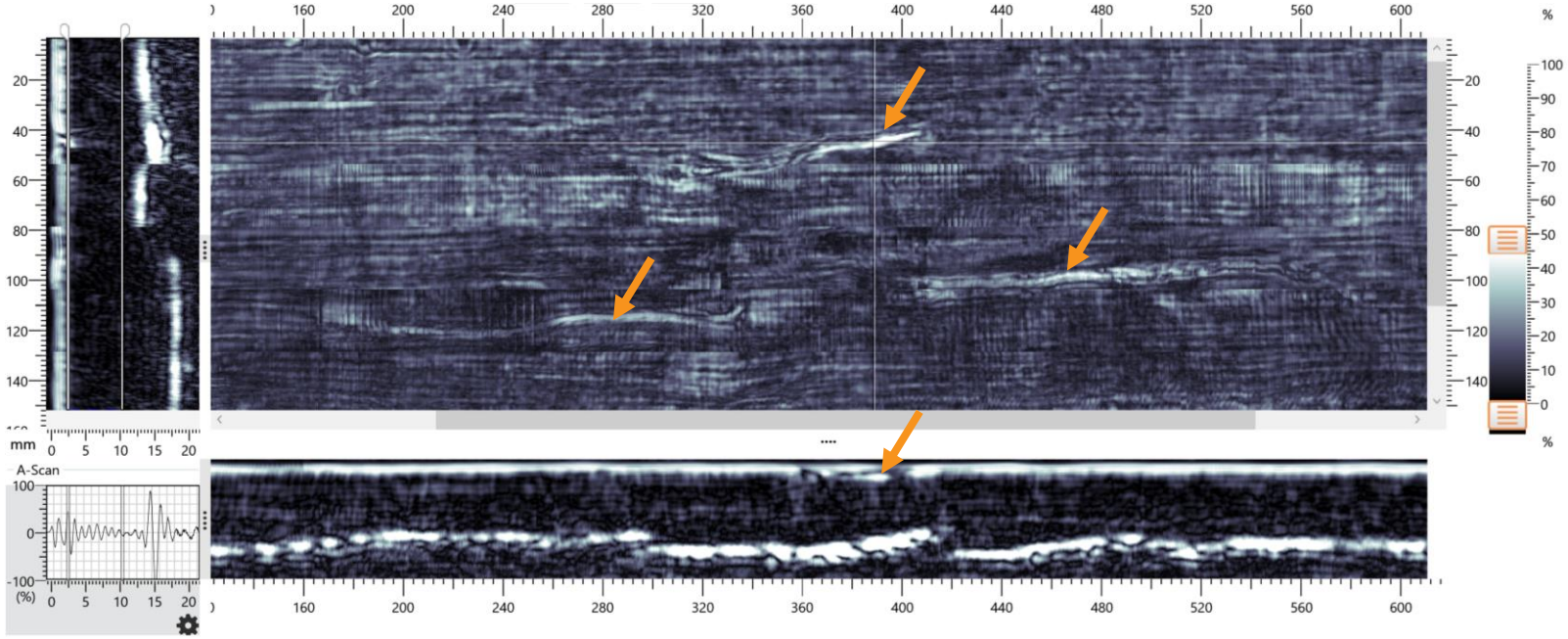
- 20mm thick section of wind turbine blade skin material containing out-of-plane wrinkles.
- Wrinkles successfully resolved and found to be near the surface.
- Data can be gated with a threshold applied to highlight and quantify wrinkles.



Thickness (ToF) with an amplitude threshold

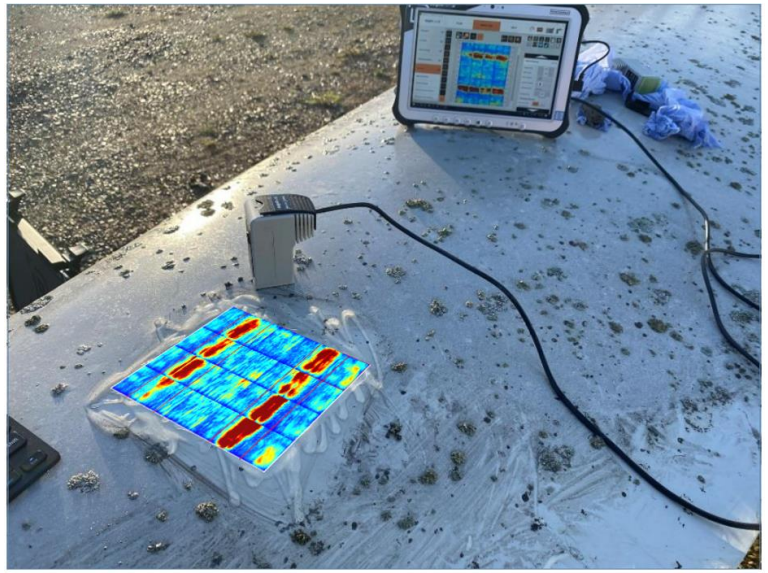


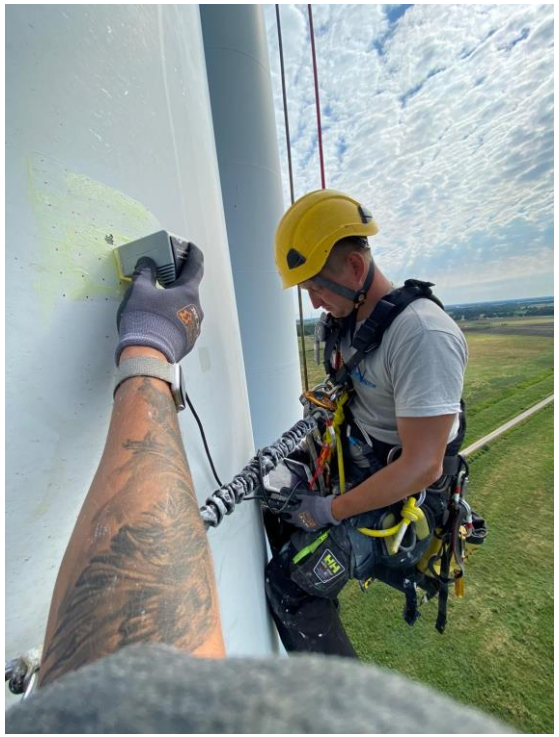
Amplitude

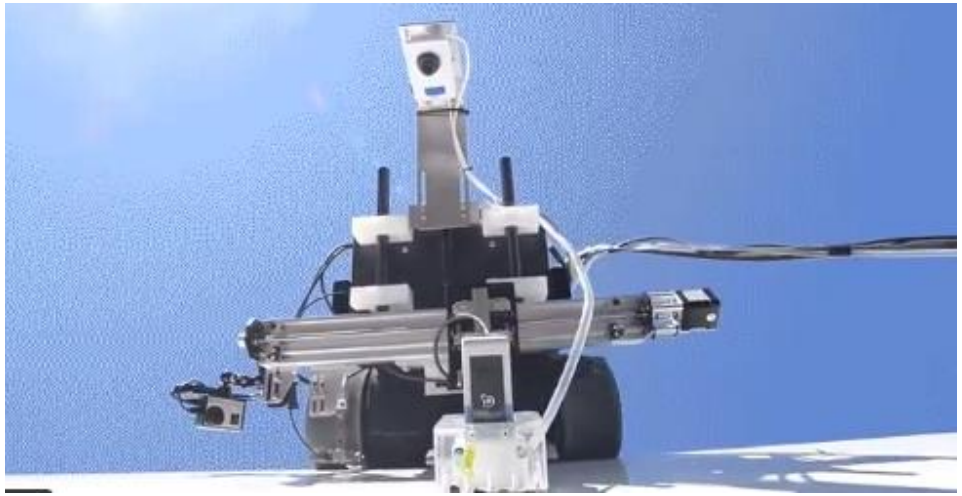


Wind blade inspections

– The dolphicam2 can be used both free hand by rope access technicians and by crawlers

