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Advanced ultrasonic testing on helicopter blades and aircraft structures

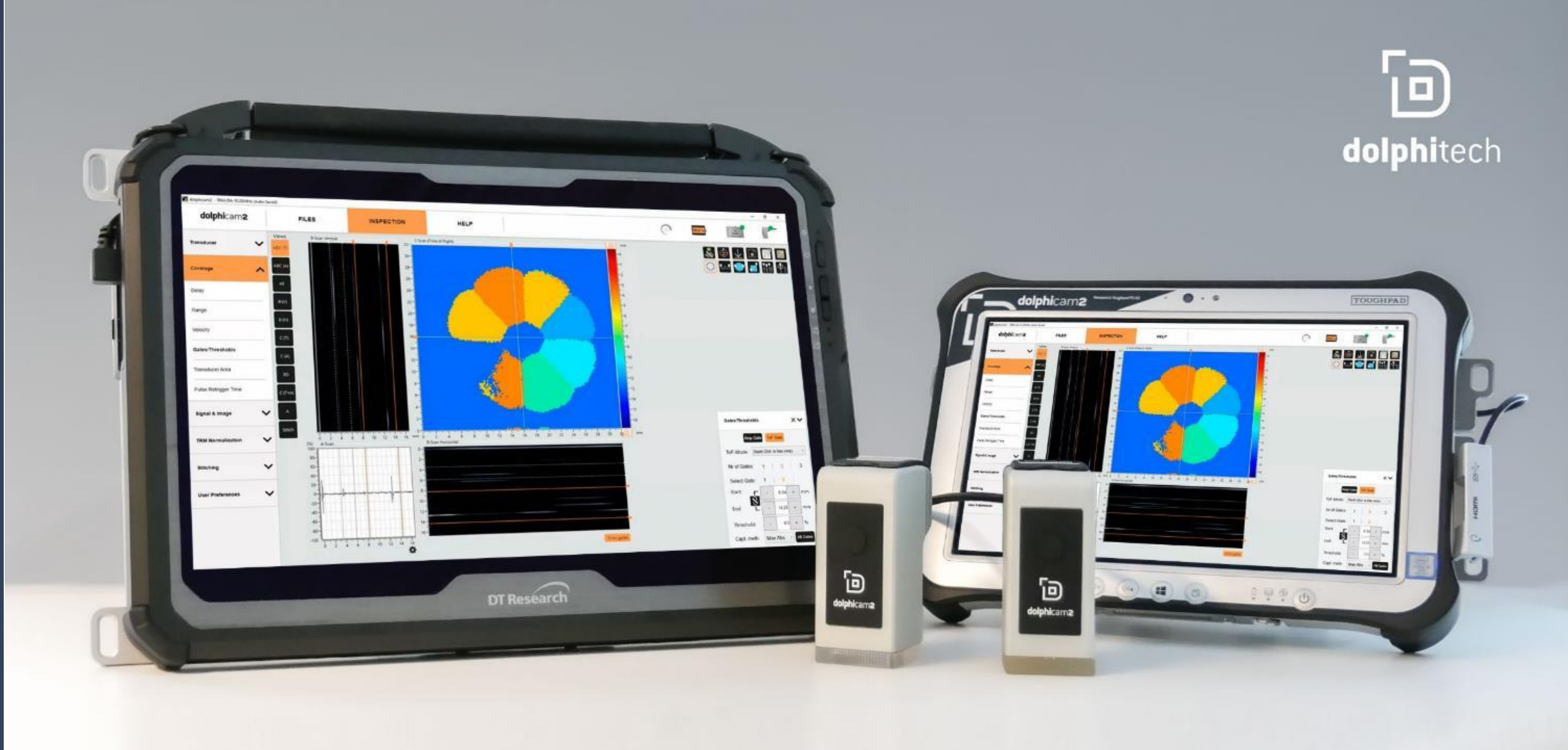
JCAMS Presentation

Jason Smith – CEO Dolphitech Defense

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
- Digital Twin compatible (MOSA*)
- MAUT – ASTM E3370 https://www.astm.org/e3370-23.html
- NATO stock number NSN 6635-20-A0Z-0556

* MOSA – Modular Open System Approach



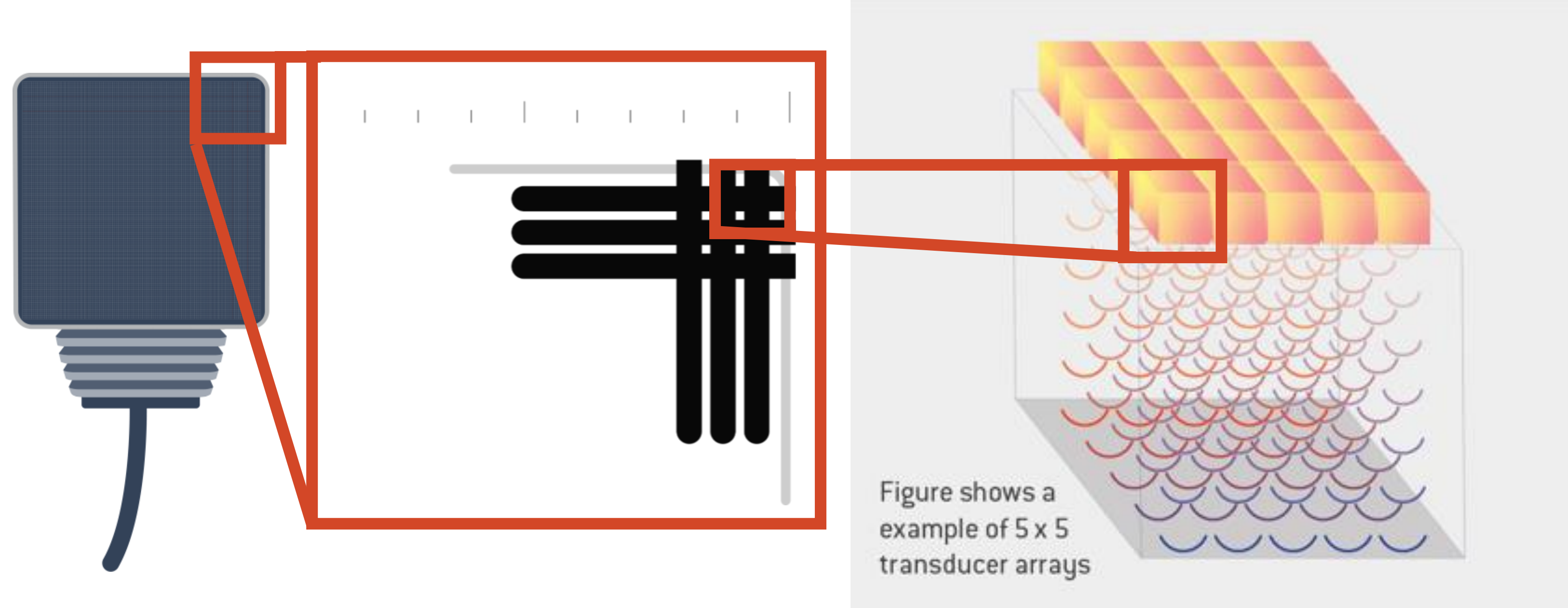
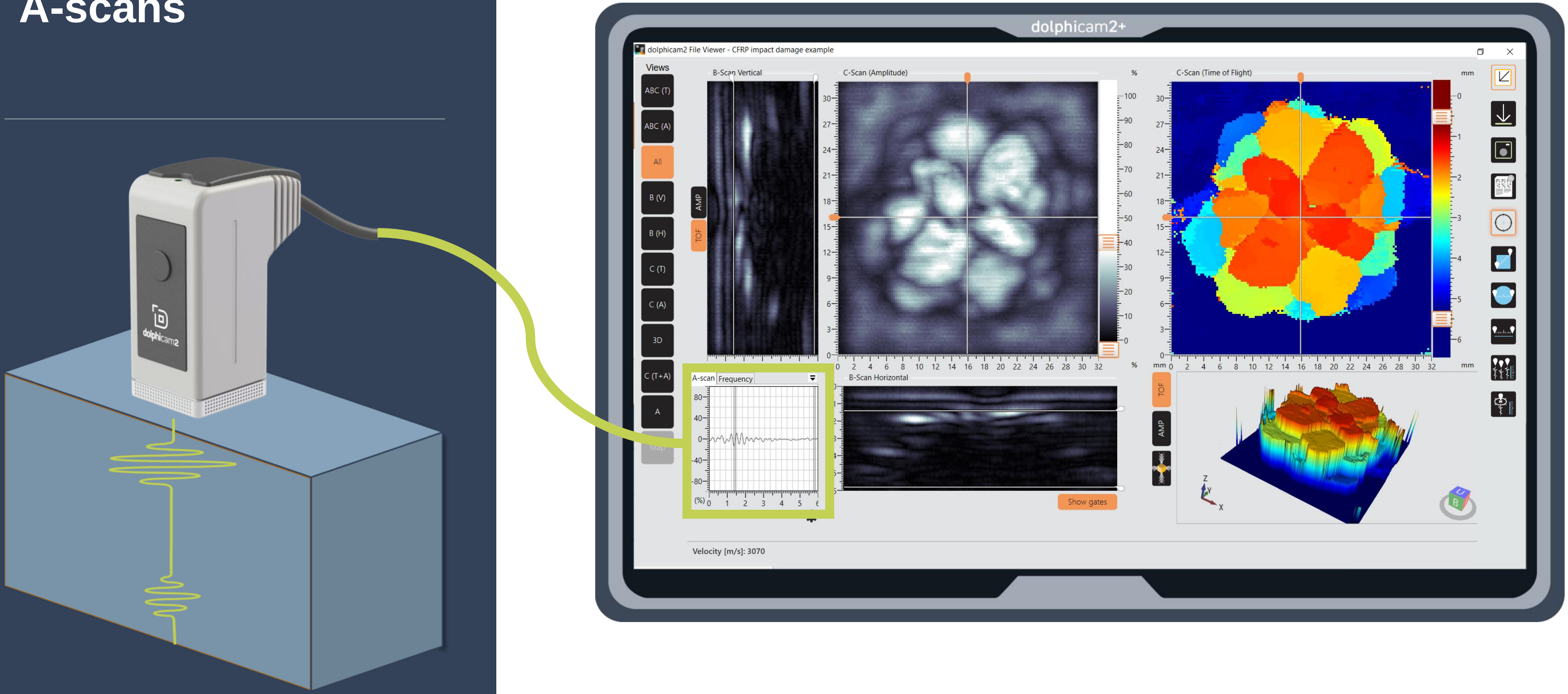


Figure shows a example of 5 x 5 transducer arrays

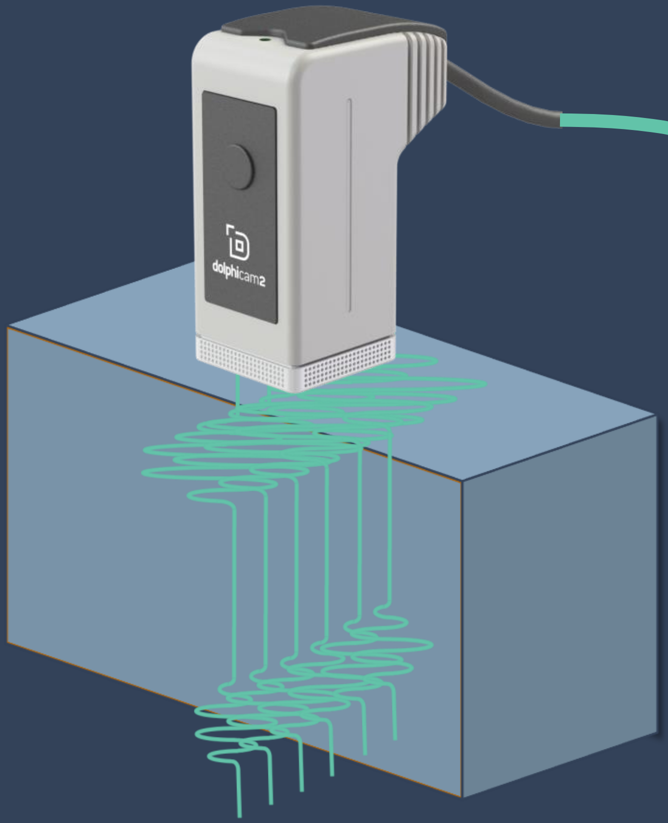
How do we display this unique data?

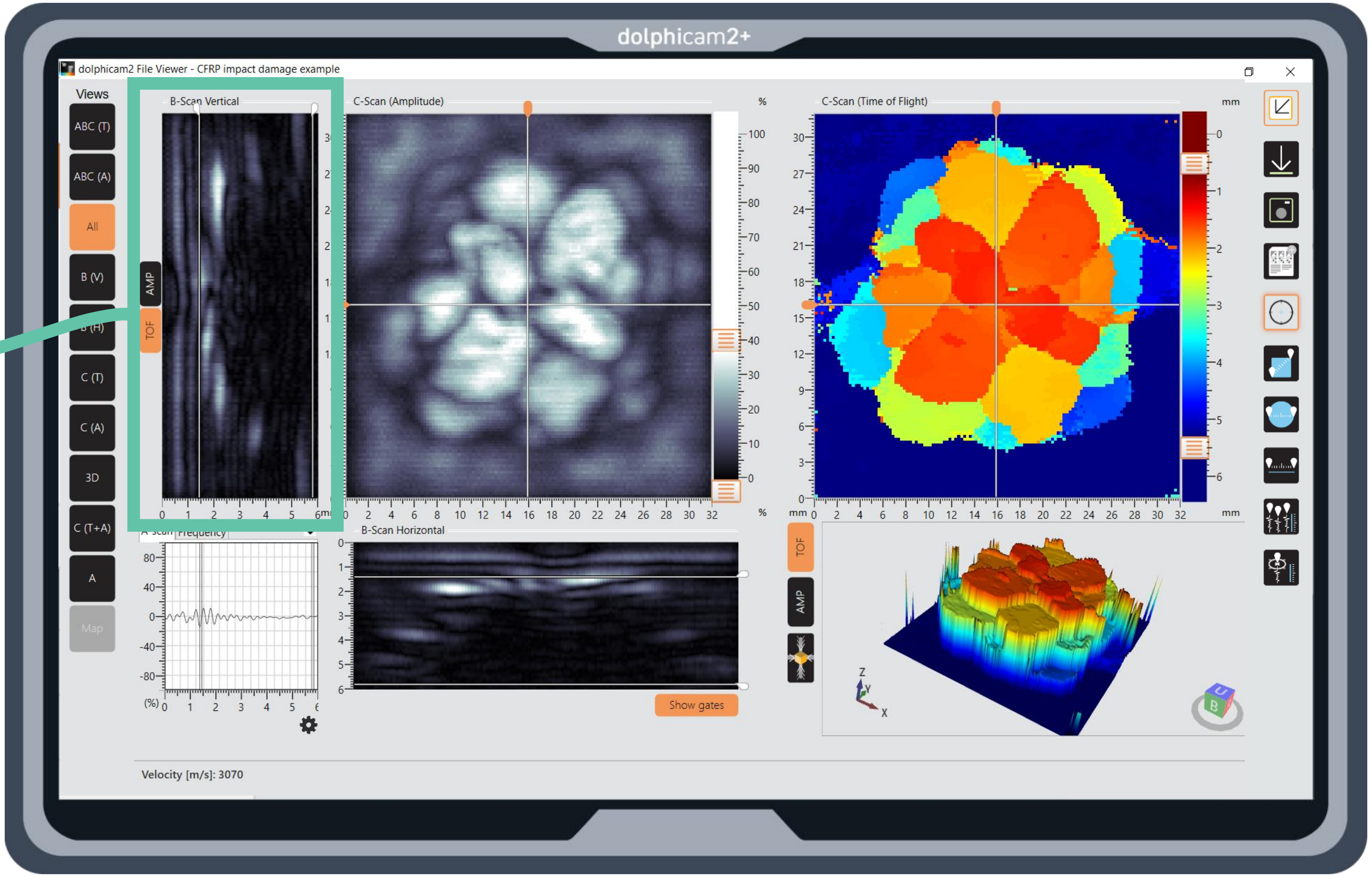
A-scans



How do we display this unique data?

