CFLUX

CFLUX Project- EASN 2020

Eddy current inspection of Carbon fibre raw materials and cured parts in the Aerospace industry

ETHER NDE

Far COMPOSITES

TWI

M.Wright & Sons Ltd.
Engineered Textile Structures
(Established 1860)

AHS
Advanced Hall Sensors Ltd

InnovateUK funded project 113229 - CFLUX 30236

Non destructive testing of composite materials in aerospace.

Complex geometry

Disadvantages of other techniques-

- Ultrasonic , Laser, Air coupled

Why use eddy current ?-

- Non contact, safe, sensitive, volume fraction detection, weave flaws detection

The challenges-

- Signal to noise ratio, vibrations, constant standoff, equipment integrations

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Development of two non-contact:

- Dry NDE techniques for carbon fibre parts.

- Eddy current and Magnetic flux leakage to retrieve high-resolution signals from carbon fibre surfaces

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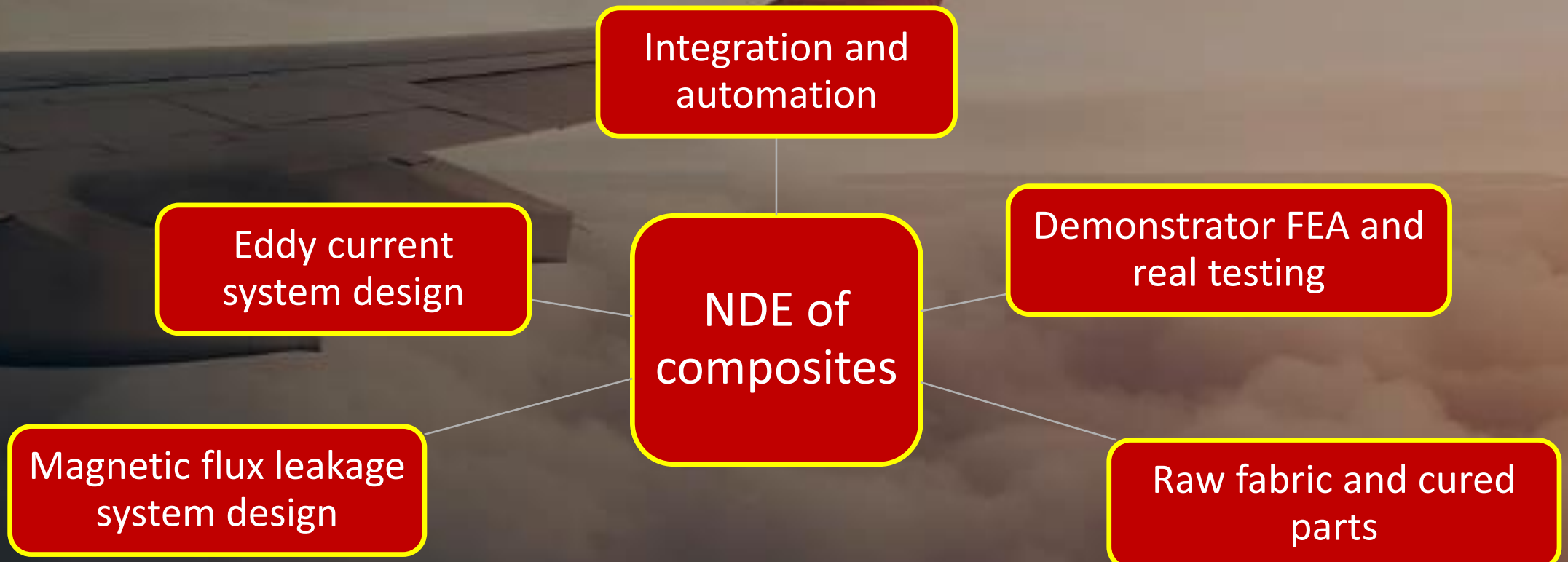
How will we achieve this?



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Key activities of consortium partners

Company	Key activity
M. Wrights and sons	Use of advanced testing equipment in production, and manufacture all of the 3D woven fabric for project reference samples. Project management.
TWI	Create Eddy current viewing and interrogation software, by integration of positional and eddy current signals from a 2D scanner, 3D Cobot and EtherNDE unique probes. Validation against conventional methods. Project management.
EtherNDE	Manufacture the Eddy current end effectors and control systems for CFLUX, marketing the entire automated systems. They will also develop high-sensitivity hardware applicable for additional markets beyond CFLUX
AHS	Manufacture the MFL sensor head and control systems for CFLUX, marketing the entire automated systems. They will also develop high-sensitivity hardware applicable for additional markets beyond CFLUX
FAR	Design of reference samples, and performing FEA and tool design for the project, alongside mechanical testing and validation