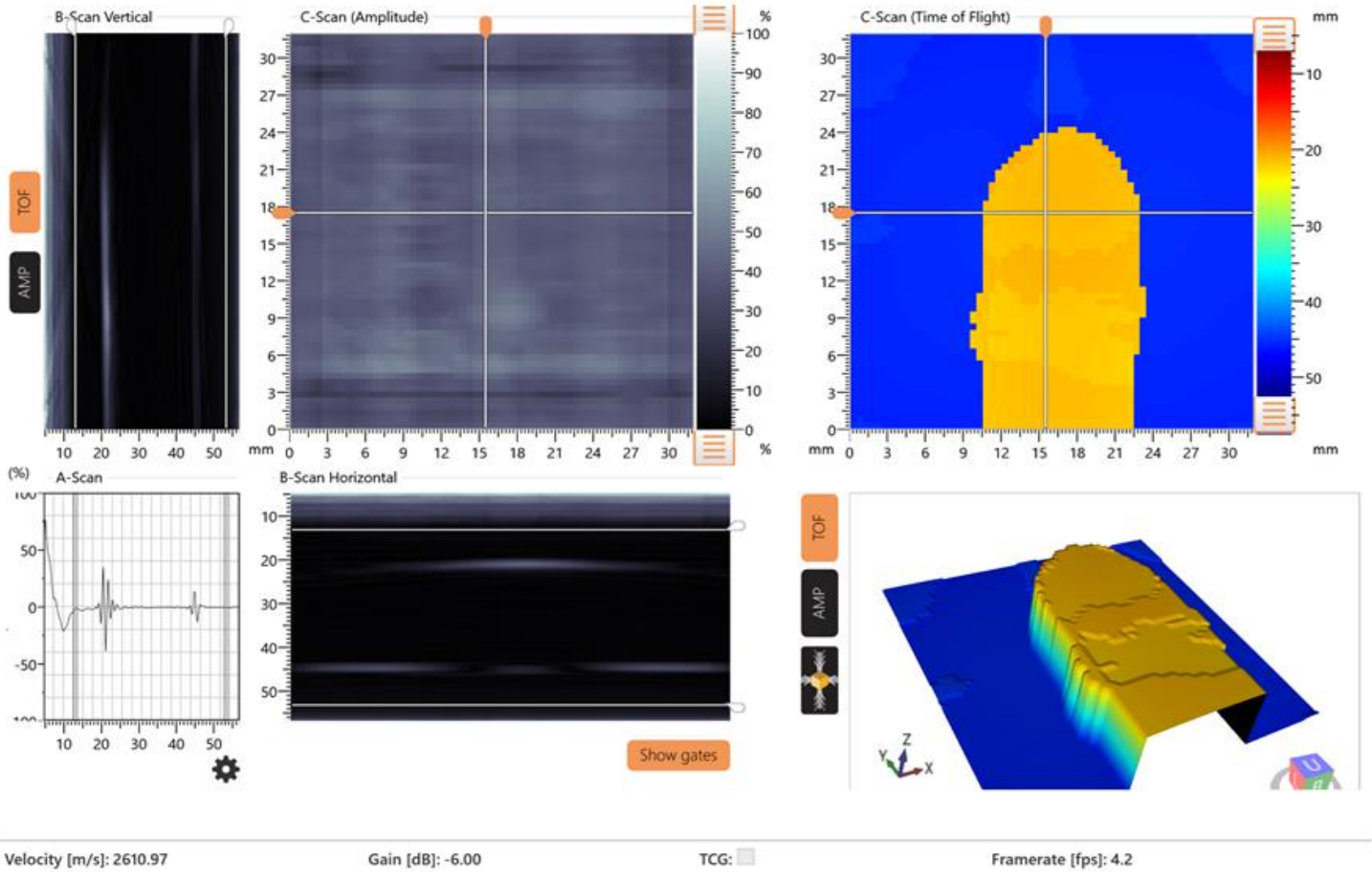






Polyethylene piping

- 40mm thick polyethylene piping sample
- Clear detection and visualisation of side drilled holes at 20mm depth
- On electrofusion welds, voids and copper wires also visible to depths of 40mm
- Images courtesy of Research Institutes of Sweden

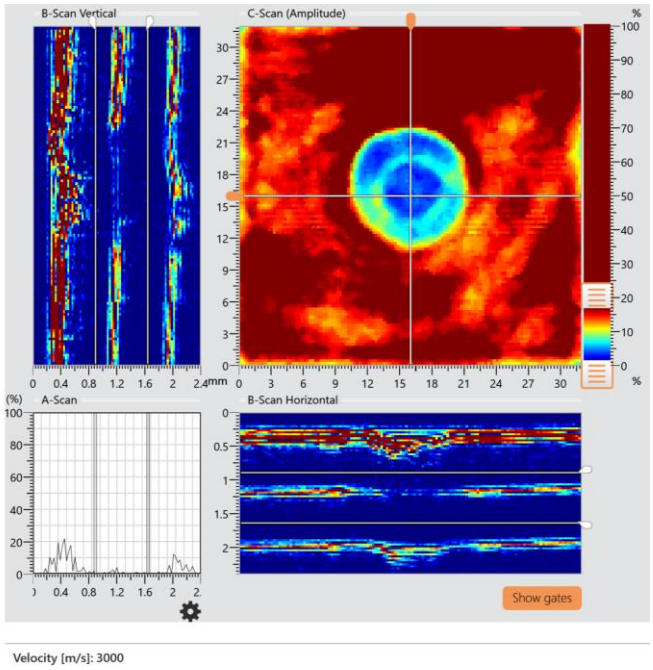


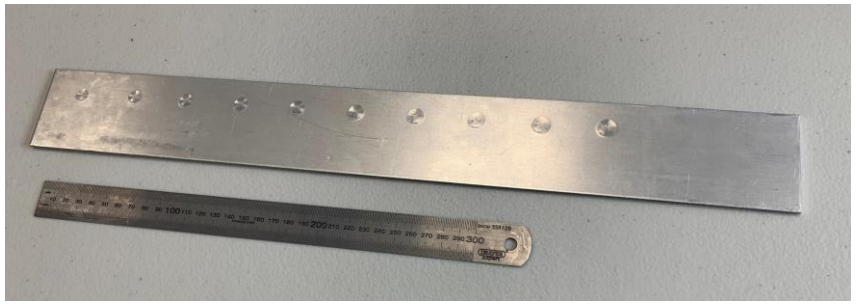
RI. SE

Metals and bonding

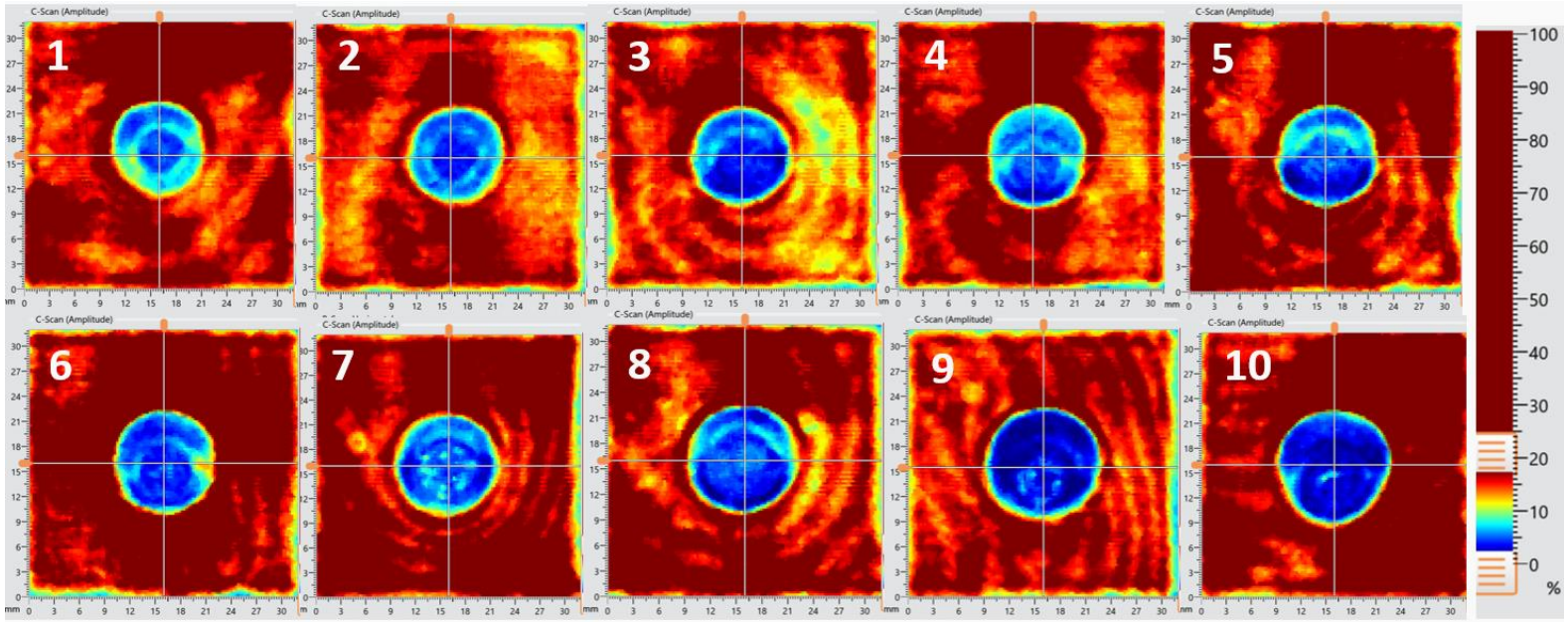
Automotive spot welds

- 10x aluminium spot weld inspected
- Weld diameters and contact spots identified
- 32x32mm aperture ideal for single location capture
- Mid thickness welded interface is gated in the B-scan