Vertical B-scan





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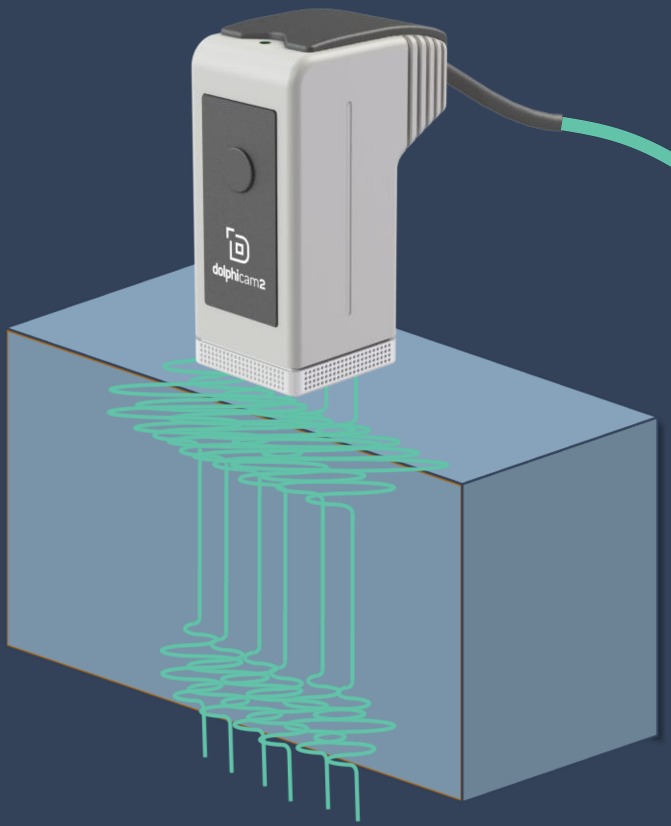
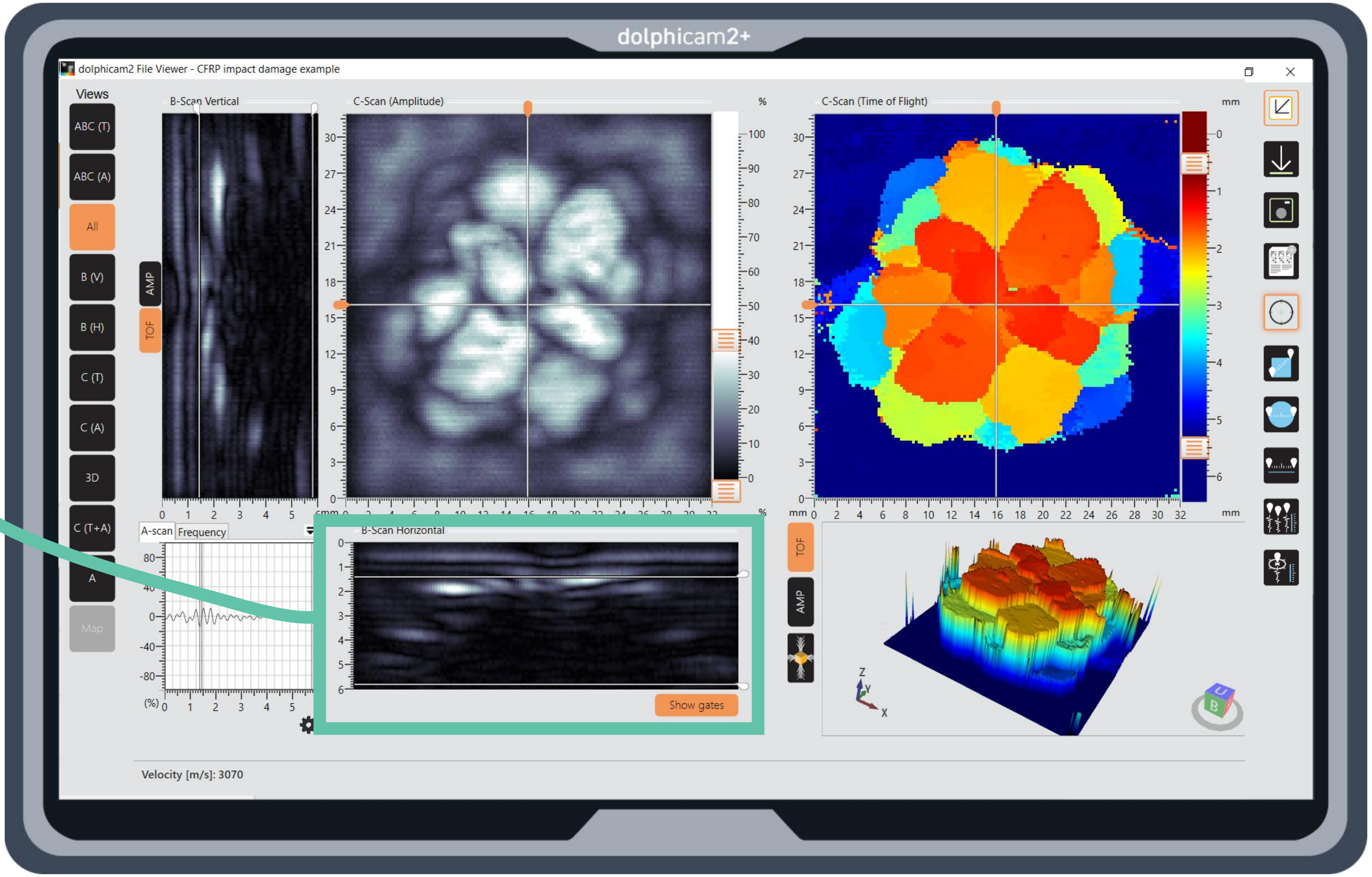
How do we display this unique data?

Horizontal B-scan



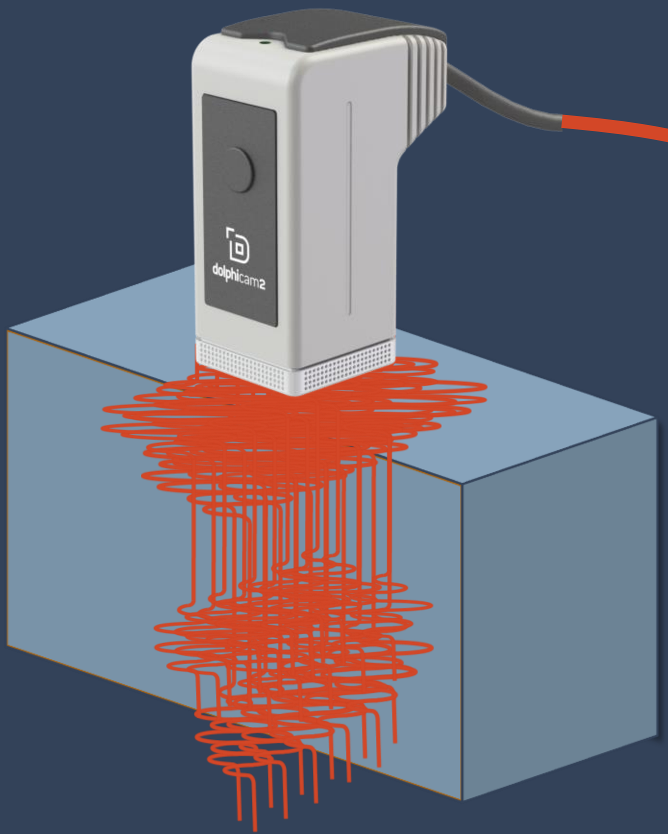


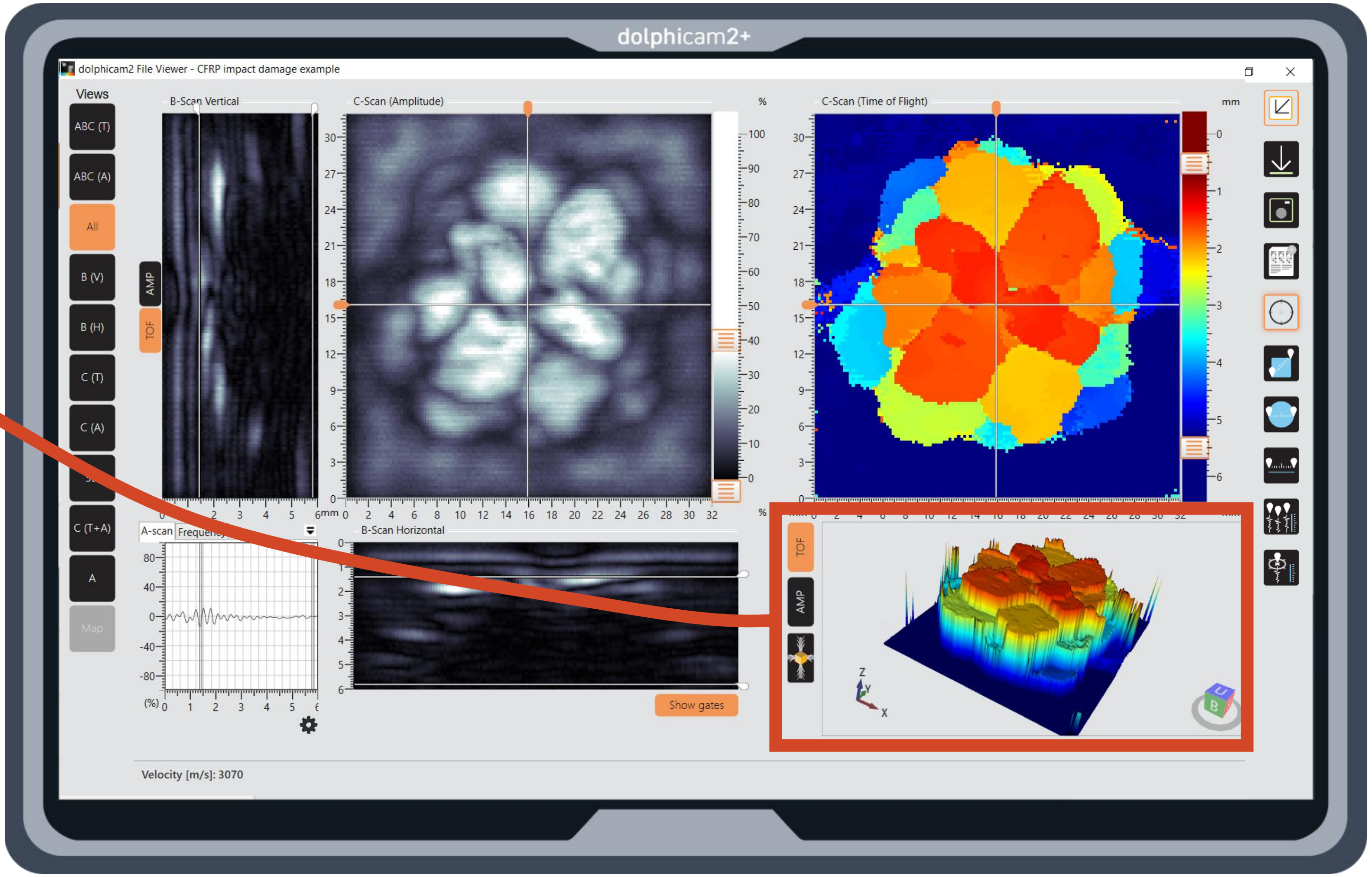
How do we display this unique data?

C-scans

How do we display this unique data?

3D View





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What sets Dolphitech apart?

Fast
Out-of-the-box to inspection in 60 seconds – and up to 61% faster inspection timing overall

Easy to use
Simple interface and intuitive layout – 2 hours training to get going

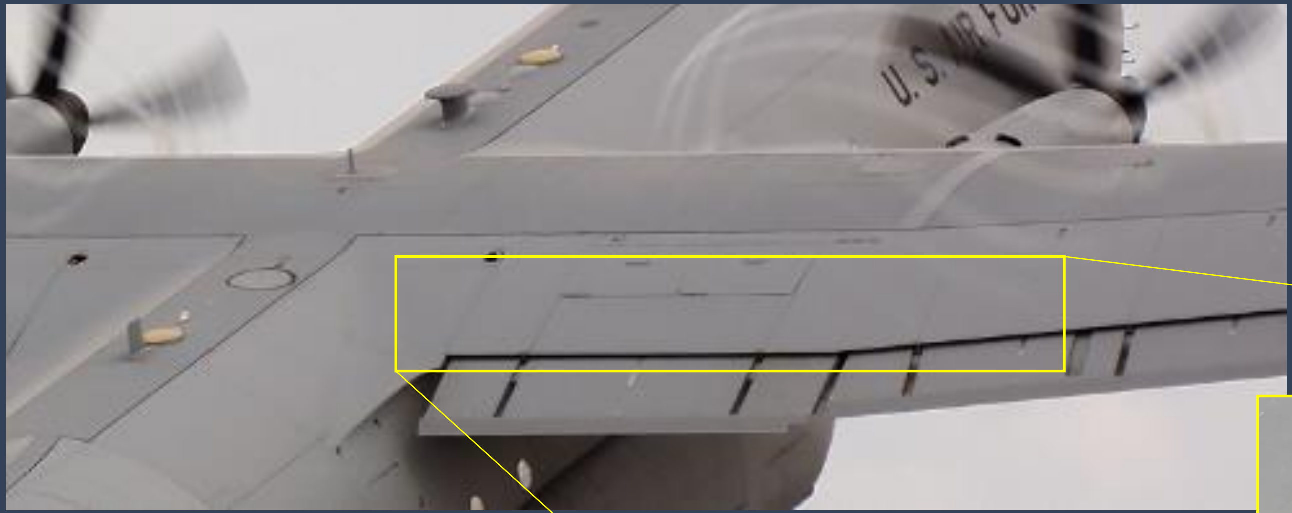
Data Rich
Digital records (auto report generation) of all data with the press of a button – sync to digital twins, no more paperwork

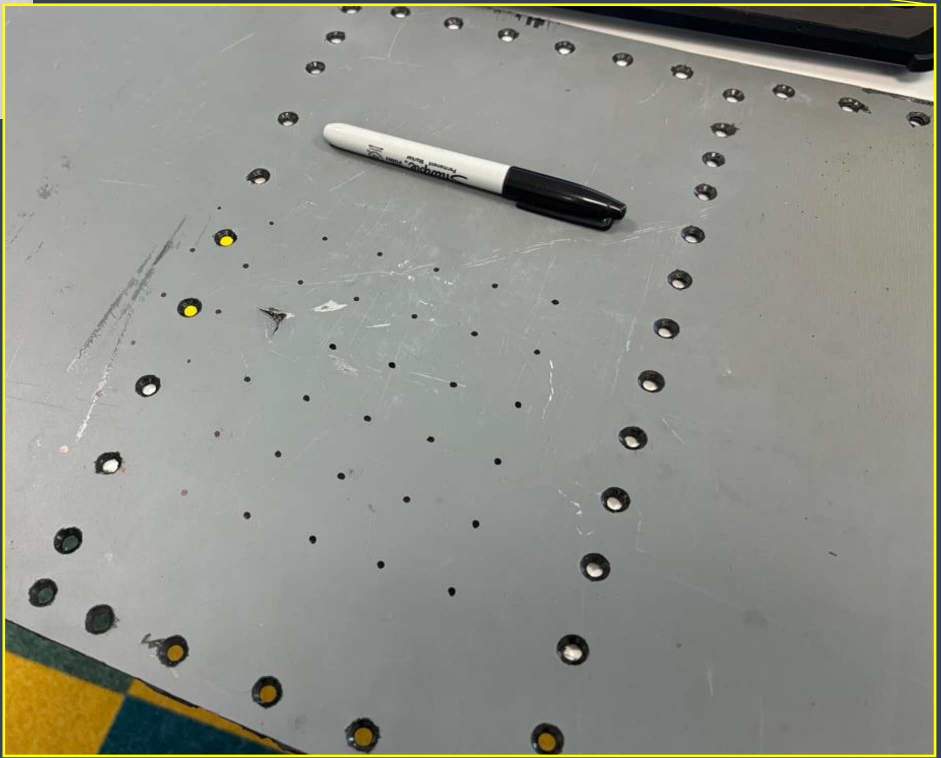
Highly cost-effective
simplified training and maintenance procedures – calibrations are online, the unit never leaves you