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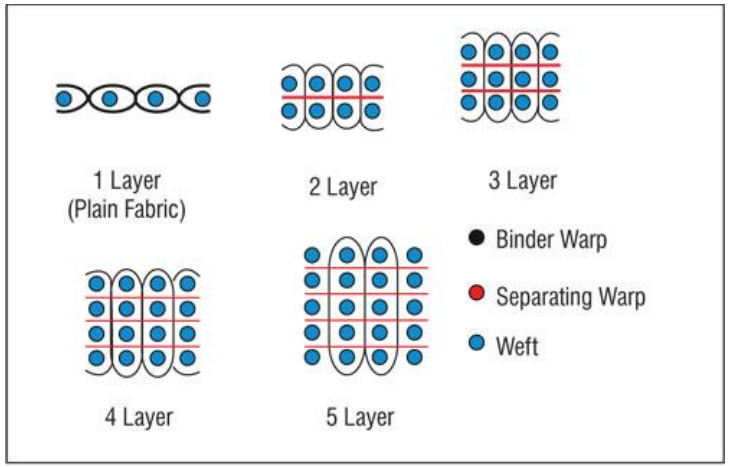
M Wrights and sons 3D woven textiles in carbon fibre for aerospace

- Weight saving
- Space saving
- High temperature performance
- Chemical resistance
- Flame retardant
- High strength, low extension at failure
- Creep resistance
- Ballistic performance
- Cut and penetration resistance
- Significant cost reduction opportunities

M.Wright & Sons Ltd.
Engineered Textile Structures
(Established 1860)



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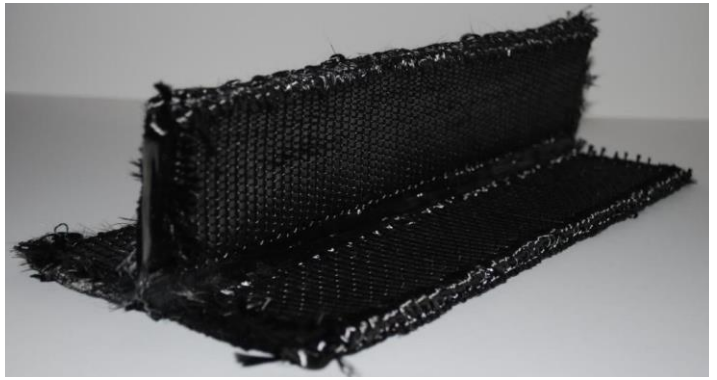
3D woven fabric-woven flat-unfolded into T shape, and then infused with resin



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Reference samples

- Raw fabric and cured parts.

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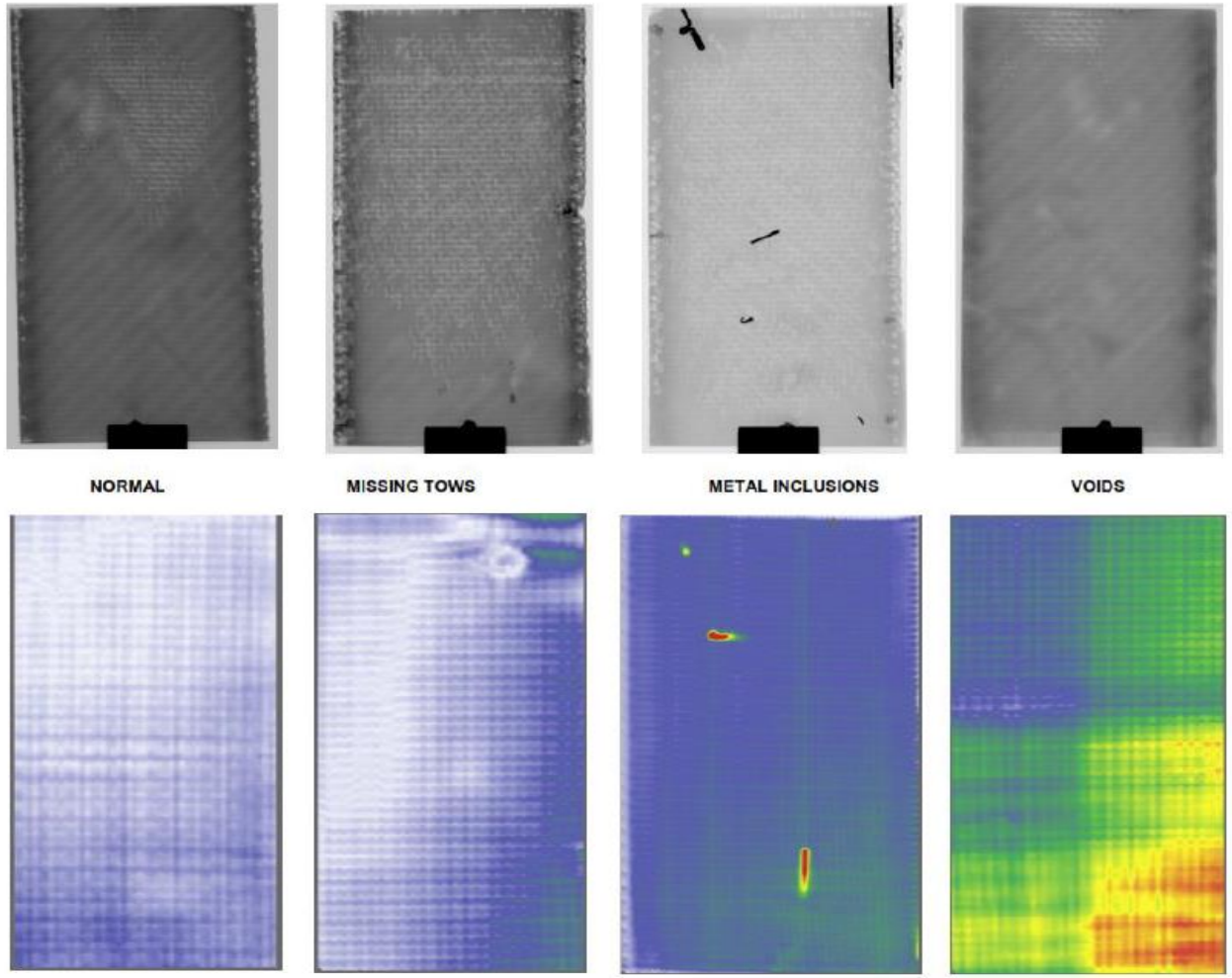
X-ray and Conventional Eddy current of initial samples