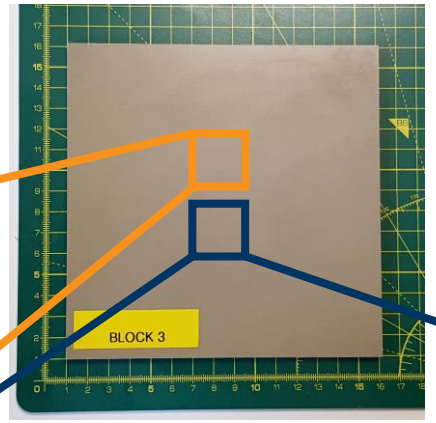


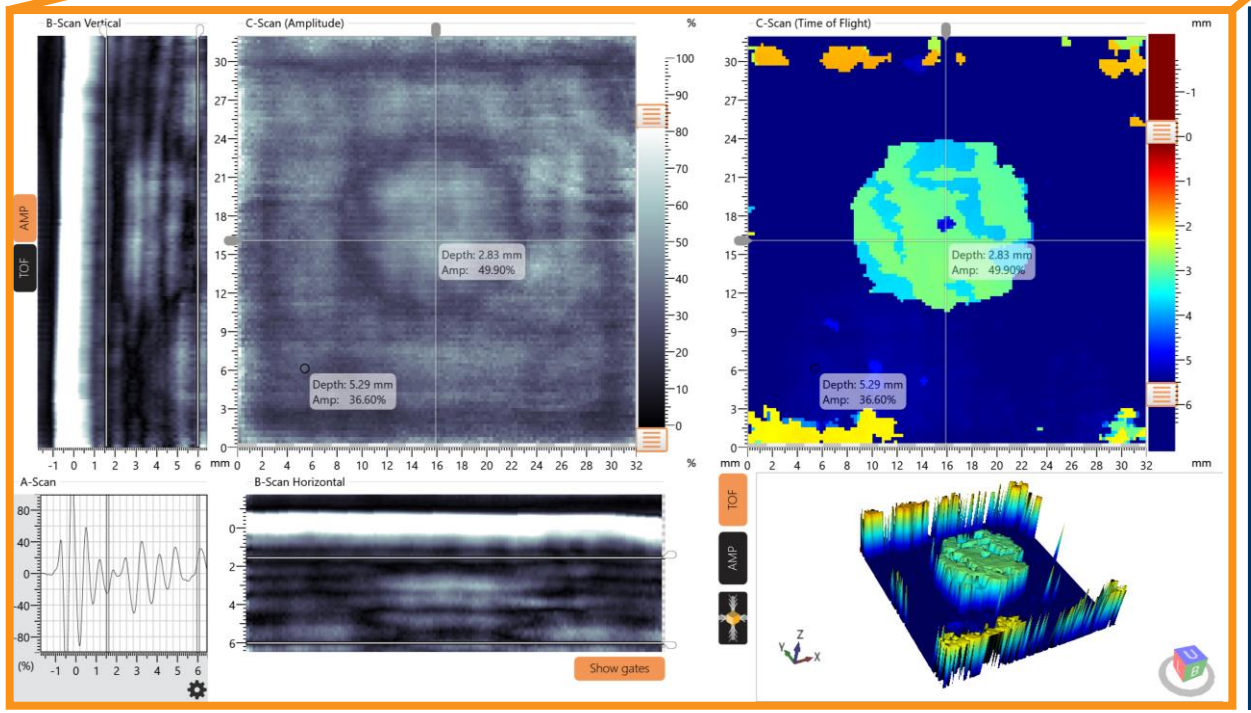
- Amplitude C-scans

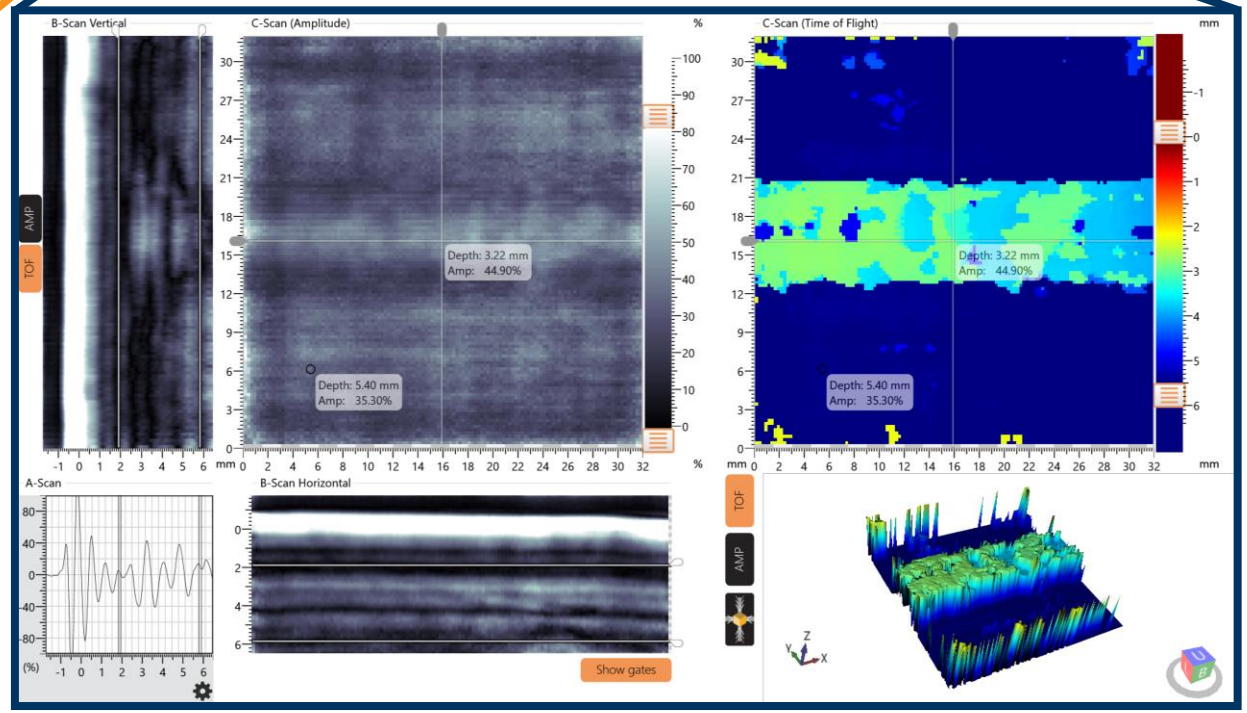


GLARE calibration blocks

- 150 mm × 150 mm × 5.6 mm GLARE3 block.
- Flat bottom hole and notch 2.4 mm deep from the back surface.

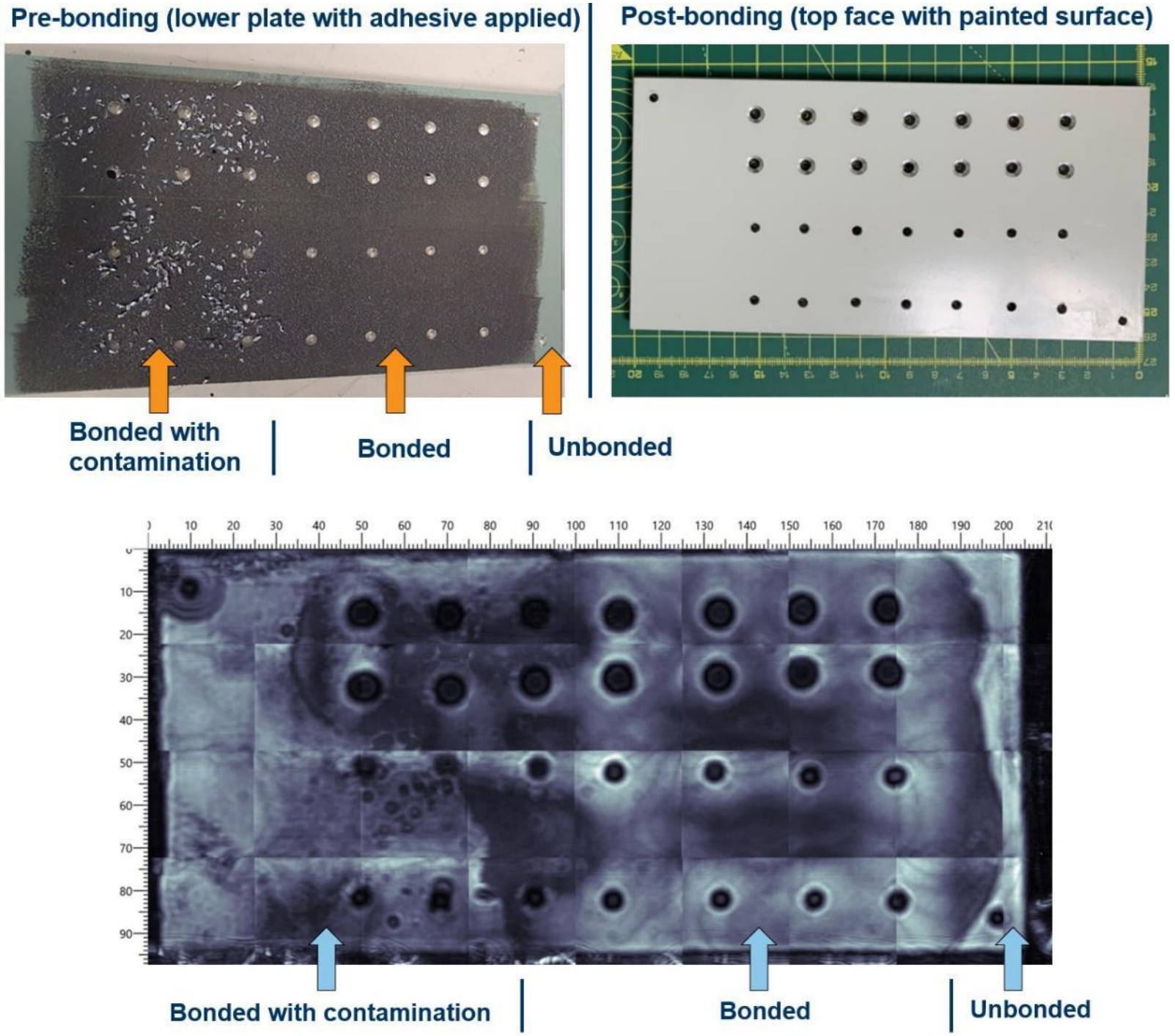






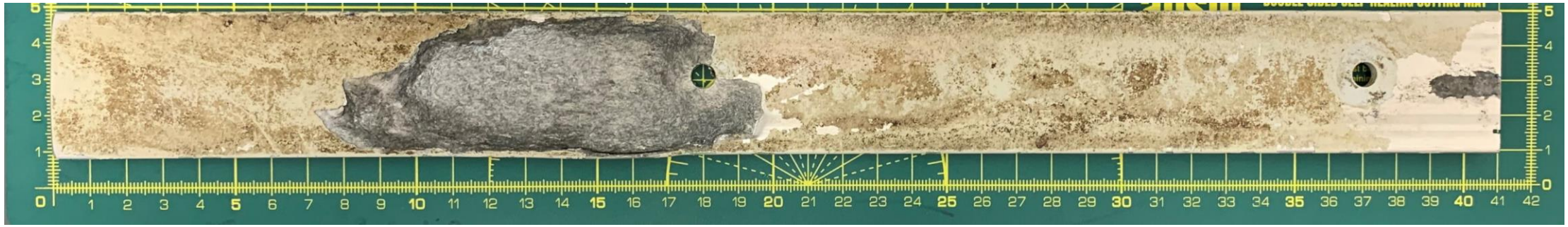
Similar metal to metal adhesive bonding

- 4mm to 4mm thick aerospace aluminium alloy
- Aluminum shavings introduced in adhesive layer
- Differences in contaminated, non-contaminated, and unbonded regions resolved