“ACE” compatible
Can be used anywhere, by anyone, with remote support direct to the unit from an expert if required

Portable
6lbs combined system weight for comfortable on-site working

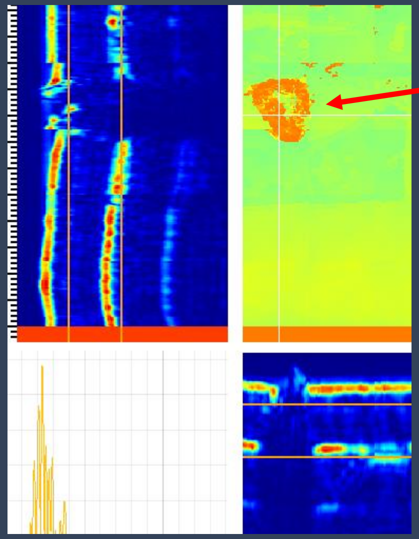
C130J Flap False Work. Impact damage and BVID - 0.102in Monolithic Carbon

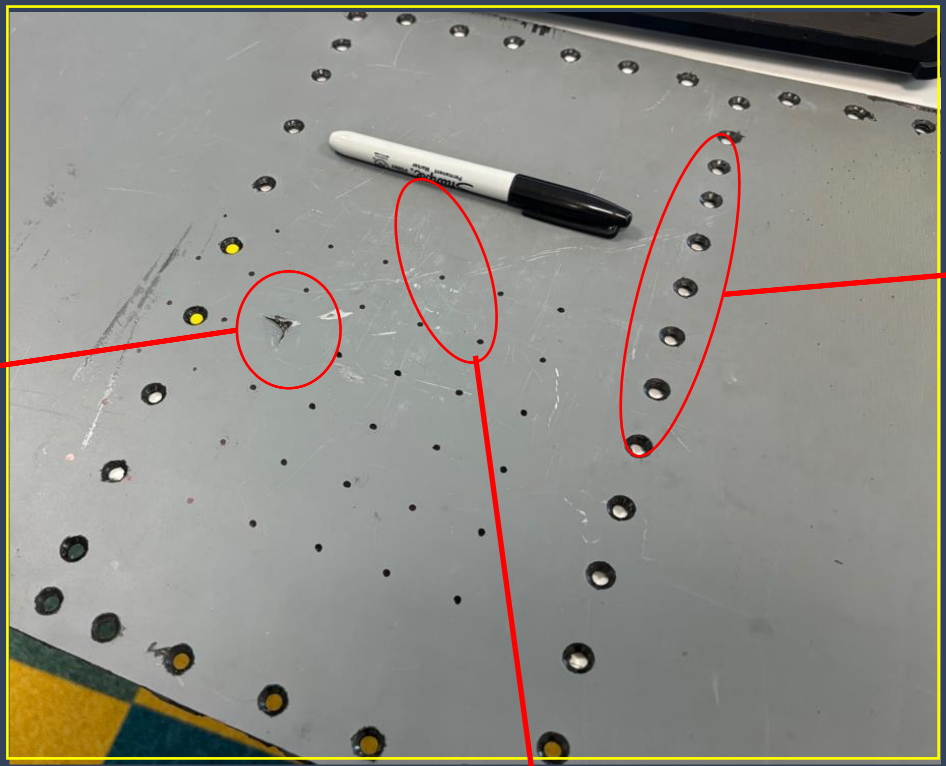


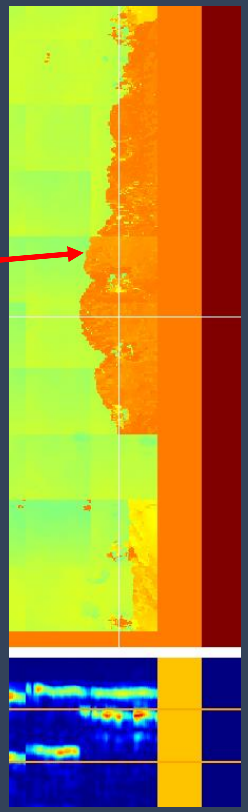


C130J Flap False Work. Impact damage and BVID - 0.102in Monolithic Carbon

Impact damage from dropped tooling.

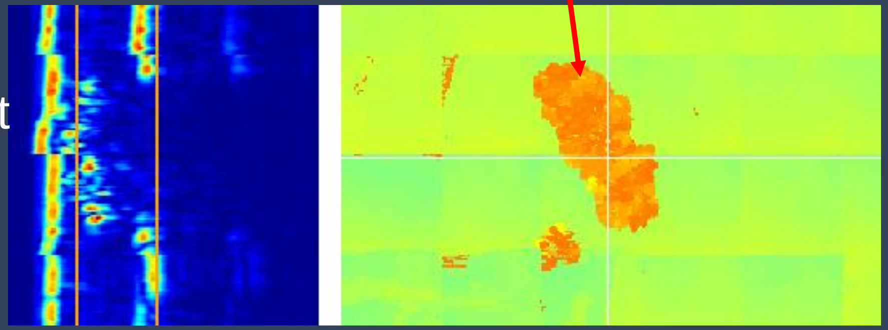






Delamination due to removal. Lower surface was adhered to the frame.

BVID from impact damage.



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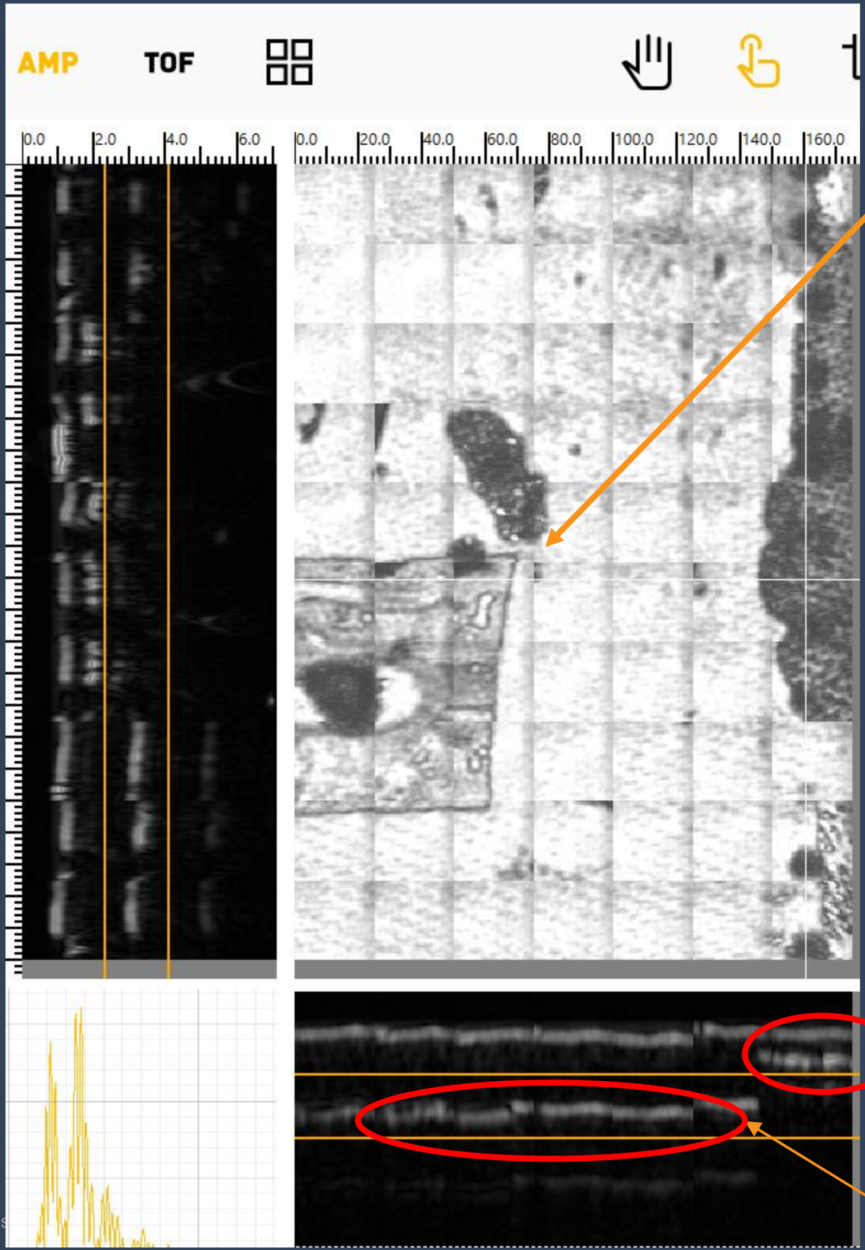
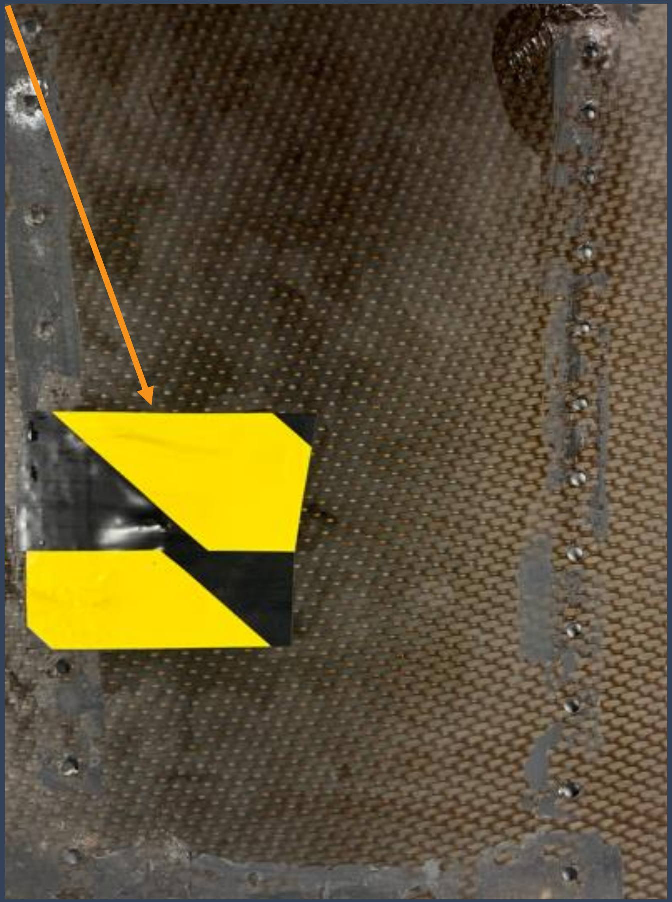
C-130J rear of the panel

Three areas of delamination in the C-Scan view with accompanying B-Scan data view.



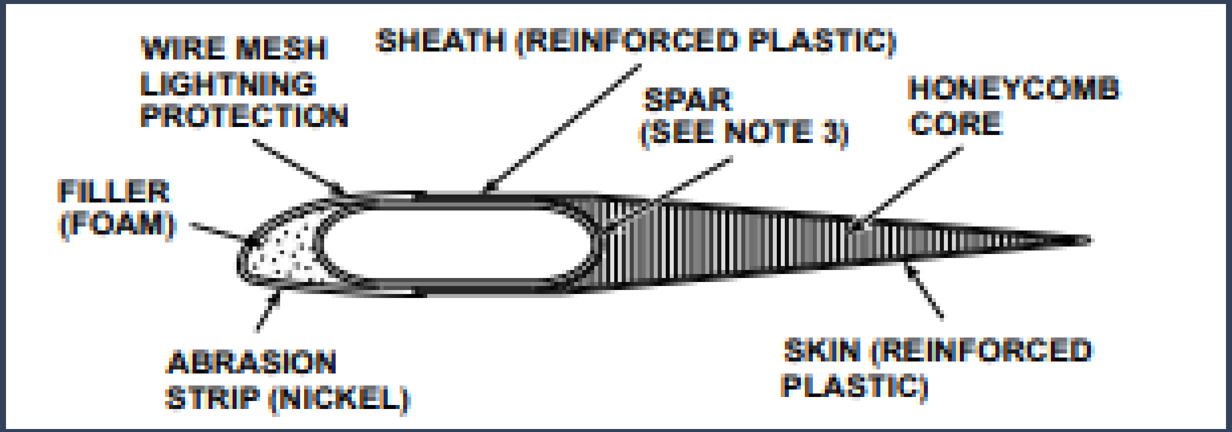
Tape can clearly be seen in amplitude view



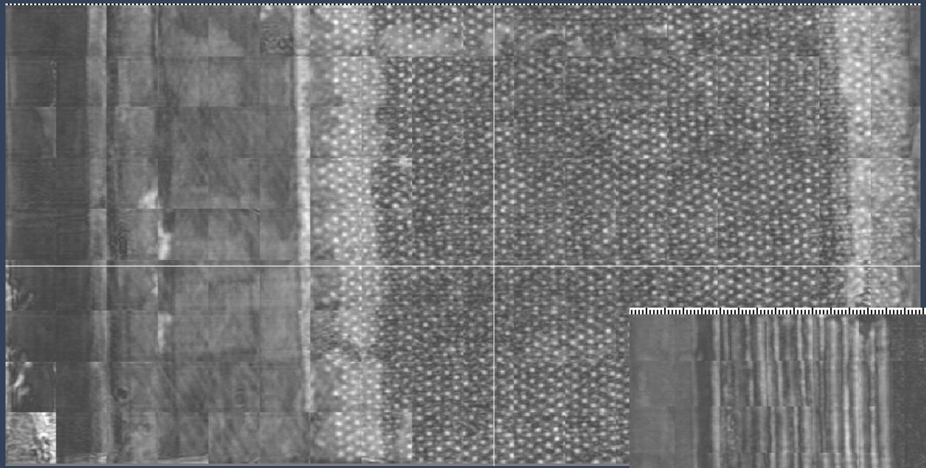
Delamination near surface.

Back wall echo.

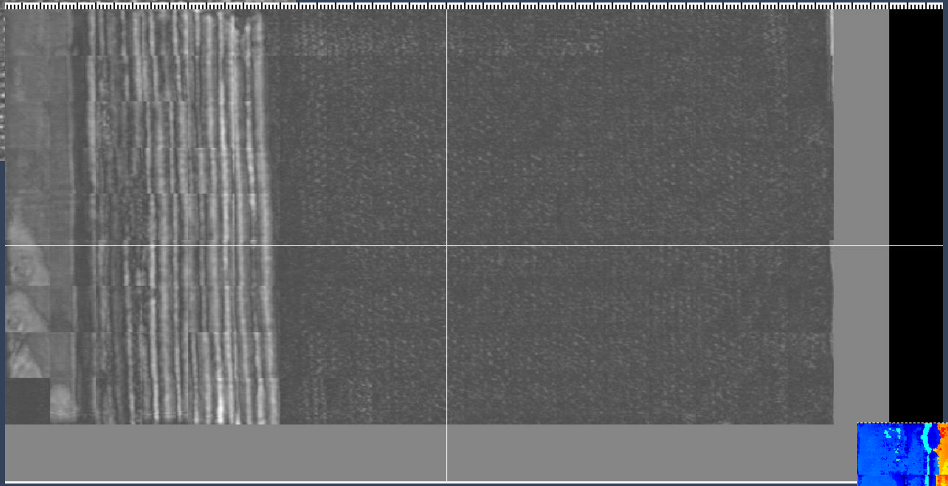
Black Hawk Blade section.