80kV,160uA,SDD 1148mm, SOD 619mm,Mag x1.85
Resolution 0.11,1000msec exposure,8 frames averaged

XY scanner-2MHz
probe, 1mm increment

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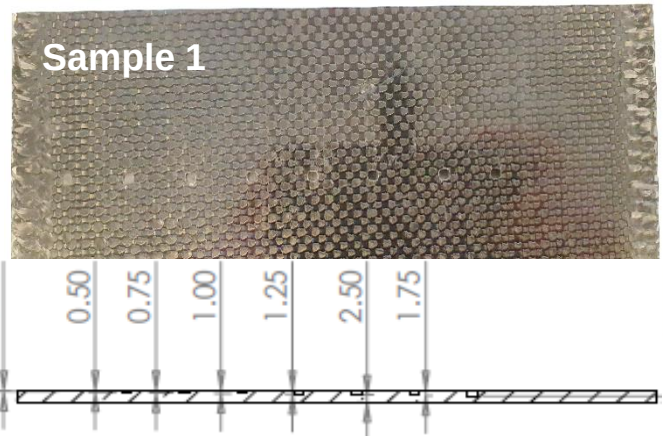
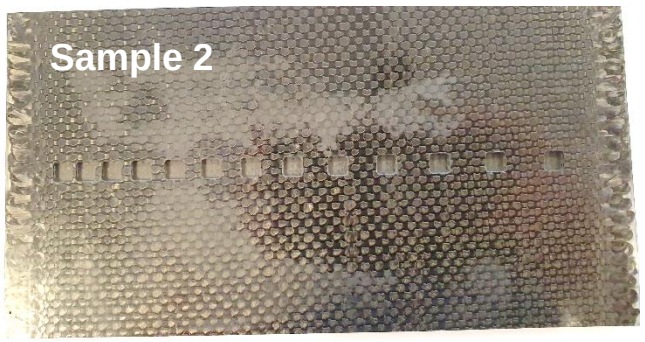
Machined reference samples