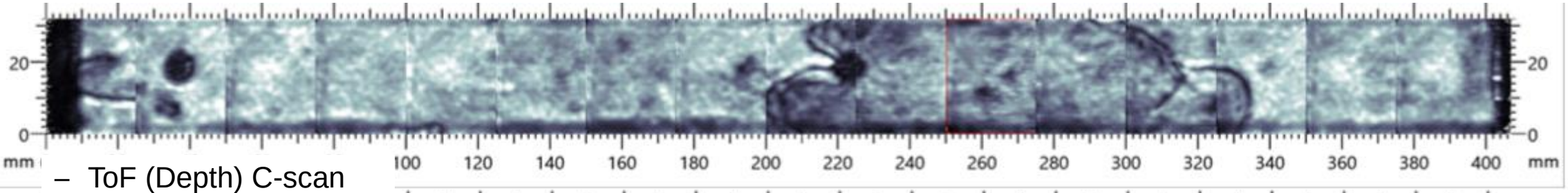


General corrosion

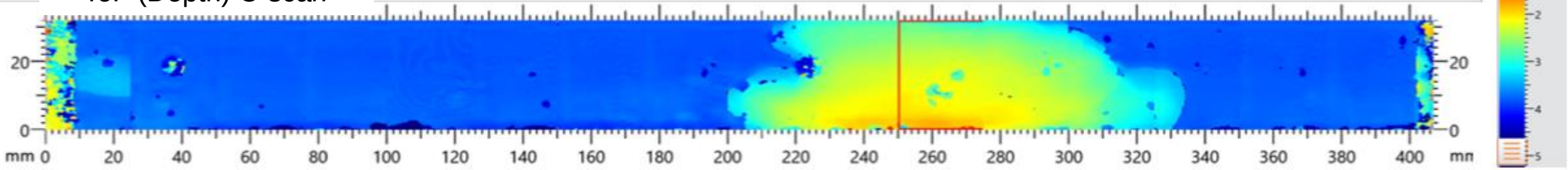
- 3.5mm thick aluminium alloy
- Corrosion visible in both amplitude and ToF C-scans



- Amplitude C-scan

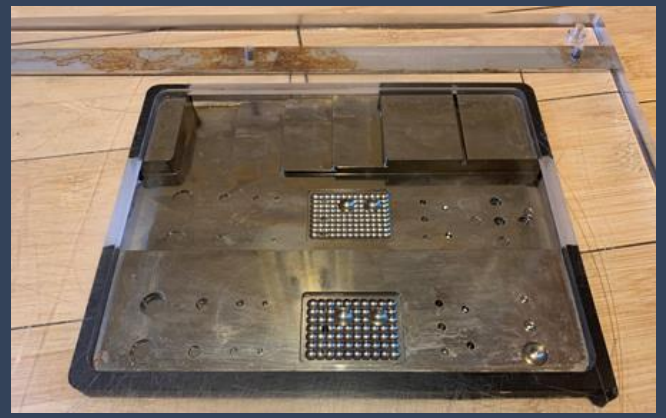


- ToF (Depth) C-scan

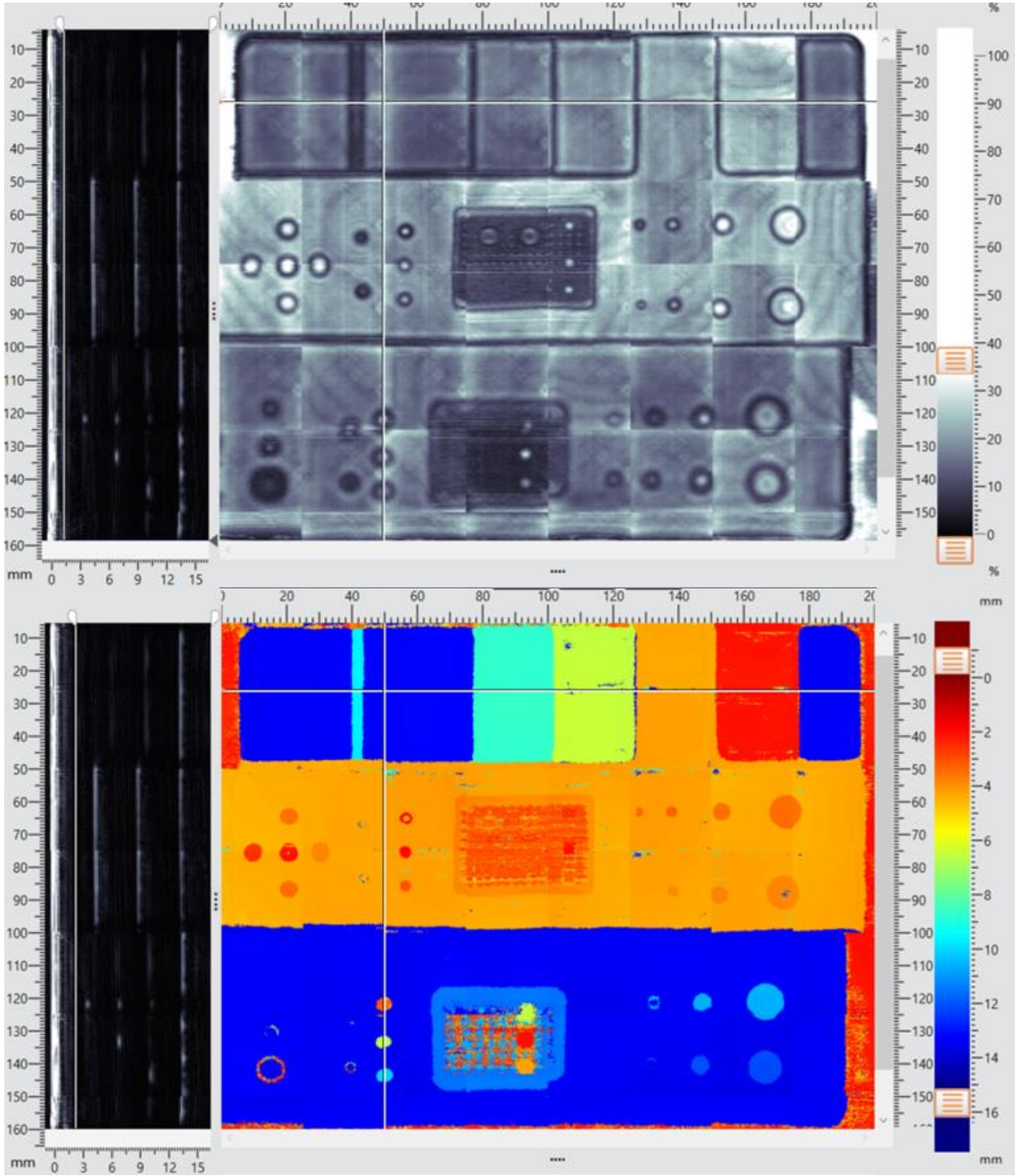


Pitting corrosion in carbon steel

- GE Calibration Block PN 109M2542
- 2-15mm thickness
- All reflectors detected



- Amplitude C-scan
- ToF (Depth) C-scan

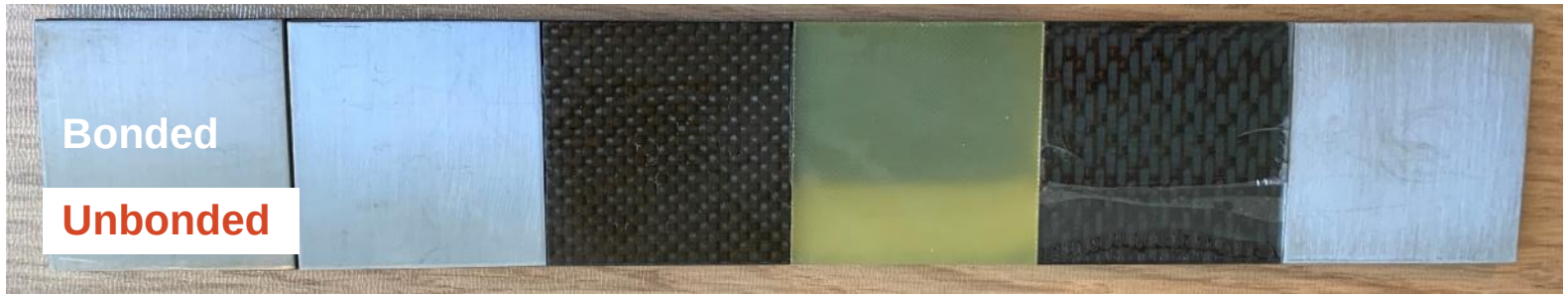


Dissimilar material bonding

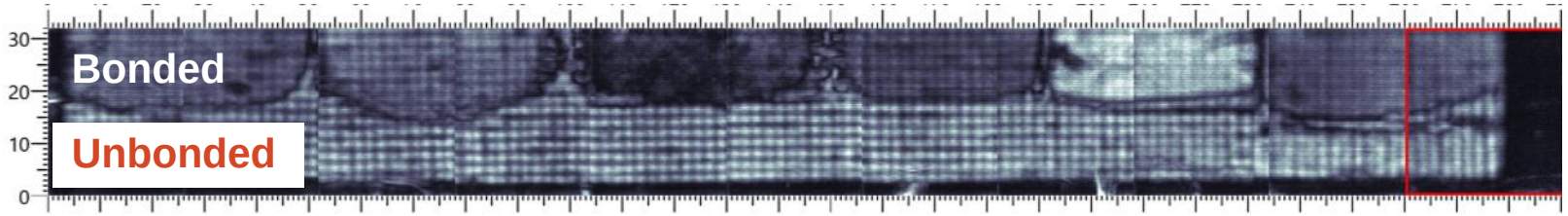
- 2mm thick woven CFRP with six different material tiles adhesively bonded to back face
- Half of each tile is bonded, half is left unbonded
- Difference between bonded and unbonded is clearly visible for all tiles
- Each tile has a different characteristic bonding signature enabling material discrimination