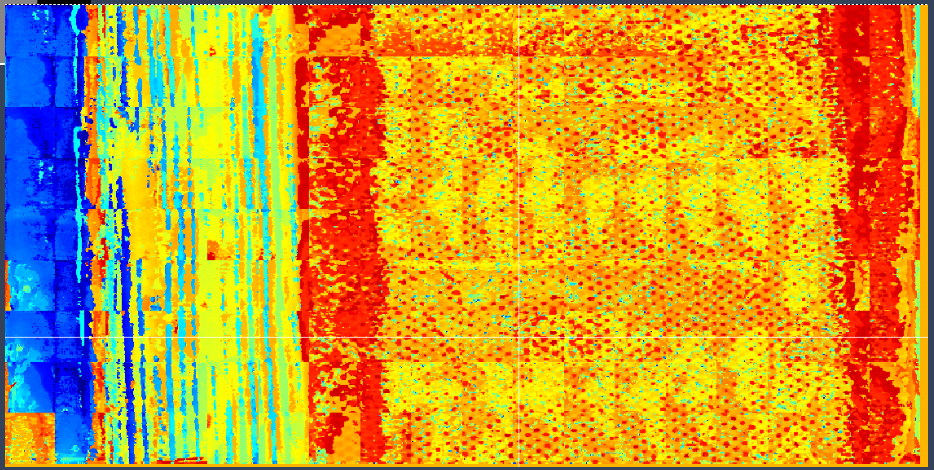
Black Hawk Blade section.



Top image displaying in amplitude to highlight bond line between honeycomb sandwich and upper skin.

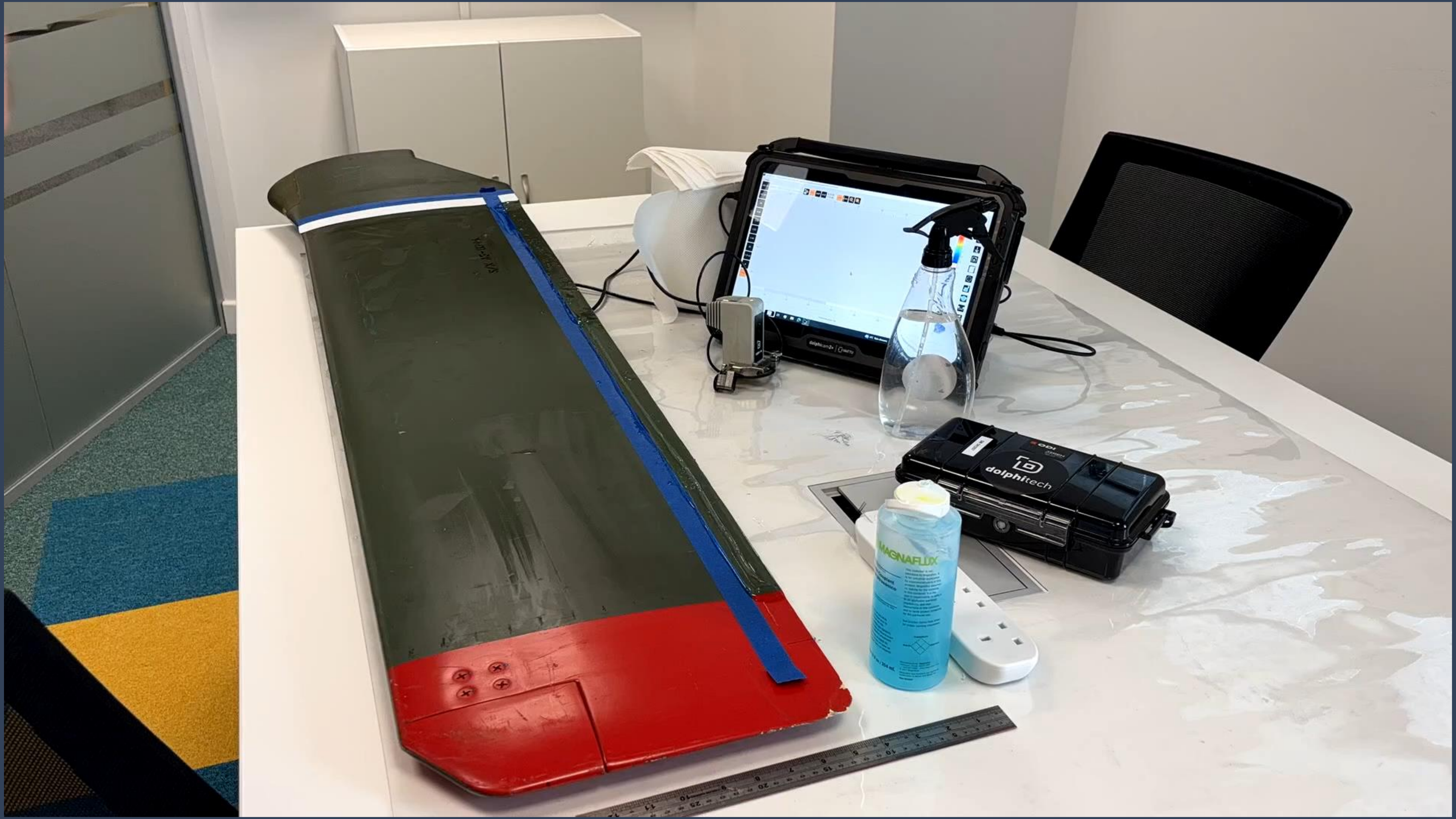


Mid image showing amplitude highlighting metallic cords within the structure between surface and inner spar.



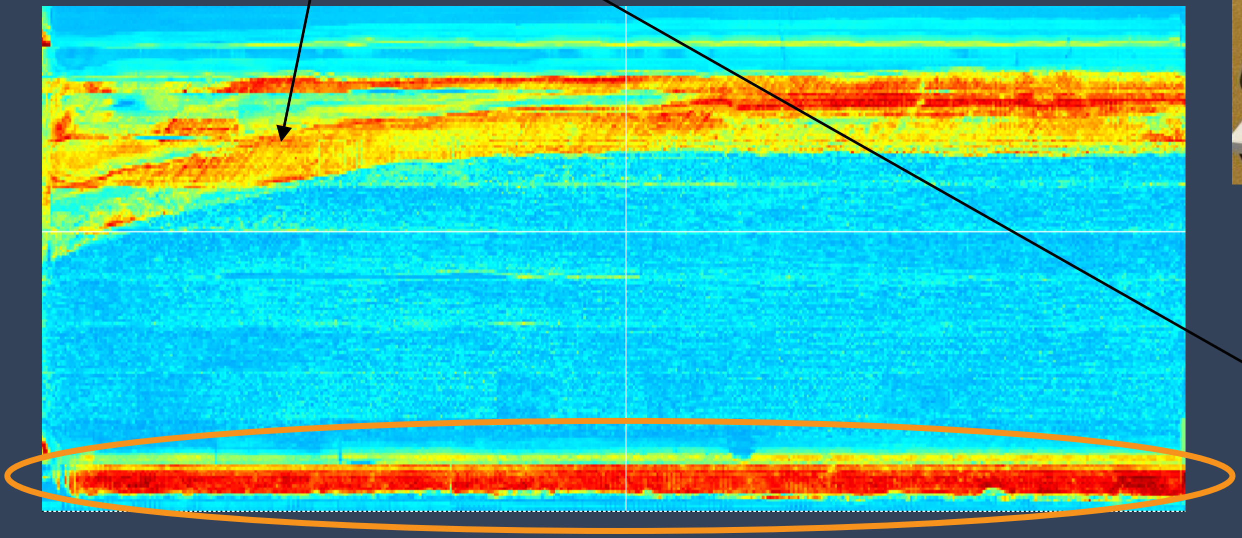
Lower image detailing Time of Flight (ToF). Red areas are epoxy filled areas and blue being the erosion shielding.

Helicopter Tail Rotor Blade.

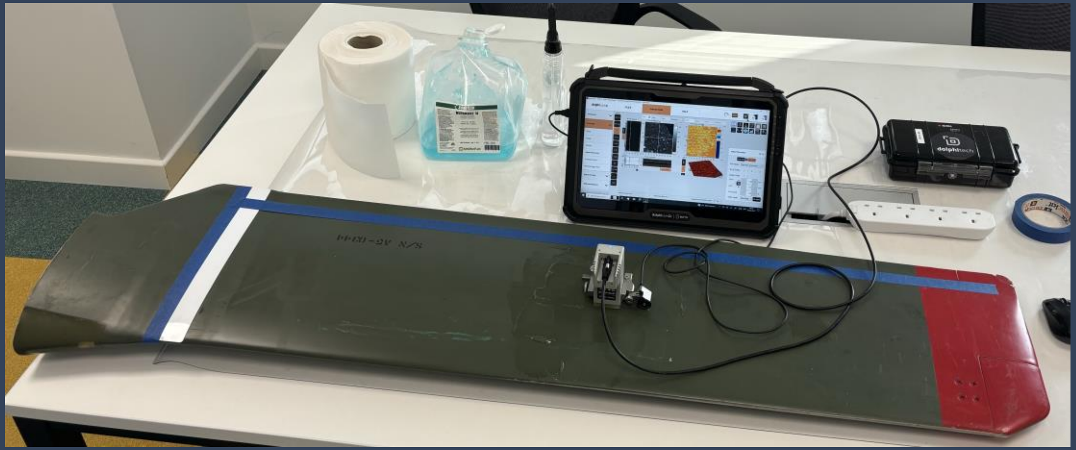


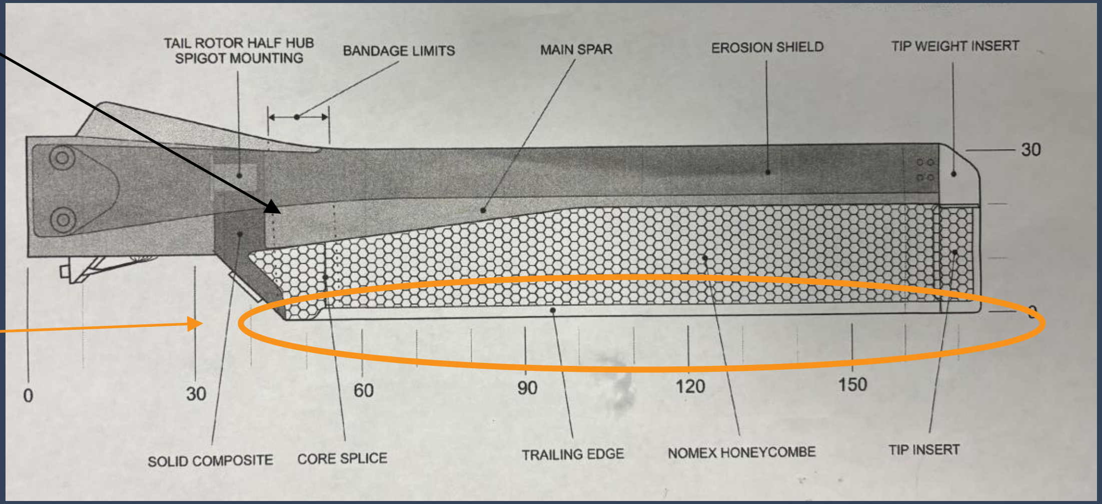
Helicopter Tail Rotor Blade.

Main Spar



Trailing edge





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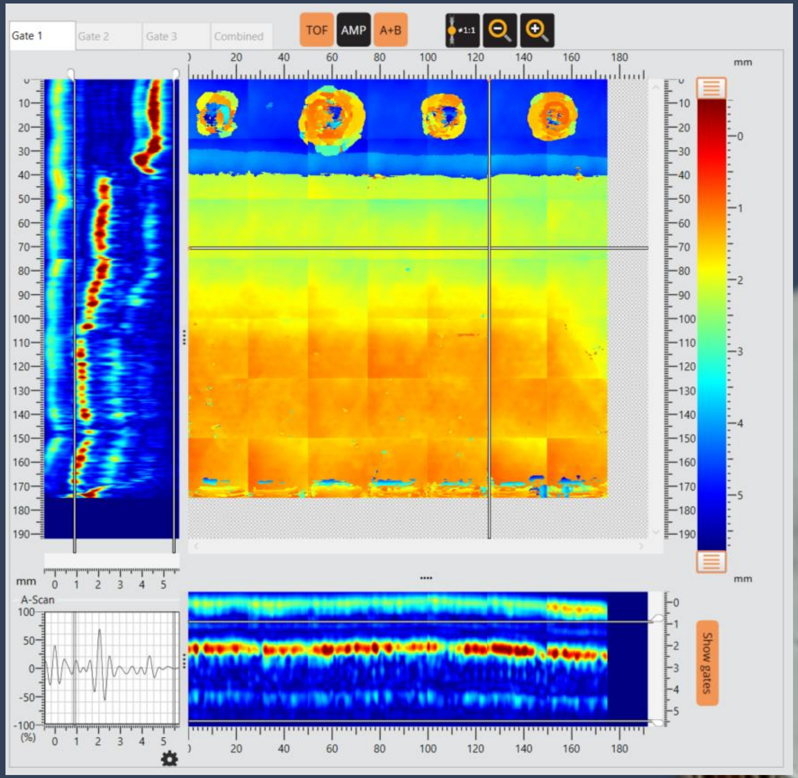
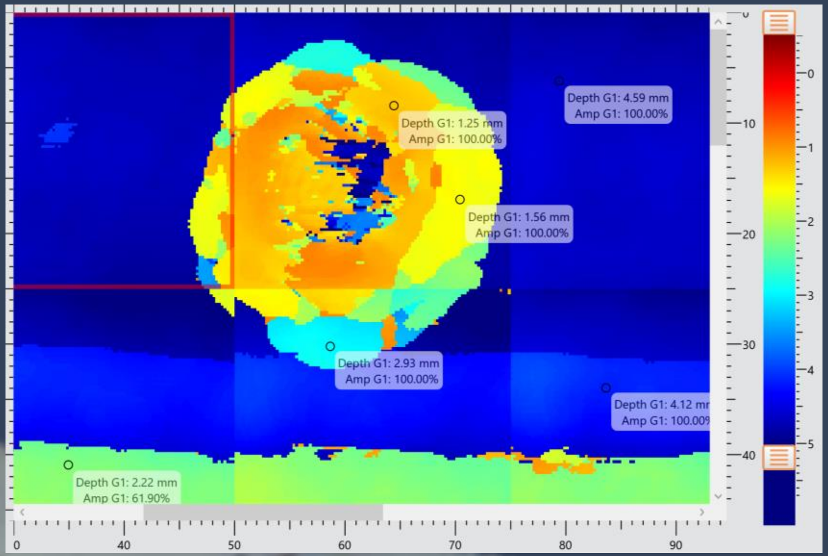
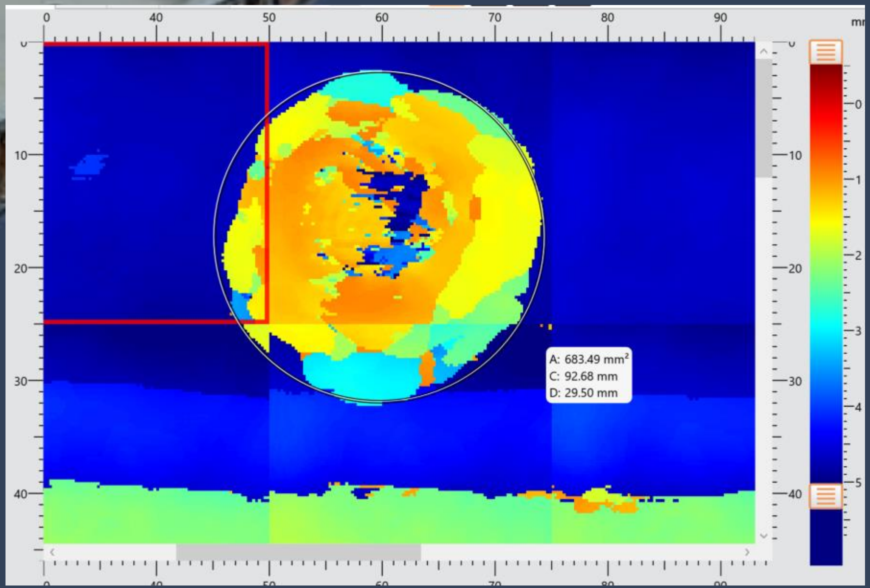
Fast Jet Panel. Delamination.