4.2mm SAMPLES

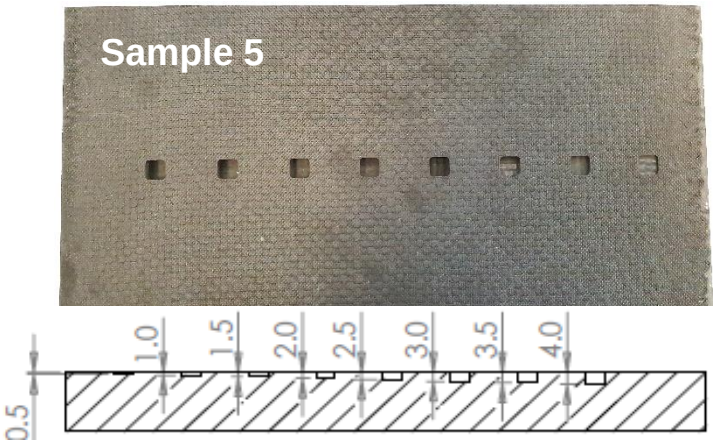


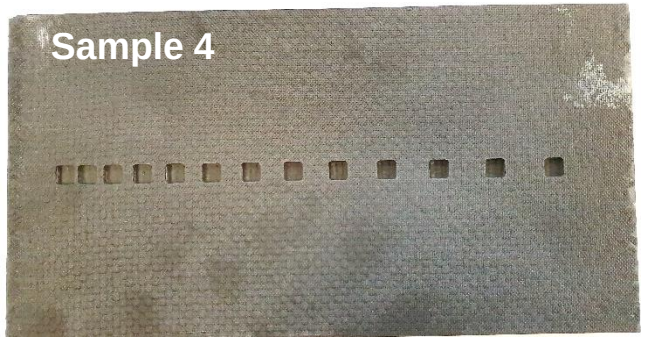


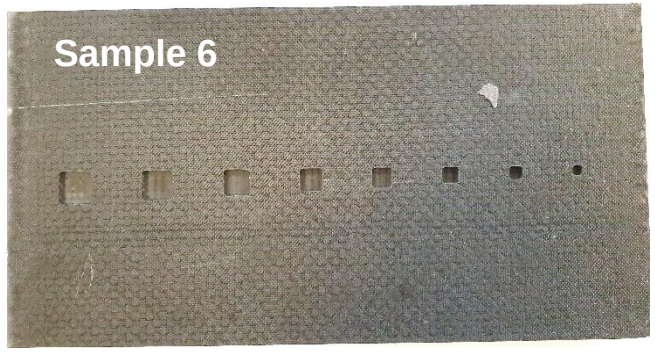
FLAW DEPTHS

RESOLUTION-DIFFERING SPACING

FLAW SIZES







15mm SAMPLES

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Approach

- Development of Eddy Current techniques for carbon fibre parts.