– Inspection face

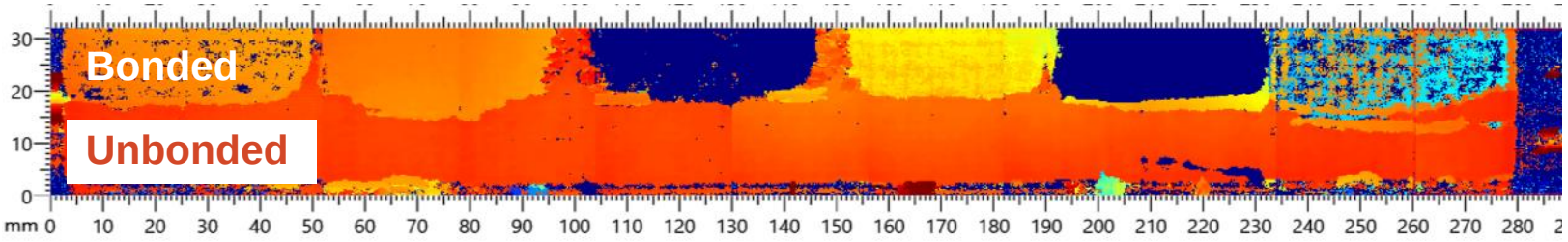
– Back face



– Amplitude C-scan



– ToF (Depth) C-scan



Specifications & Accessories

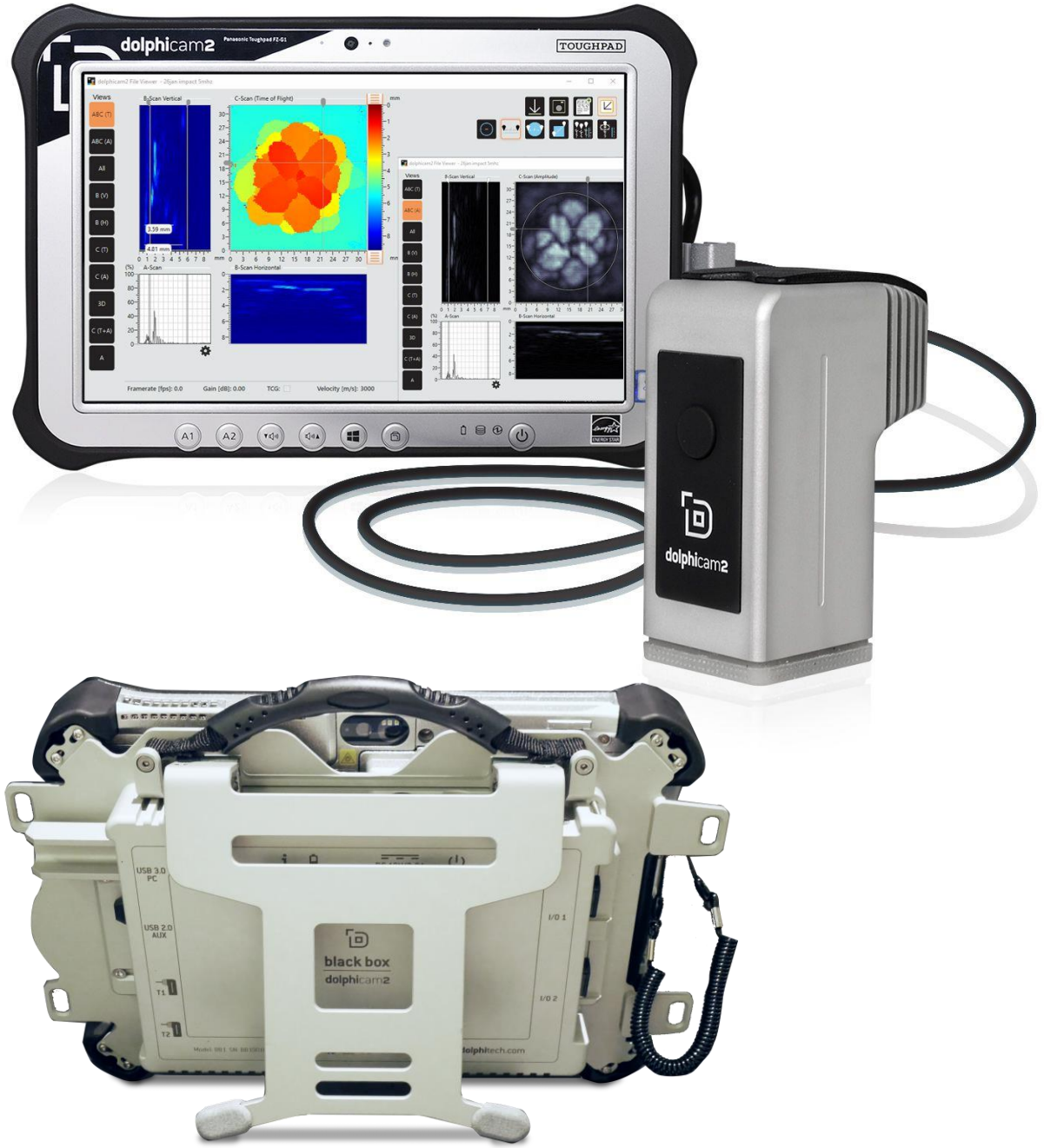
What is the dolphicam2?

Platform specifications:

Combined system weight:	3kg
Display size, resolution:	10”, 1920 x 1200 pixels
Tablet specification:	Intel Core i5, 8GB RAM, 256 GB SSD
Dimensions:	300 x 188 x 70mm
Transducer ports:	2x USB-C
Battery life:	6-8 hrs continuous usage

Platform features:

- 1- & 2-axis encoded mapping
- Grid and freehand stitching
- Configurable settings files
- Full Matrix Capture (FMC)
- Total Focusing Method (TFM)
- Analogue and digital TCG functionality
- Auto-report generation
- Defect detection
- Advanced statistical toolset



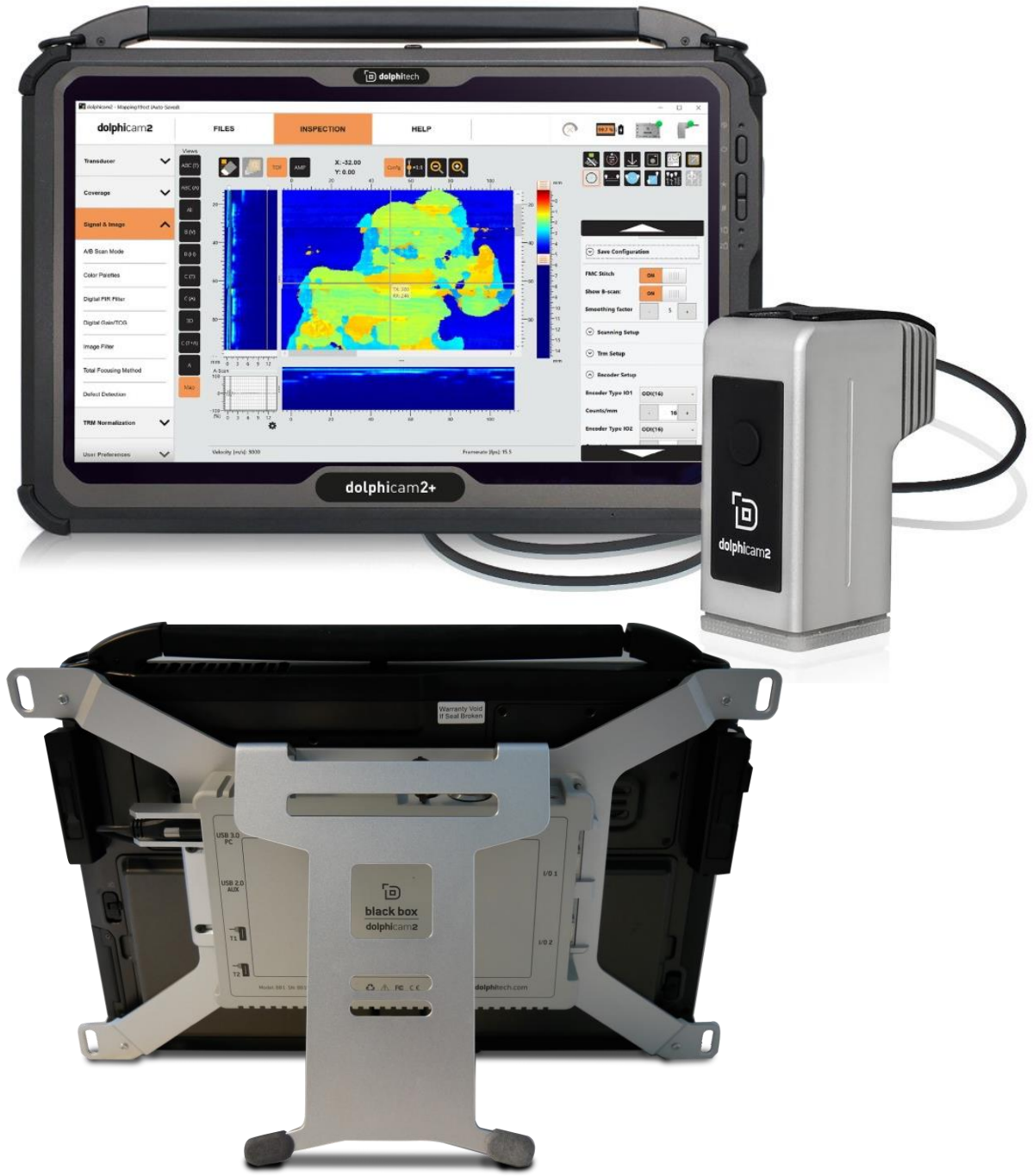
What is the dolphicam2+?