Multi-layer delamination due to panel fasteners being over torqued. Depth, area, amplitude are all measured with accuracy. Image fully integrated with reporting tool.

Titanium inspections

– Diffusion-welded titanium control surface section.

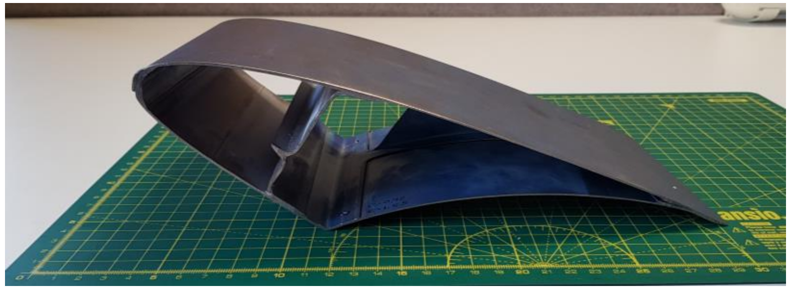
– The dimensions of the part are approximately 11” x 5” x 3” (28 cm × 13 cm × 7 cm).

– The structure is hollow with the thickness of the skins changing throughout, from <0.4” to >1.2” (<1 mm to >3 mm) at the welded joints.

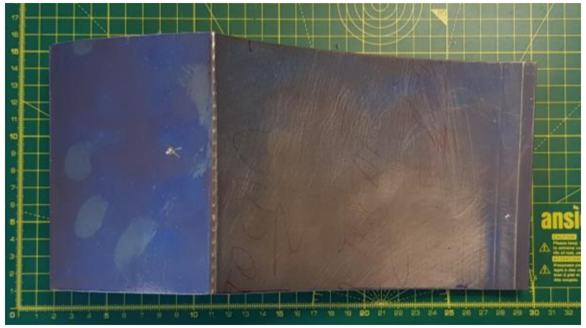
– Additionally, there are various ridges, indentations and drilled holes.

Top

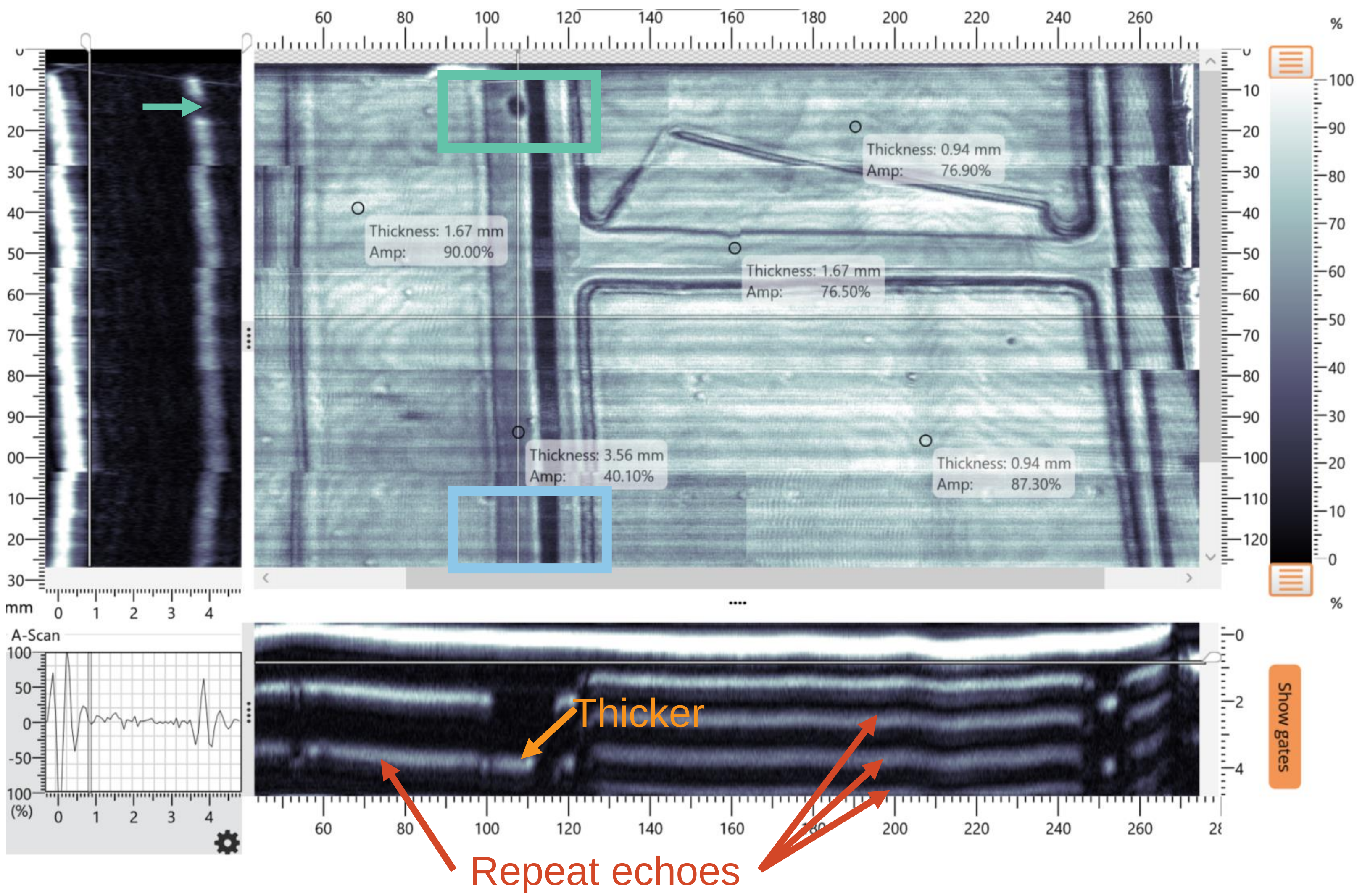
Side



Bottom



Results: Encoded scan of top surface



- Shown is the amplitude view.
- Can see dark ridges in the C-scan as the profile of the sample varies.
- Can see the drilled hole on the bottom side as a dark circle in the C-scan (green box) and as a discontinuity in the back wall in the B-scan (green arrow).

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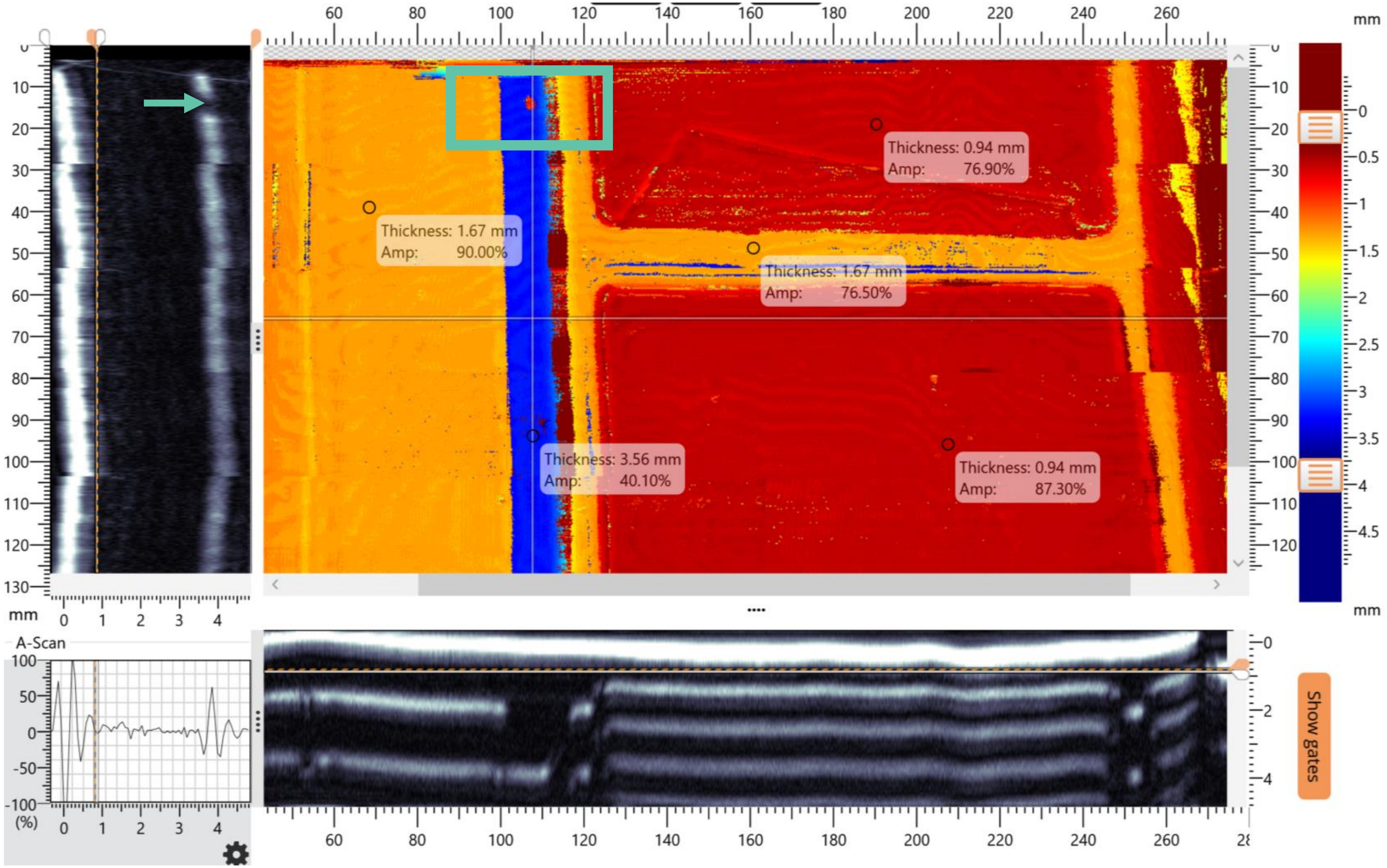
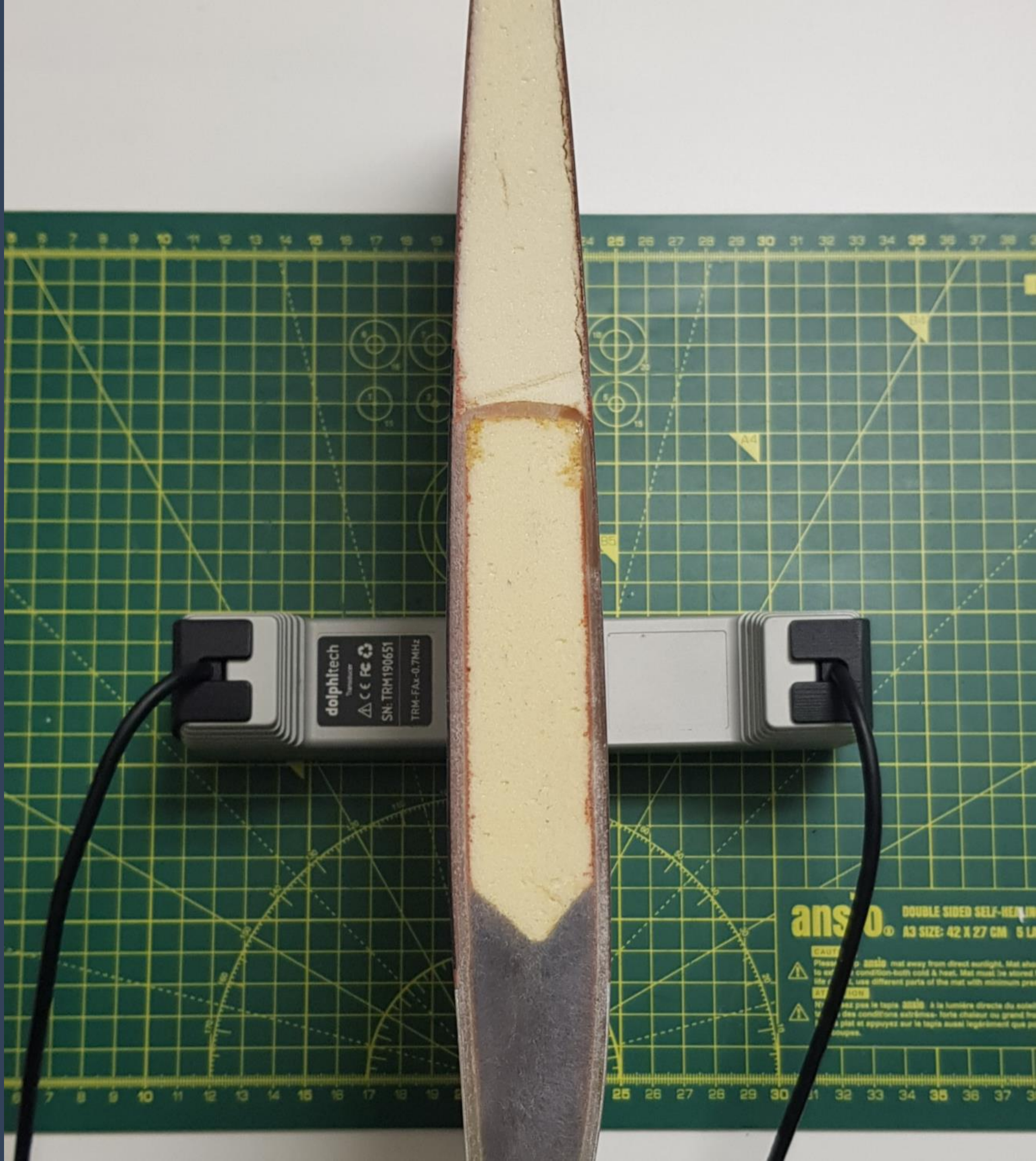
Results: Encoded scan of top surface



- Shown is the thickness (ToF) counterpart.
- Can see the dark ridges in the amplitude scan are caused by variations in the thickness. For example, the skin to spar can be seen as a dark blue region corresponding to a greater thickness.
- The drilled hole presents itself as a near-surface circular indication in the thickness C-scan (green box) as there is no clear back wall reflection (dark circle in amplitude C-scan and discontinuity in the back wall in B-scan).