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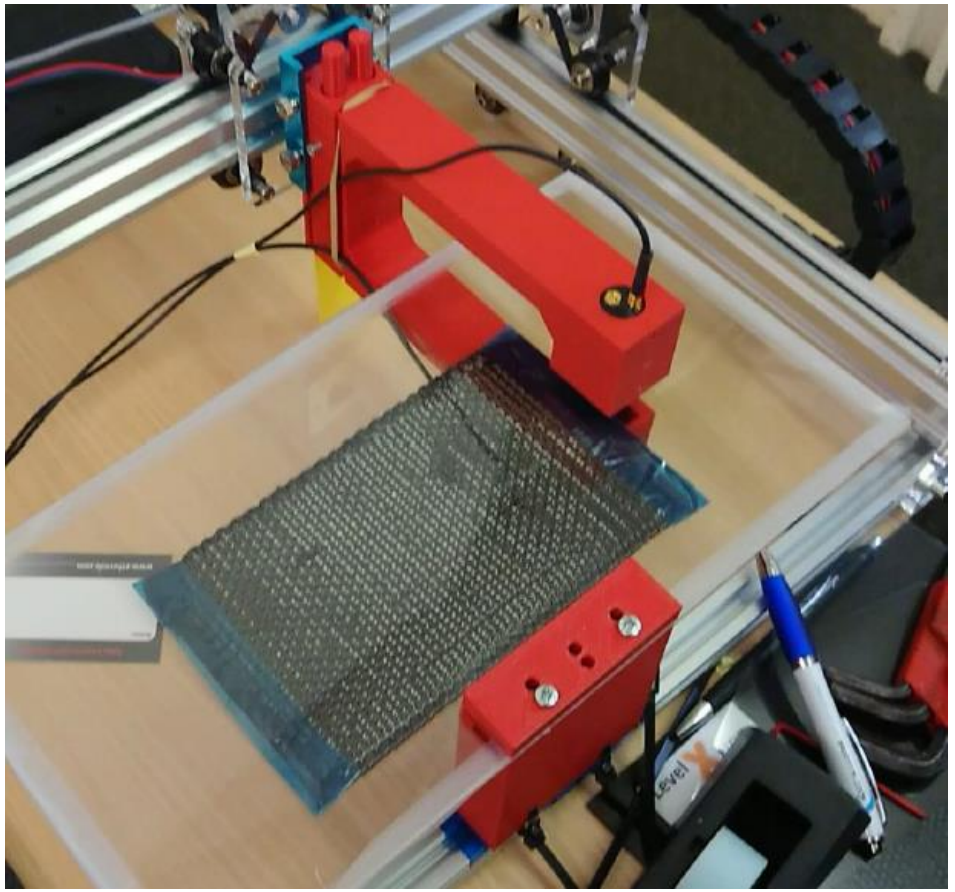
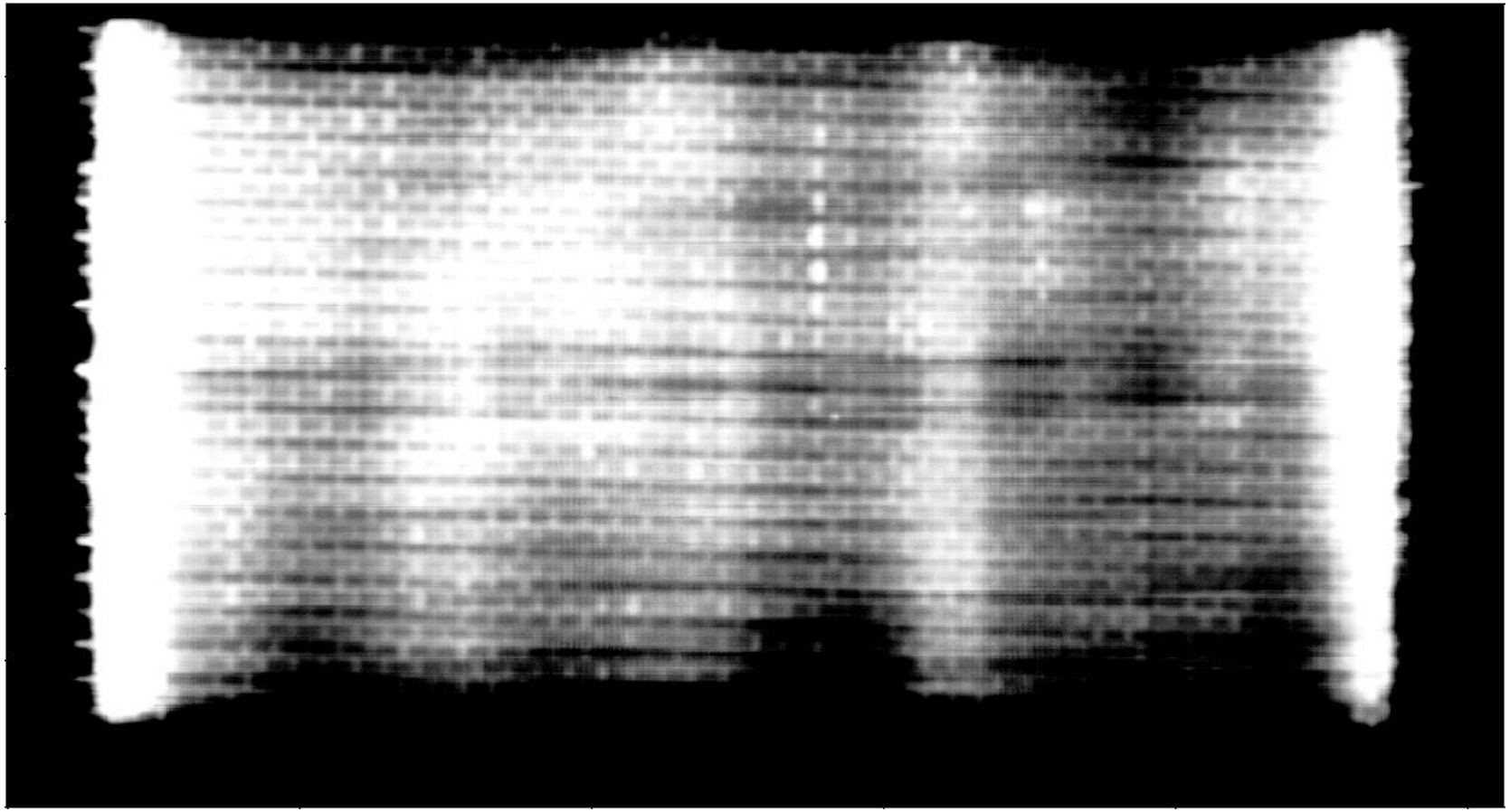
Ether NDE design and build of 2D scanner and 3D printed probes