Platform specifications:

Combined system weight:	5kg
Display size, resolution:	14”, 1920 x 1200 pixels
Tablet specification:	Intel Core i7, 16GB RAM, 256 GB SSD
Dimensions:	376 x 244 x 61mm
Transducer ports:	2x USB-C
Battery life:	6-8 hrs continuous usage

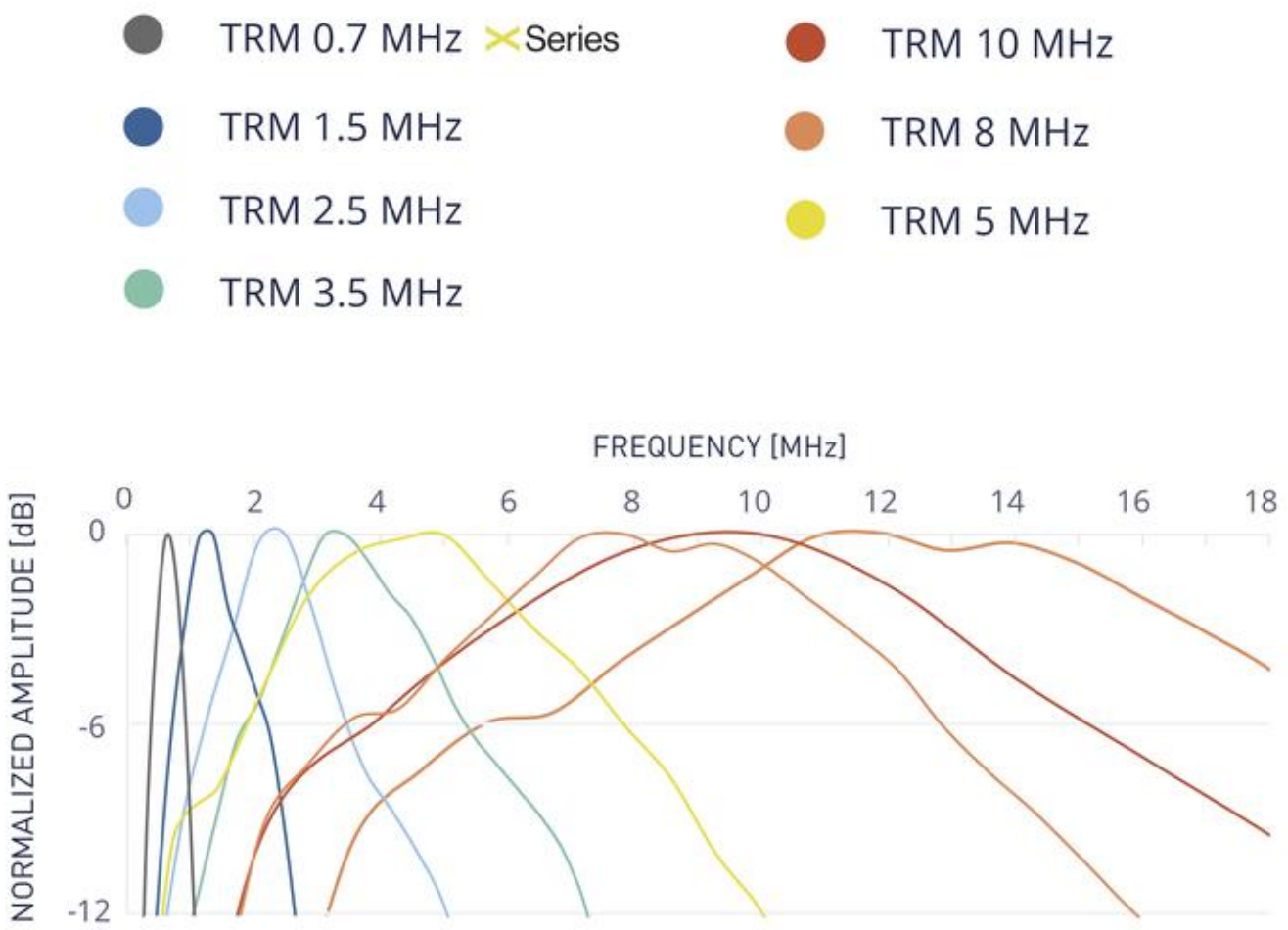
Platform features:

- 1- & 2-axis encoded mapping
- Grid and freehand stitching
- Configurable settings files
- Full Matrix Capture (FMC)
- Total Focusing Method (TFM)
- Analogue and digital TCG functionality
- Auto-report generation
- Defect detection
- Advanced statistical toolset



Transducer details

- We offer seven transducer models with frequencies from 0.7 – 10MHz, all with our unique 2-dimensional matrix array of ultrasonic elements
- Our 0.7MHz TRM has 32x32 elements, 1.5MHz TRM has 64x64 elements, while all other TRMs have 128x128 elements
- All TRMs have an active transducer area of 32x32mm
- All transducers are broadband, with ~100% -6dB bandwidth, which enables a superior ultrasonic response in composites and through coatings



Note : X-Series is a new range of transducers with increased sound energy being rolled out across our lower frequencies

Compliance & Conformity

- Dolphicam2 user manual (hardware), contains:
  - Introduction to dolphicam2, technical specifications and safety & handling guide
- Dolphicam2 user manual (software), contains:
  - All software functionality of the dolphicam2, updated for each software release and accessible in PDF form directly from the dolphicam2 tablet

The dolphicam2 system confirms to the following certifications:

CE	See CE DoC dolphicam2 for additional information
UKCA	See UKCA DoC dolphicam2 for additional information
FCC	FCC Part 15 , Clause B, Class A FCC Part 18 See FCC DoC dolphicam2 for additional information

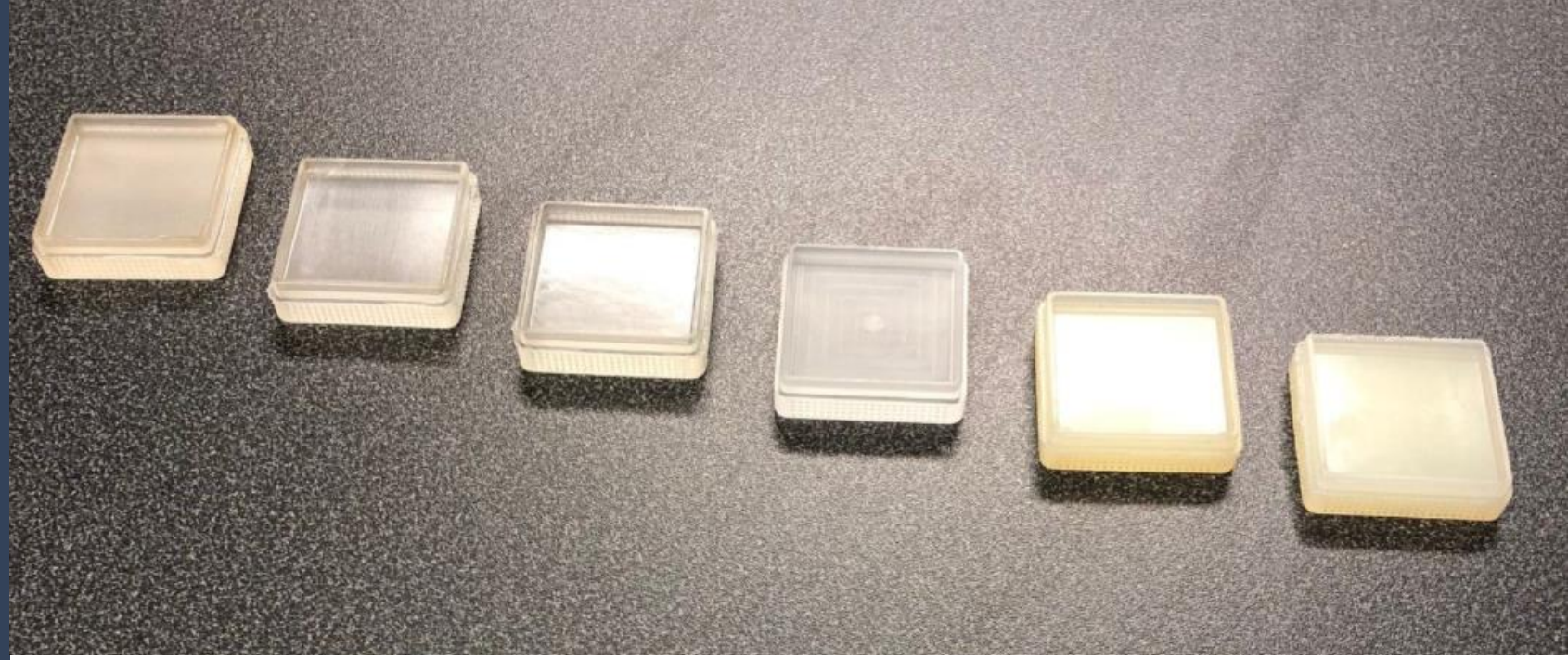
The dolphicam2 system is tested according to the following standards:

Health & Safety:	EN 61010-1:2010 and Switzerland national differences: SN EN 61010-1:2010
EMC:	EN IEC 61326-1:2013
RoHS:	EN IEC 63000:2018
FCC	FCC Part 15 , Clause B, Class A FCC Part 18
Drop test	IEC 60068-2-31 (2008), Height: 1220mm
Ingress Protection (IP)	EN 60529 (1991) + A1 (2000) IP 66

The following environmental information is related to the dolphicam2 system:

Operating temperature	0°C to +40°C (32°F to 104°F)
Operating temperature with degrading	-20°C to +50°C (-4°F to 122°F)
Storage temperature	-20°C to +65°C (-4°F to 149°F)
Altitude	2000 meters (6562 feet)
Ingress protection	IP 66
Humidity	Maximum relative humidity 80% for temperatures up to 31°C Decreasing linearity to 50% relative humidity at 40°C