Foam Core helicopter blade

- To penetrate through the foam core, through-transmission ultrasound (TTU) needs to be used.
- Our version of this is called MxTTU, which is a matrix array implementation of TTU.
- The sample was tested with both a 0.7 MHz pair of transducers and a 1.5 MHz pair. The 0.7MHz pair were found to produce better results so results from these scans are shown.
- Some scans from individual locations are shown, along with a manually-stitched scan
- Manually-stitched scans are formed by freehand positioning the transducer with the data from each location being stitched together



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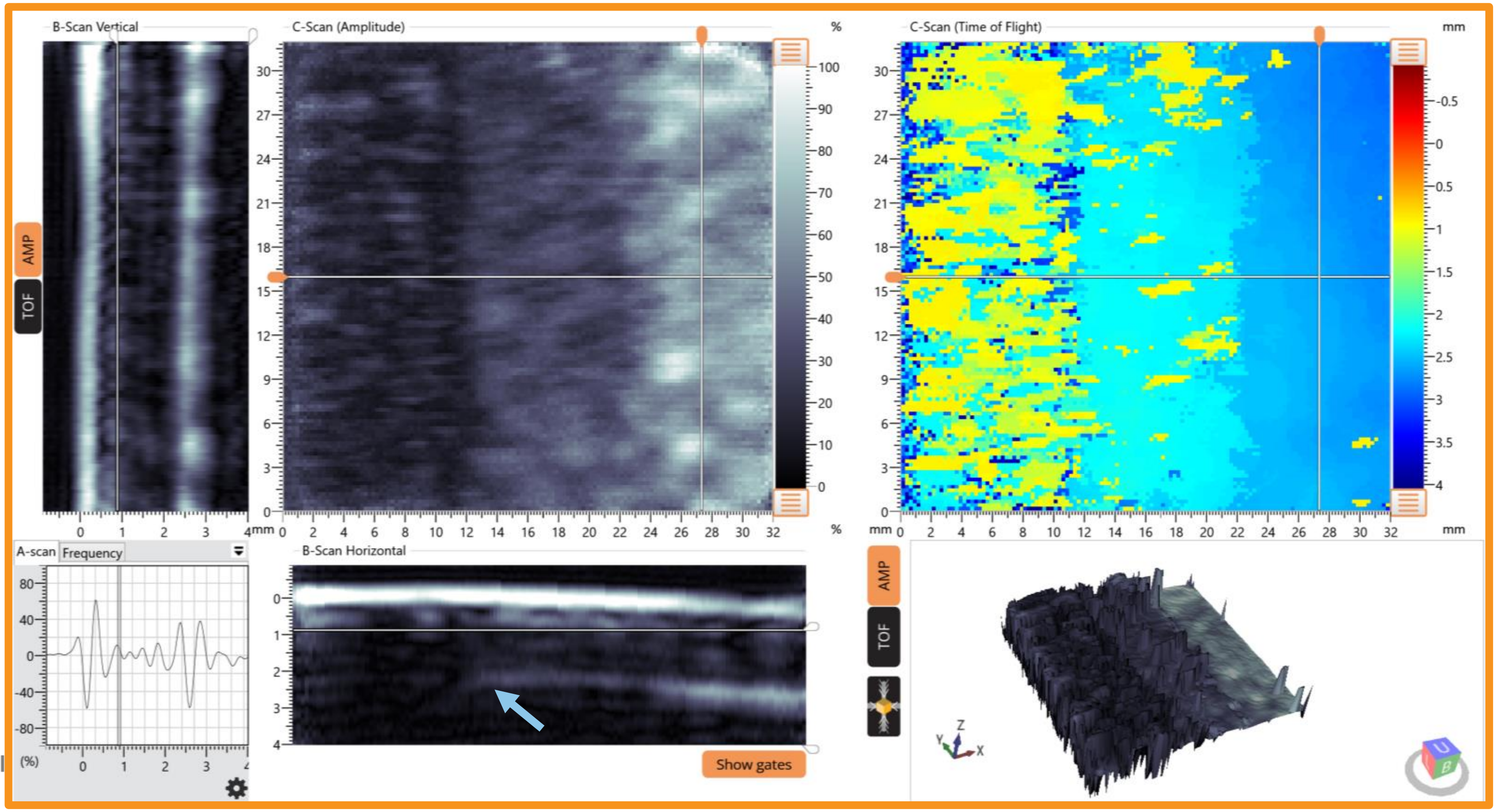
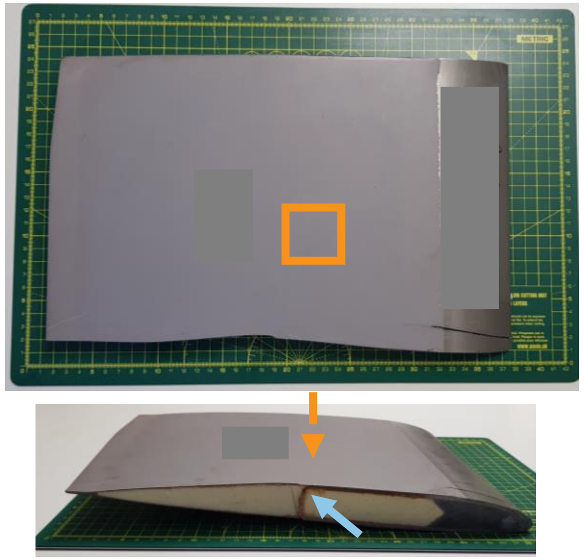
Results: Single location

– A single tile scan representative of what is acquired from a single transducer location is shown below.

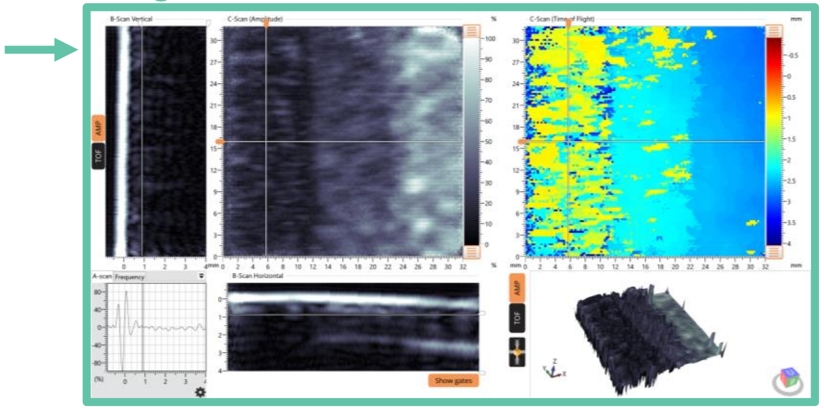
– The single location data is shown in the All view.

– Back wall is lost as it curves away (blue arrow).



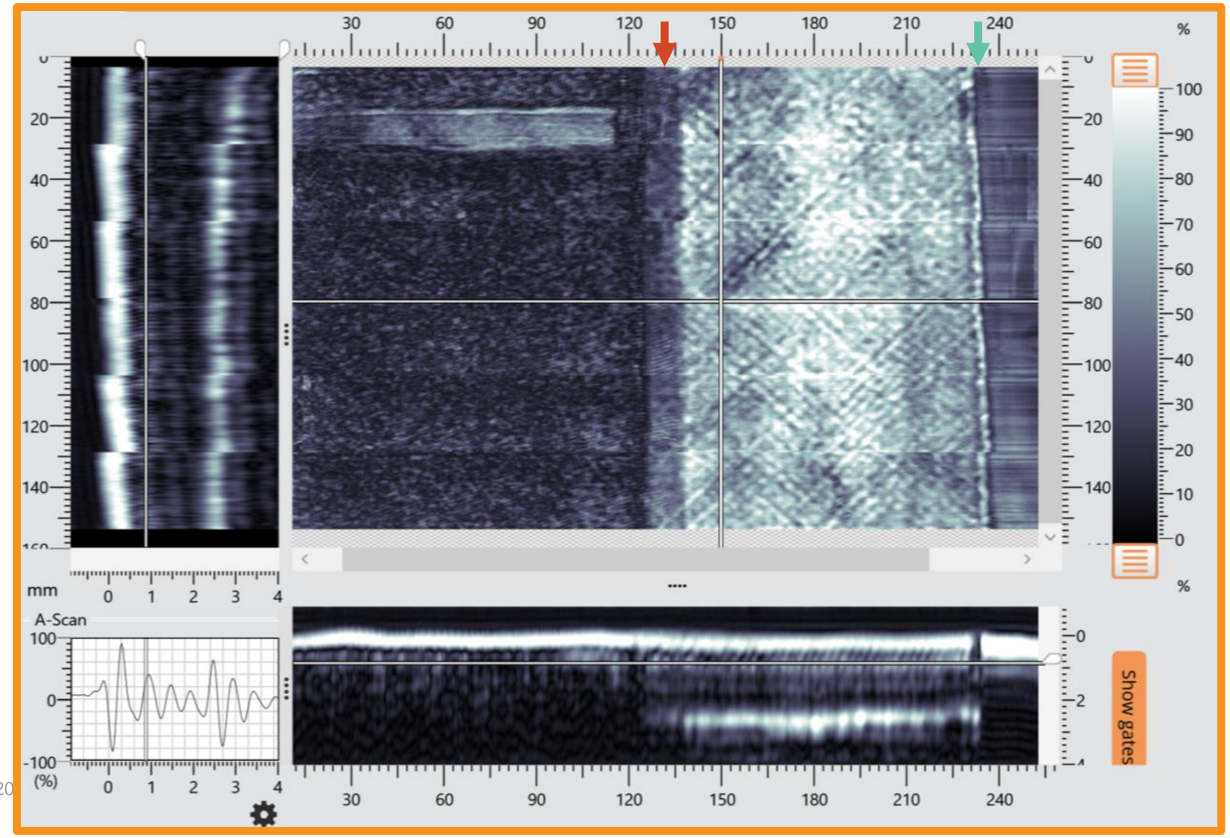


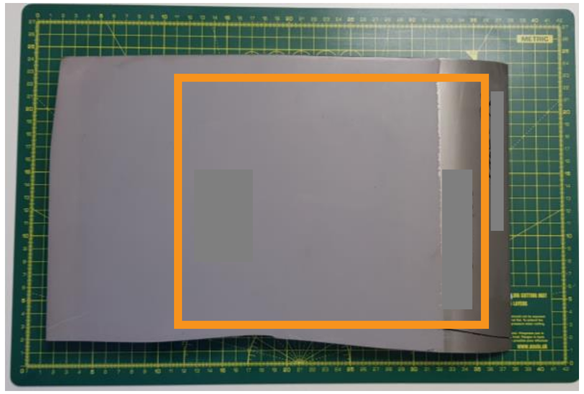
Moving cross-hairs to left

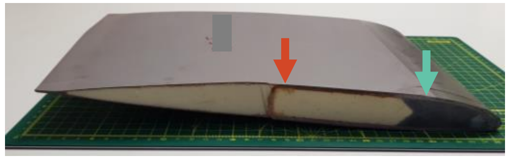


Results: Encoded map

- Shown is an encoded map covering the top surface of the sample.
- The encoded map is shown in amplitude view, but the thickness (ToF) data is simultaneously acquired and will be shown on the next slide.
- The +45/-45° plies in the thicker spar section can be clearly resolved, As can the texture change between the thin GFRP, thicker GFRP and leading edge metal region.



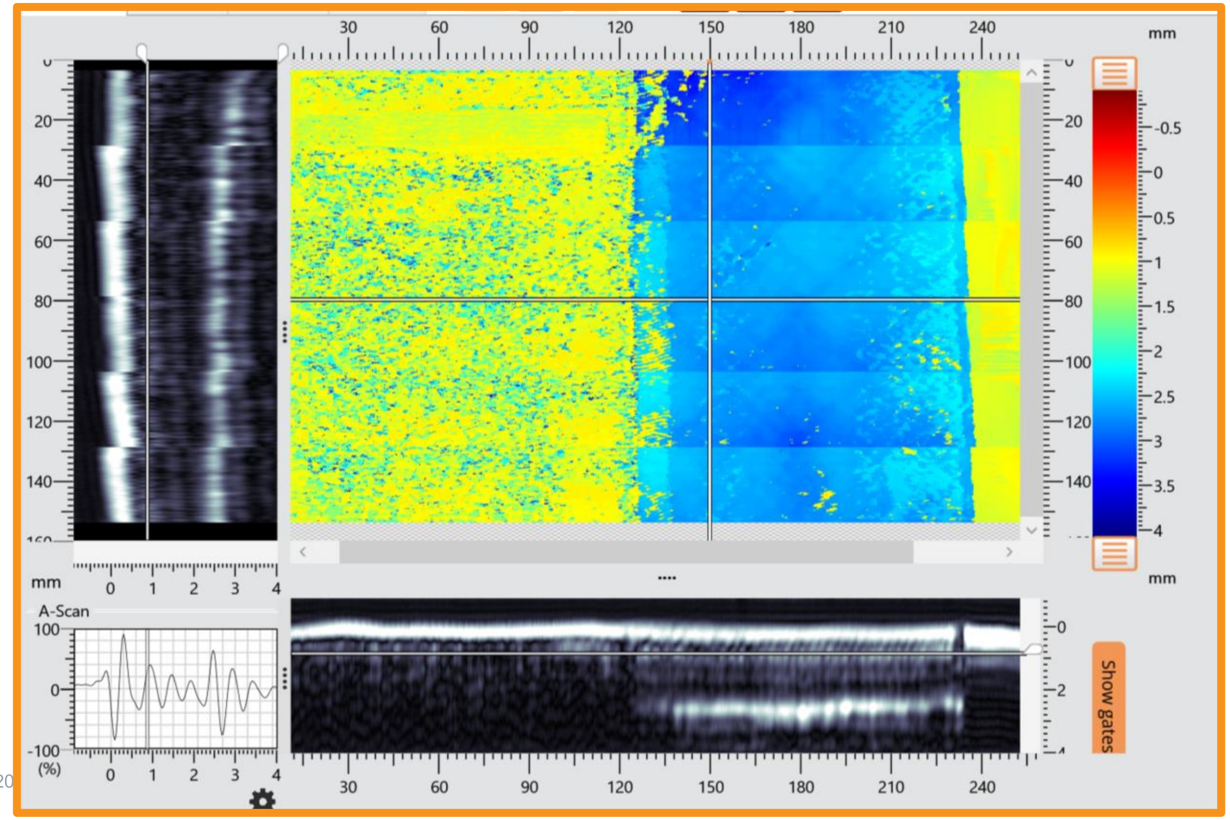


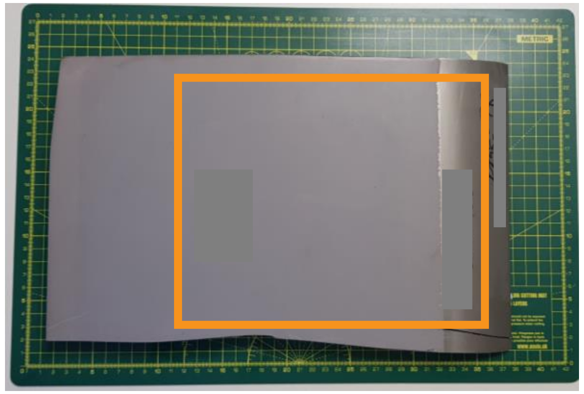


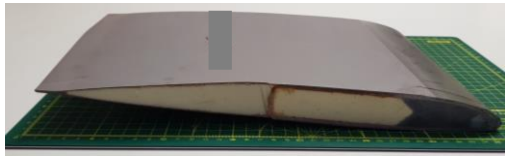
Results: Encoded map

– Below is the thickness (ToF) counterpart.

– The different thicknesses and textures of the of the different regions can be clearly identified.