4.2 mm Reference Sample 2

4 MHz Sample 2 Pencil Probe .2 mm Resolution



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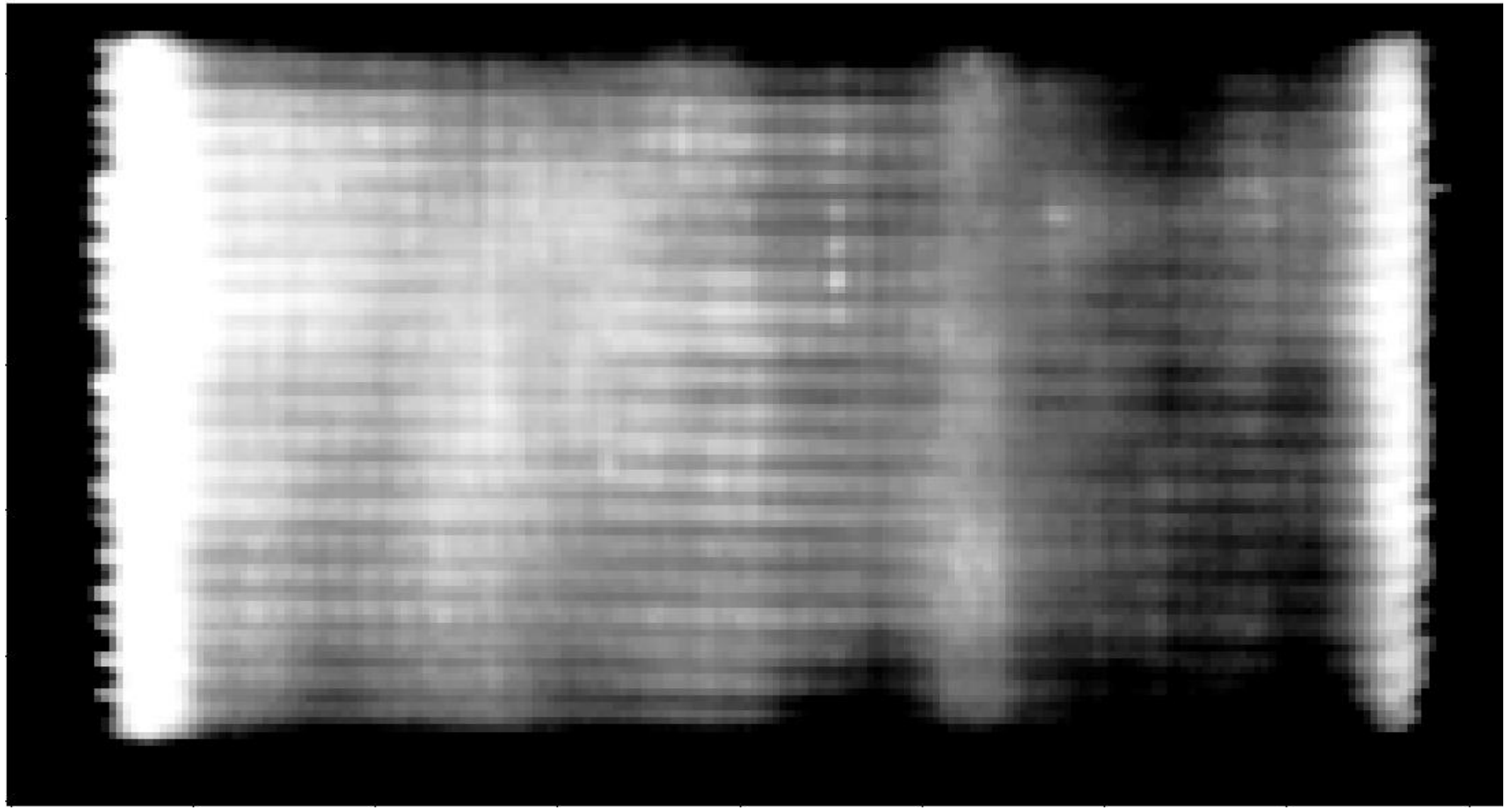
4.2 mm Reference Sample2