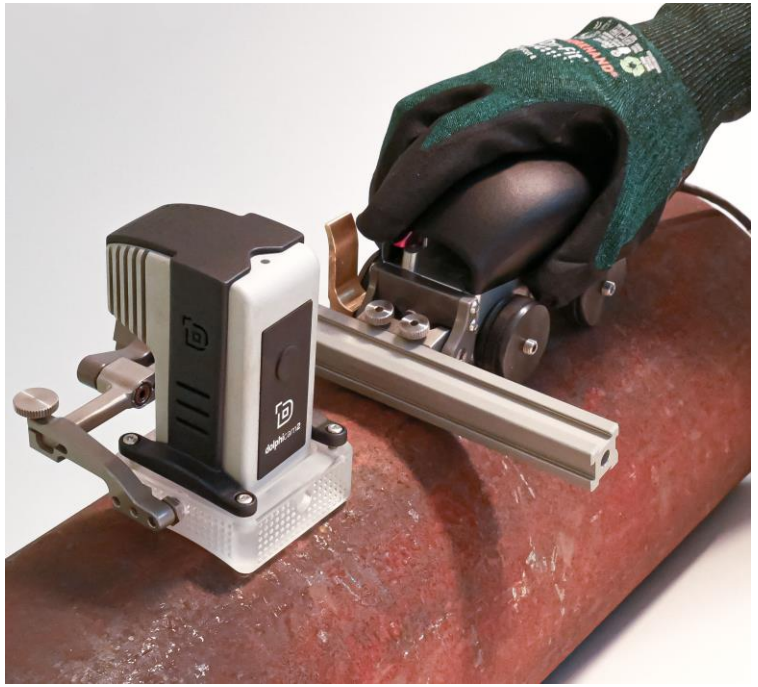
Delay lines



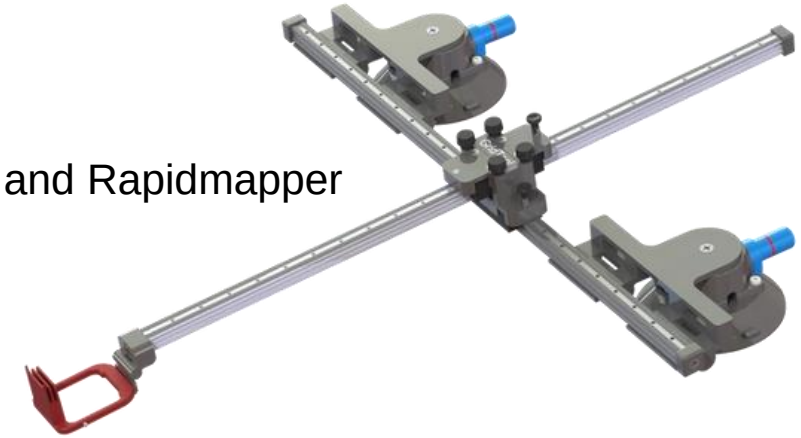
- To complement this range of TRM frequencies, we have developed a range of delay lines to suit different applications
- This includes the use Aqualene and Aqualink materials, which have some flexibility to conform to rough, uneven and curved surfaces
- It also includes curved pipe shoes, with and without irrigation