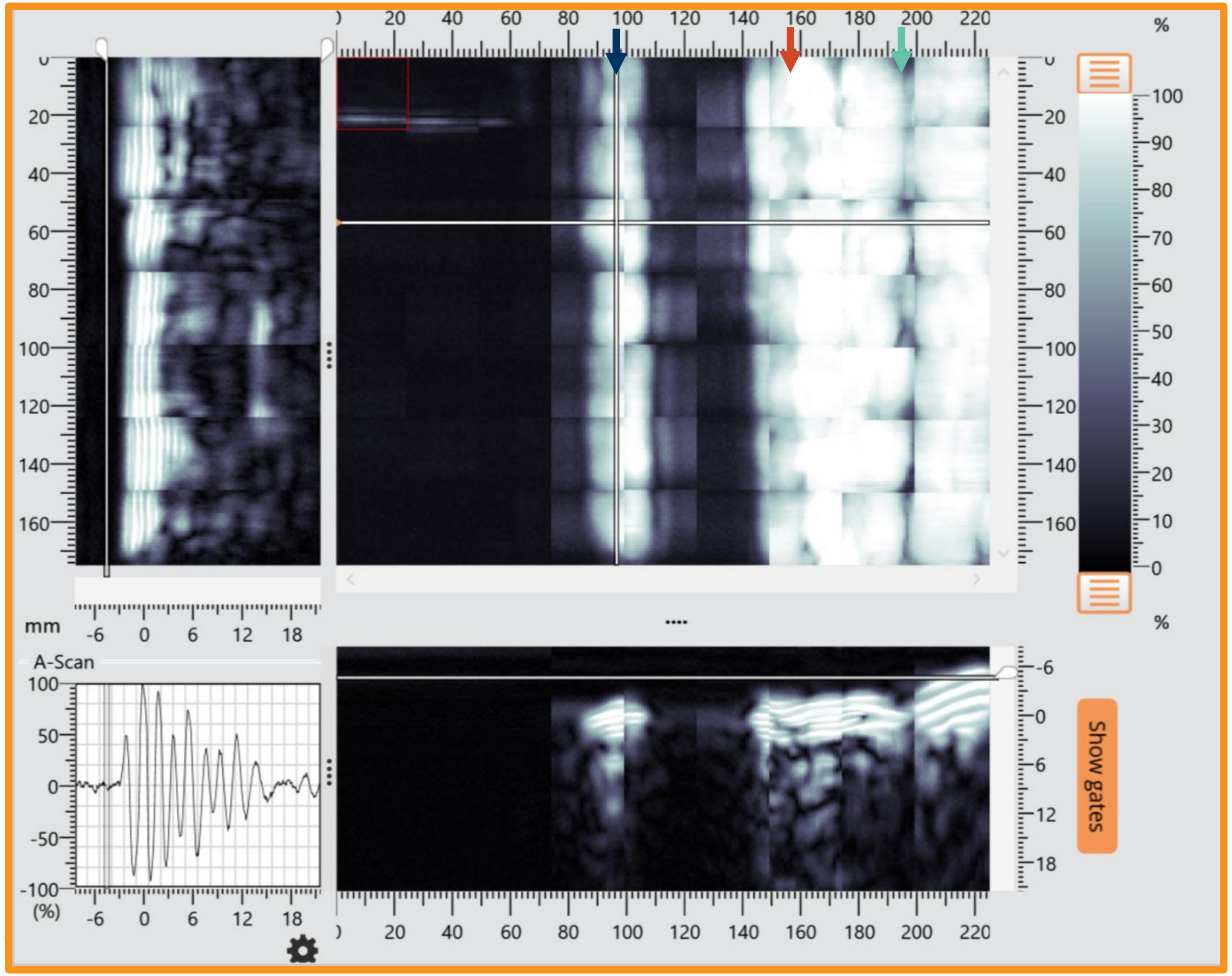


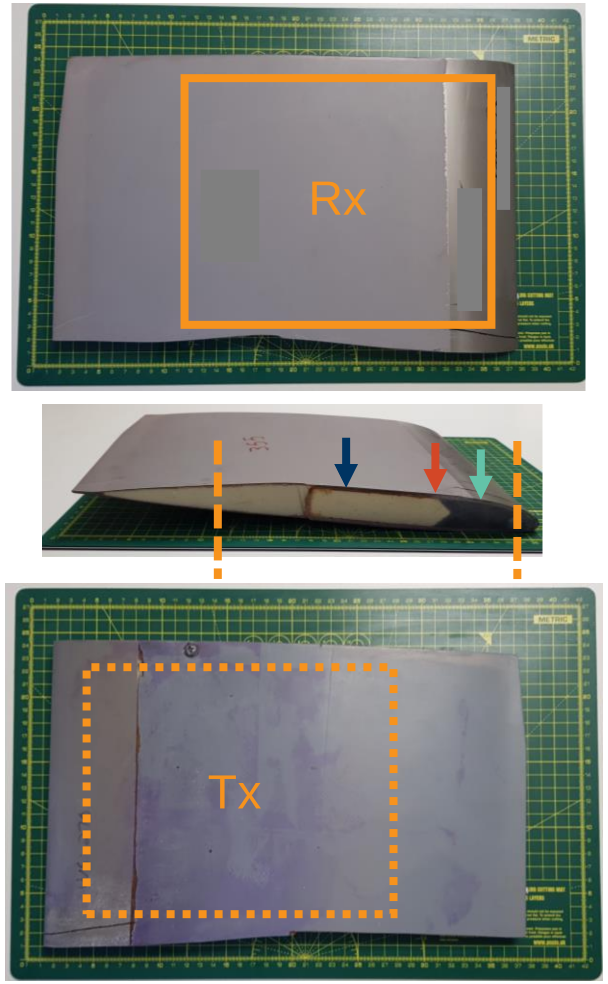




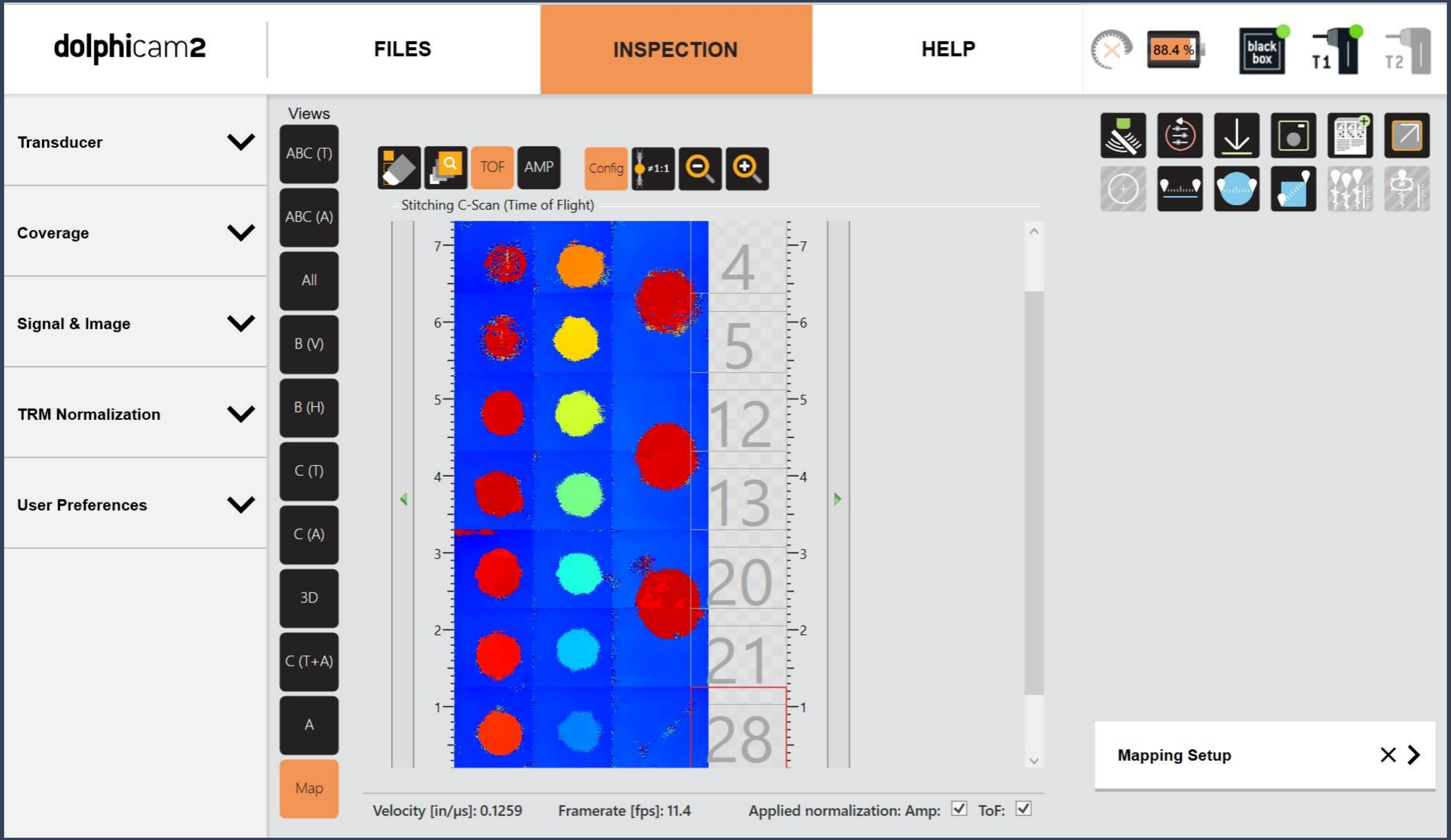
Results: MxTTU– Stitched map

– A manually-stitched map was produced using a pair of TRM-FAx-0.7MHz in MxTTU mode. The result is shown below.



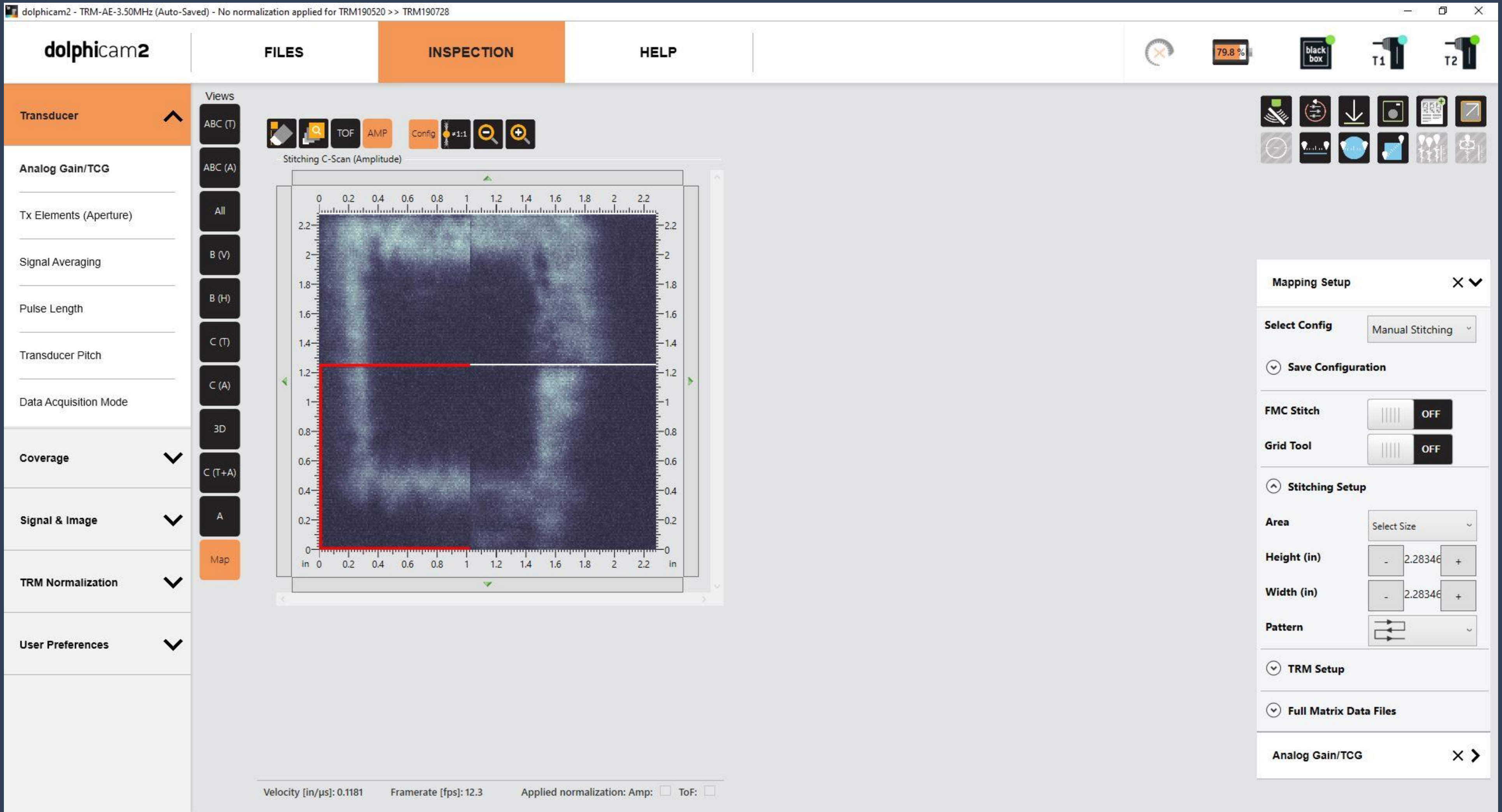


NAVAIR trials



Carbon Fiber
FBH STD

NAVAIR trials



Two bonded Al
skins with disbond

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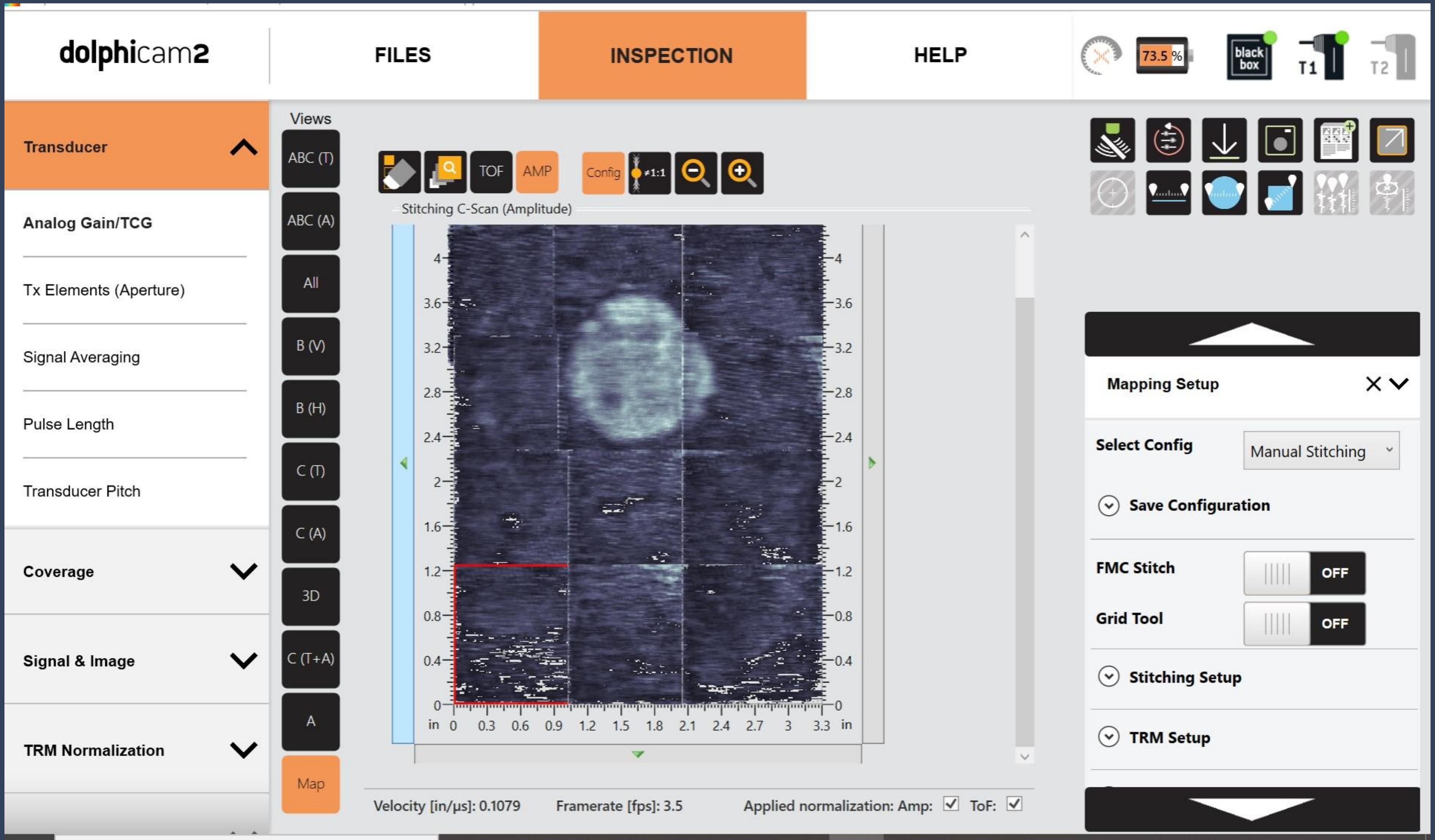
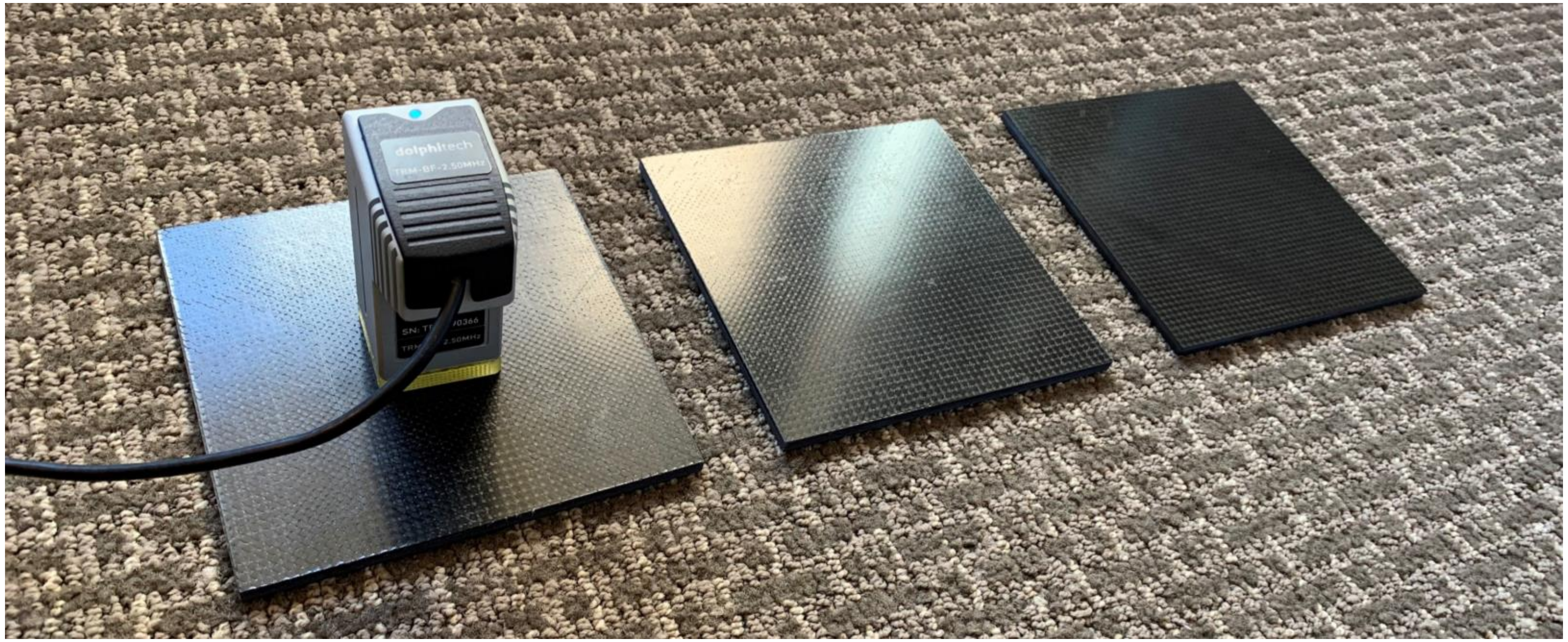
NAVAIR trials