10 MHz Sample 8mm Probe 1 mm and 0.25mm Resolution



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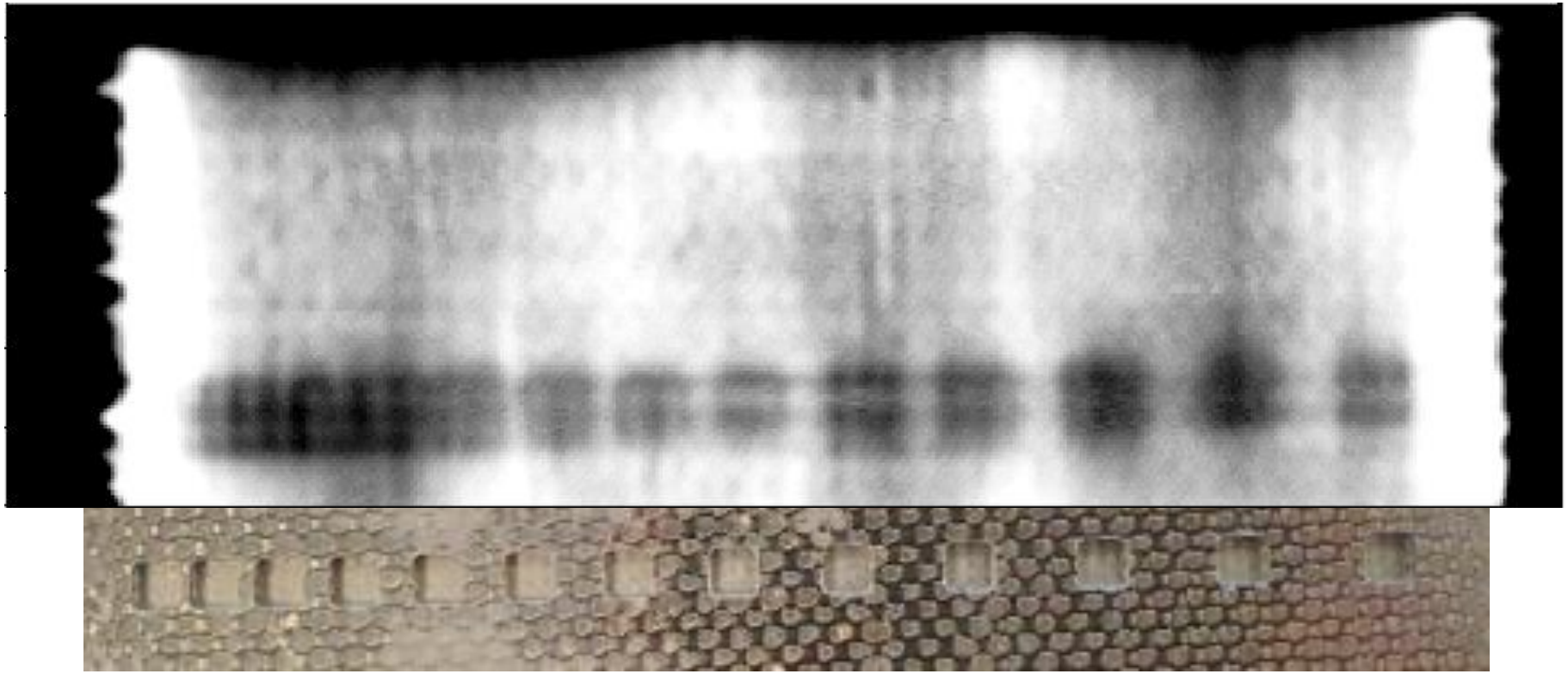
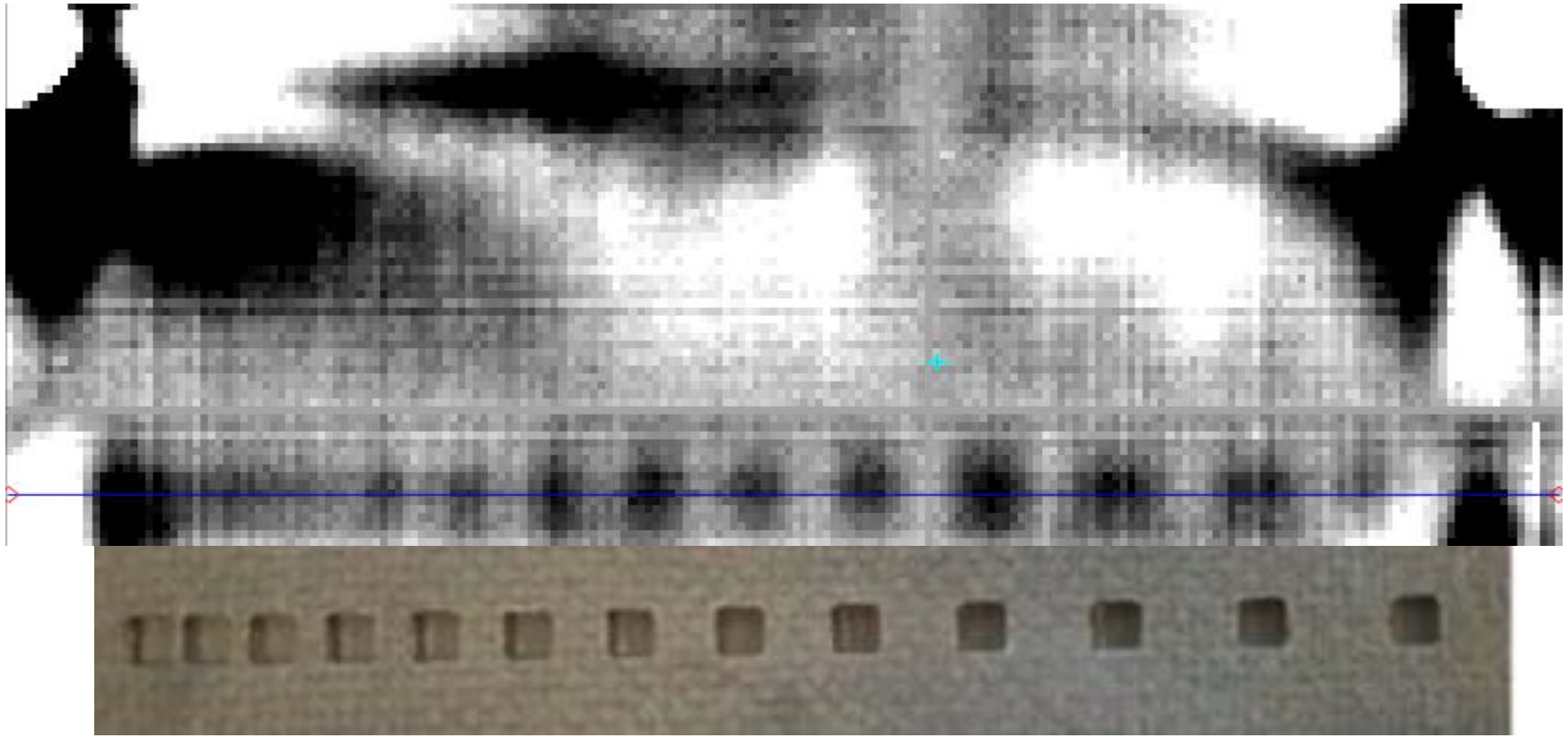
4.2 mm Reference Sample 2