Accessories

– OEM scanner compatibility

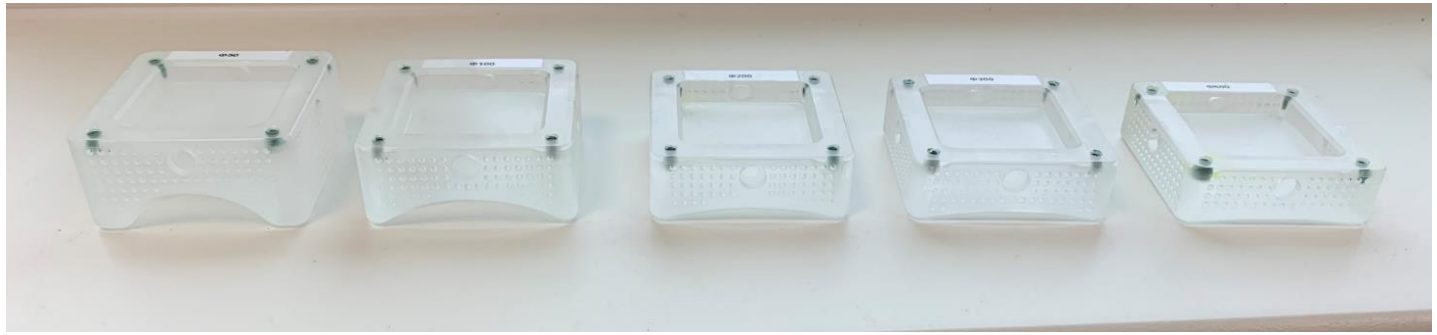


– Gridtool and Rapidmapper



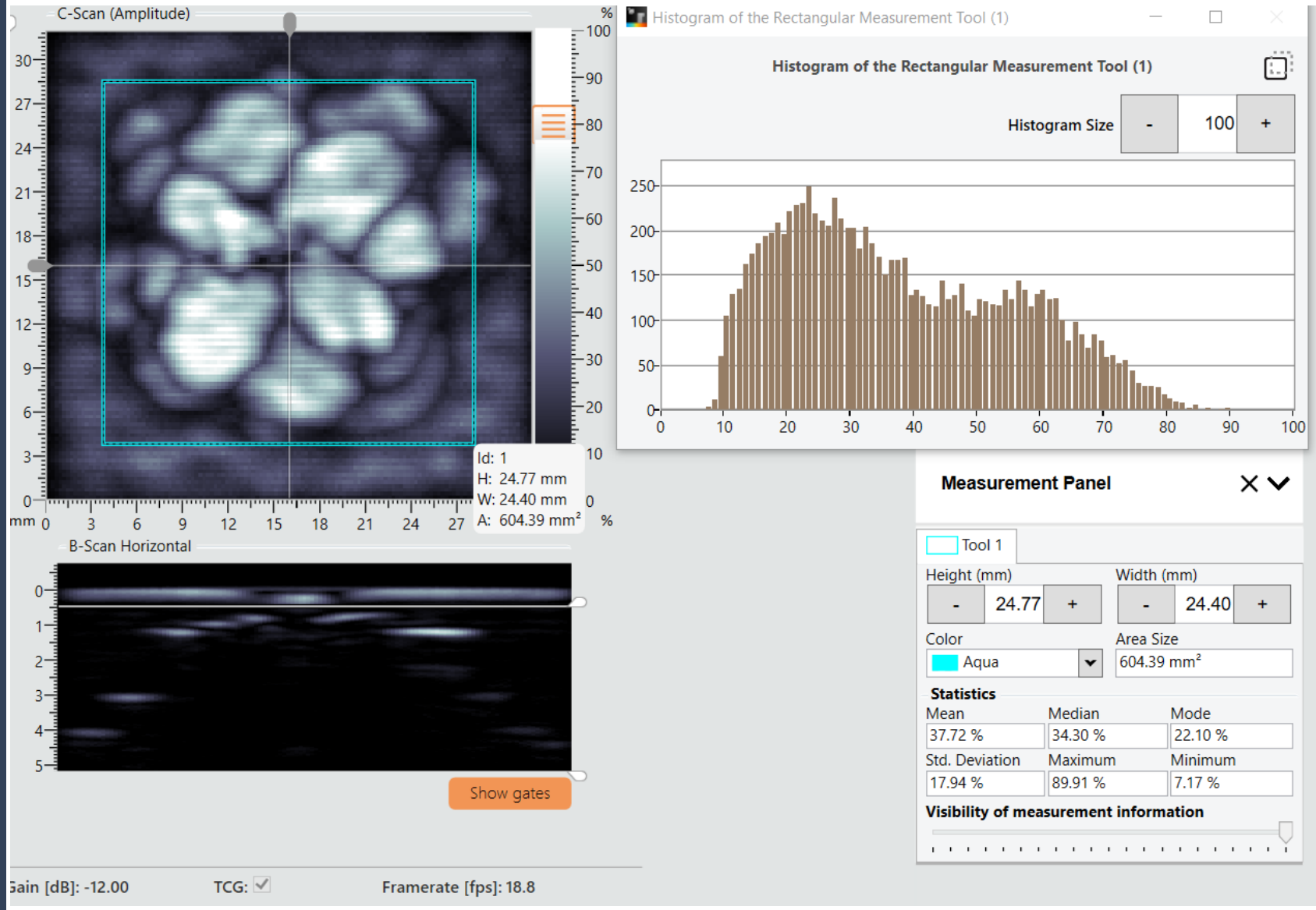
– Replaceable delay lines

– Pipe shoes, 50-600mm Ø OD, with or without irrigation ports



Statistical Features

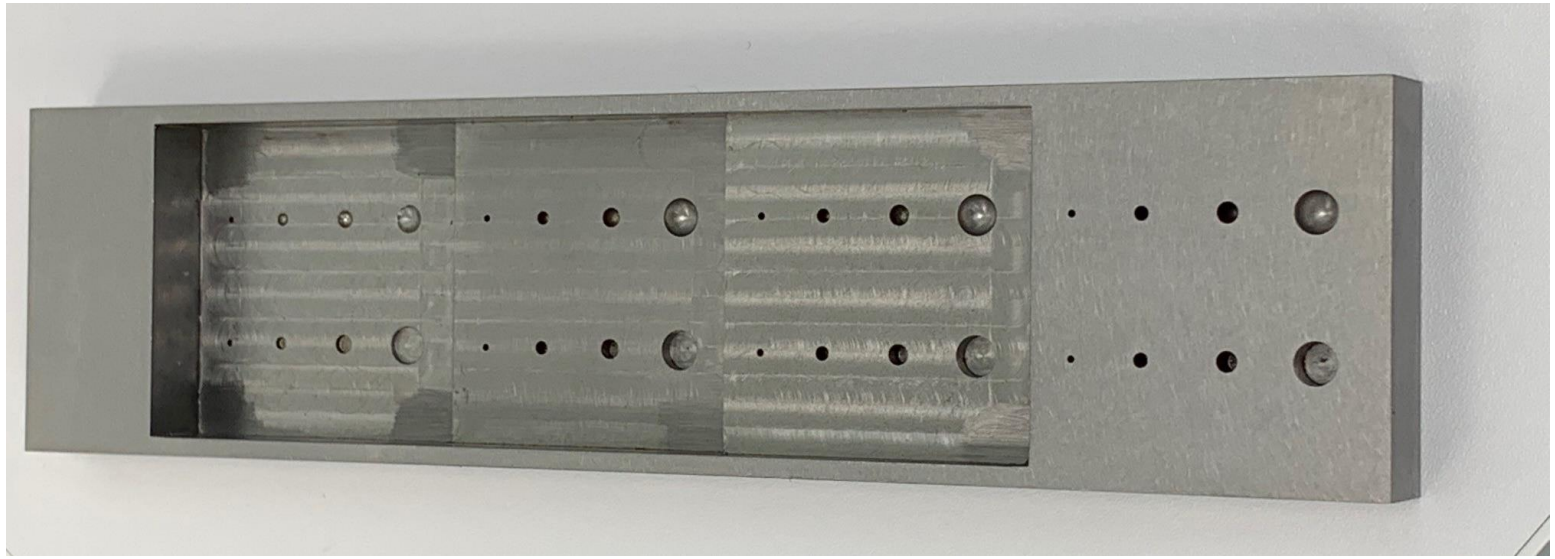
- Our latest software features a live statistical toolset, which includes a range of measurements and a histogram
- This histogram can be used with live data in both Amplitude and ToF images
- This is ideal for applications such as porosity measurement in composites



Total Focussing Method (TFM)

- TFM is a is a pixel-based reconstruction algorithm that is applied to Full Matrix Capture (FMC) ultrasound data
- It enables improved spatial resolution in homogenous inspection materials
- With the dolphicam2 it is applied in Live Acquisition mode on the two B-scans

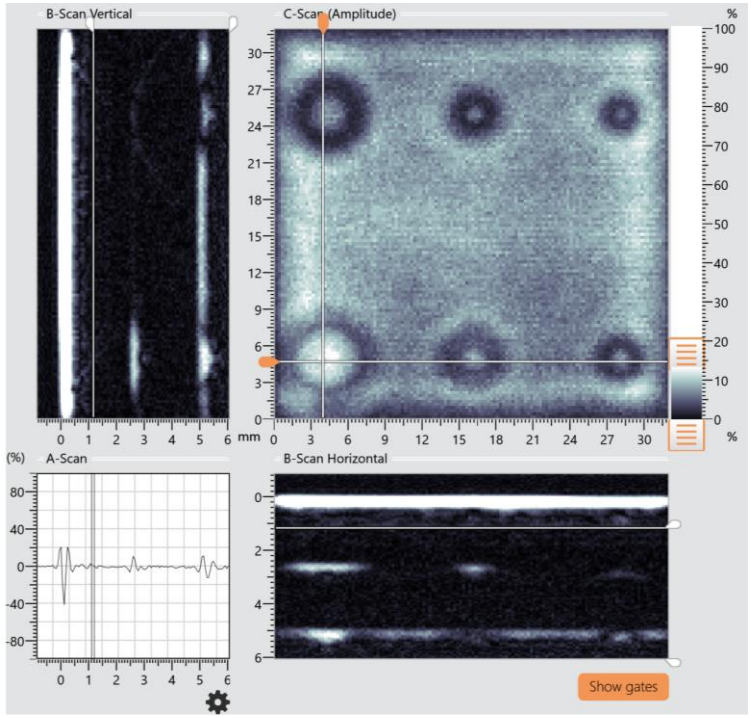
- Example specimen: Aluminium alloy step block
- Example TRM: 10MHz with 8mm Rexolite delay line
- Image location: 5mm thickness
- Image location features:
  - 6, 3, 2 mm Round Bottomed Holes
  - 6, 3, 2 mm Flat Bottomed Holes



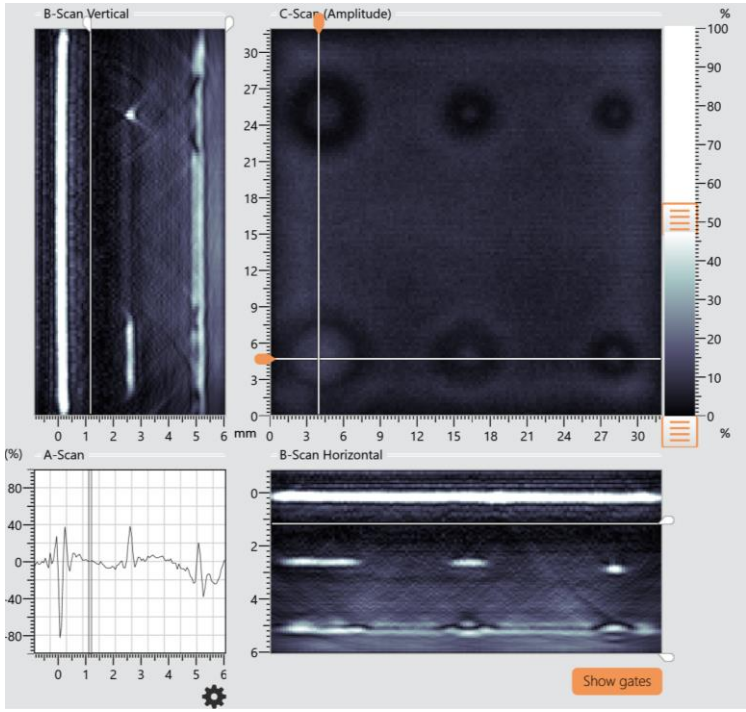
Total Focussing Method (TFM)

- TFM B-scans acquired through the flat bottomed holes

- TFM off



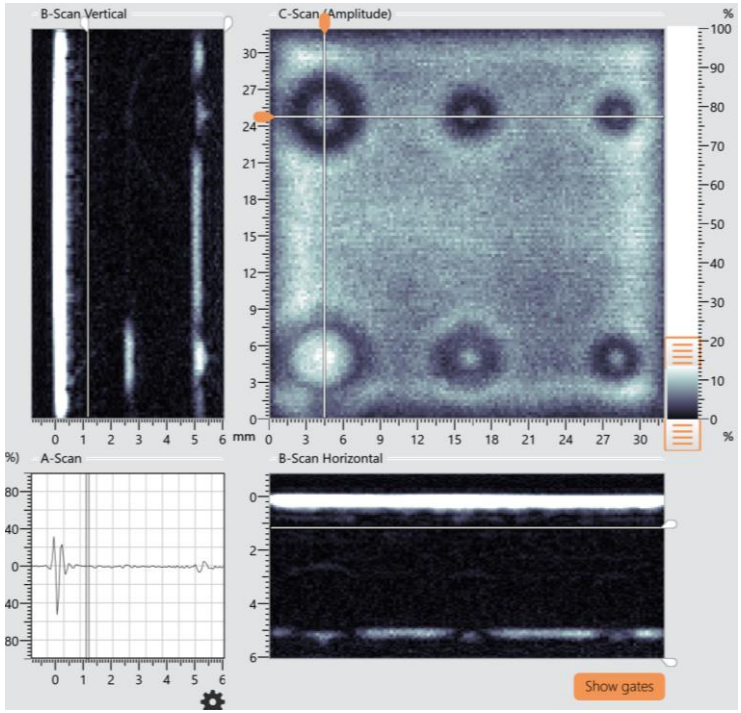
- TFM on



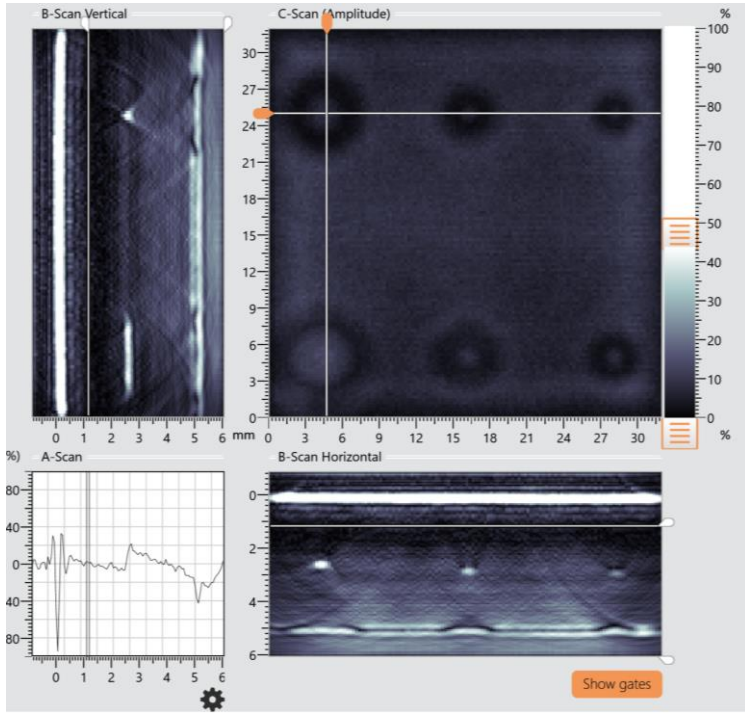
Total Focussing Method (TFM)

- TFM B-scans acquired through the round bottomed holes

- TFM off



- TFM on



Thank you

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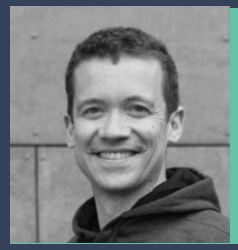

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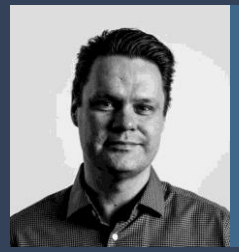

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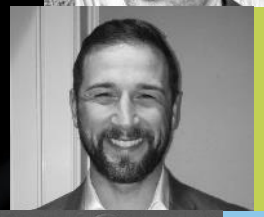

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