0.055” GFB to Phenolic Core

CFRP porosity detection

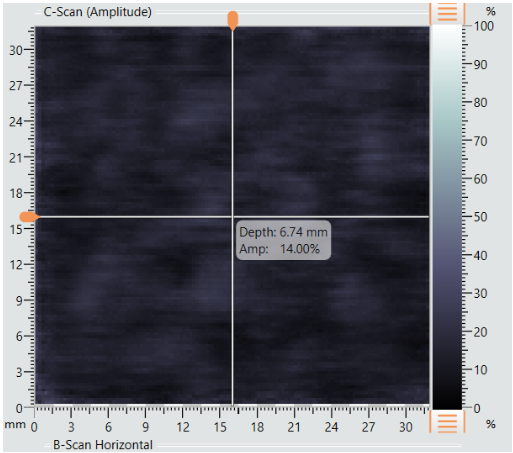
- 3x reference porosity standards were manufactured for dolphitech by Flying S Inc.
- Panels are 1/4” thick monolithic woven CFRP laminates
- To produce different porosity levels, one panel was cured at 50% vacuum, one at 75% vacuum, and one at 100% vacuum
- Back wall echo was gated and max amplitudes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



CFRP porosity detection

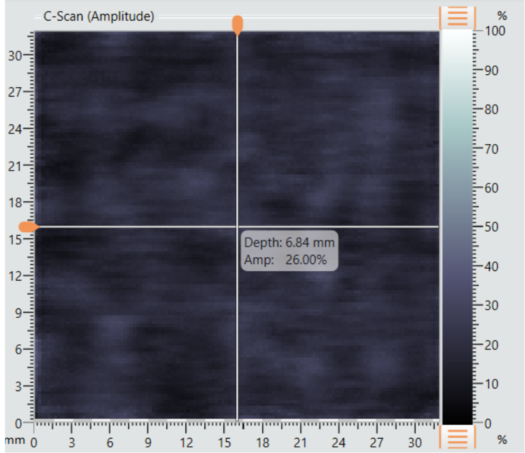
– Most basic level of analysis:
  – Qualitative evaluation of image colour
– Next level of analysis:
  – Single point amplitude measurement using crosshair marker

50% vacuum



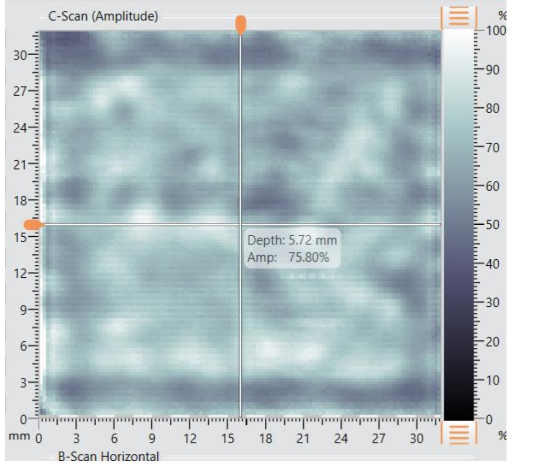
14.0% amplitude

75% vacuum



26.0% amplitude

100% vacuum



75.8% amplitude

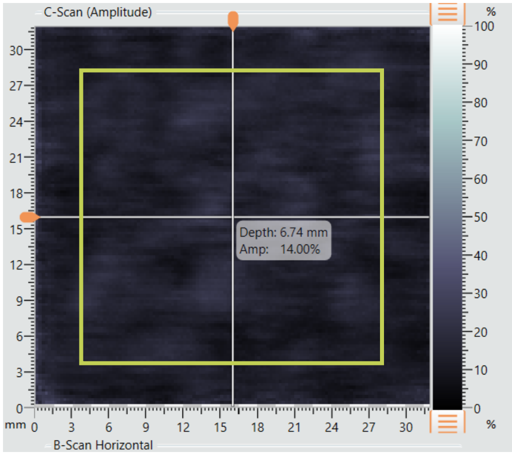
CFRP porosity detection

– Next level of analysis:

  – Statistical measurement over region of interest

  – This represents values from 10,000 A-scan (25 x 25mm measurement square)

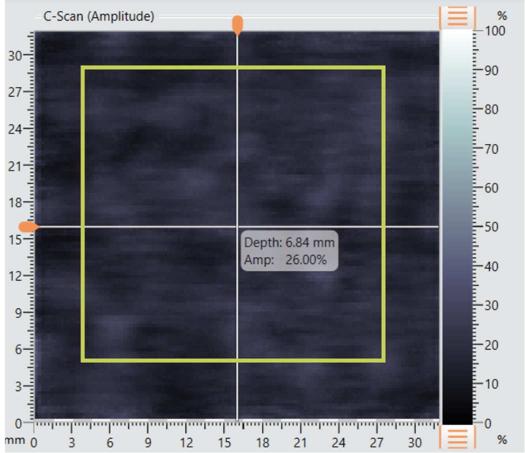
50% vacuum



Statistics

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

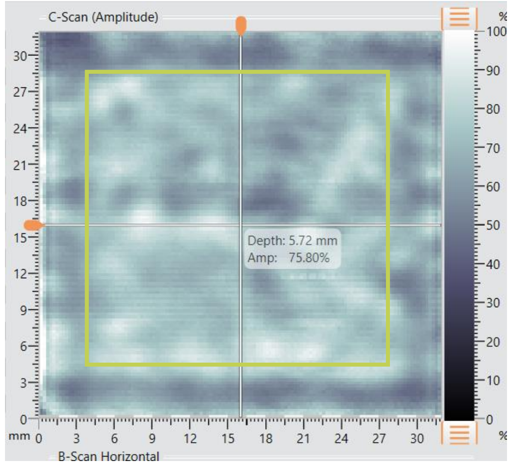
75% vacuum



Statistics

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

100% vacuum



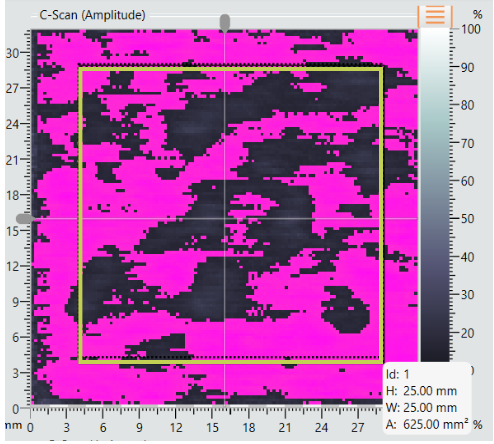
Statistics

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



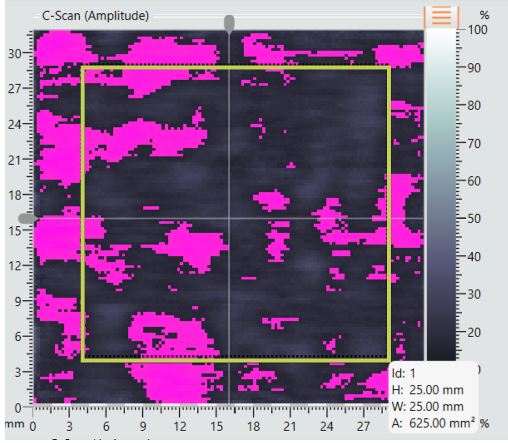
Statistics

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



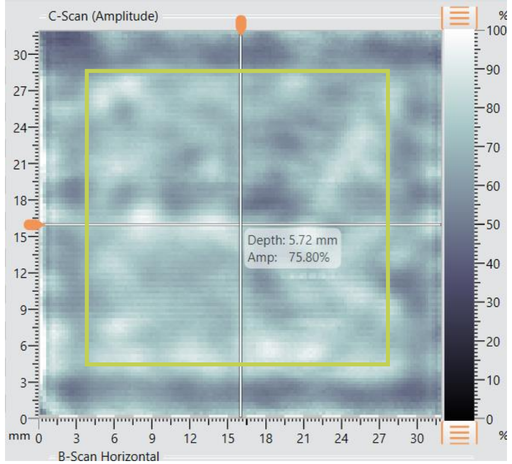
Statistics

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 %

DOLPHICAM2 NDI ENABLES ACE

Simple to operate, no expert required, due to pre-configured files per aircraft type

Instant decision if safe to fly/no-fly

Detecting damage: Battle /impact/ overstress/ weather/lightning/accidental

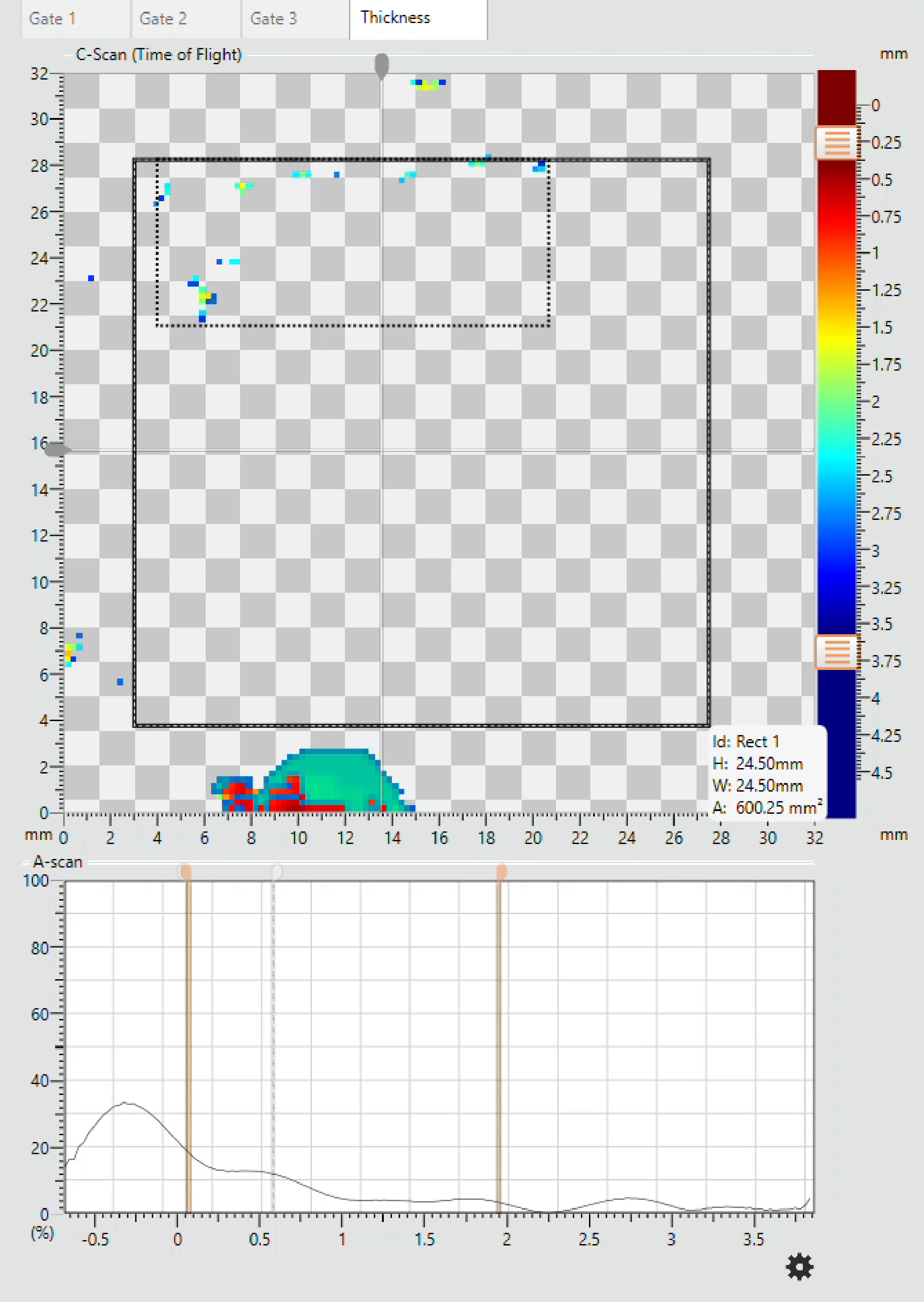
Up and running in 60 seconds

Fully portable and deployable

Works on metals, composite, through paint and LO coating

Dolphicam2 – ACE in action

- Preset file loaded to dolphicam2
- Material has damage in it, with a threshold set for tolerance
- Anything “appearing” on the scan is outside acceptable tolerance
- Auto defect detection mode also shown



Thank you

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