9 MHz Sample 2 8mm Probe

15mm resolution sample with filtering



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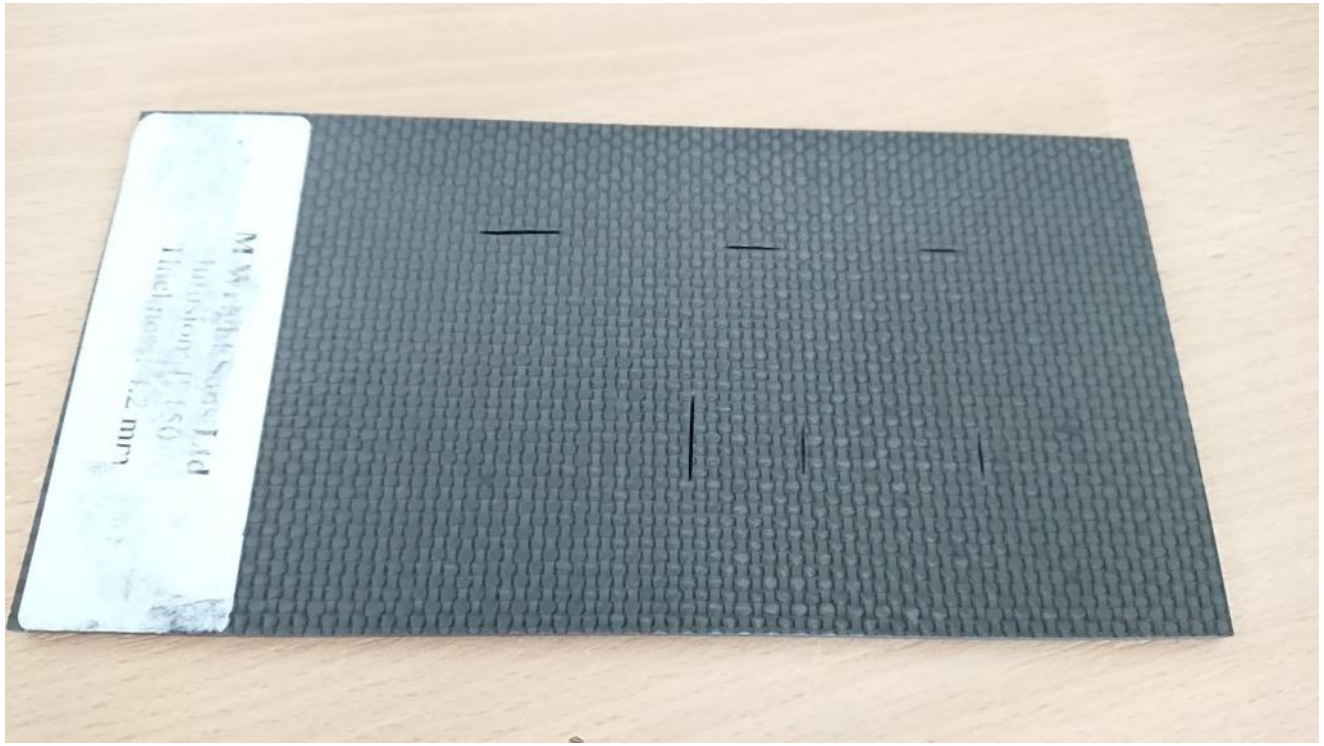
Notched 4.2 mm sample



Notches

Left to Right

Top

2.3mm deep by 17mm

1.28mm deep by 12mm

0.7mm deep by 10 mm

Bottom

2.5mm by 18mm

1mm by 11mm

0.9mm by 10.5 mm

Sample nominal 4.2mm but Right side 4.3mm left side 3.8mm

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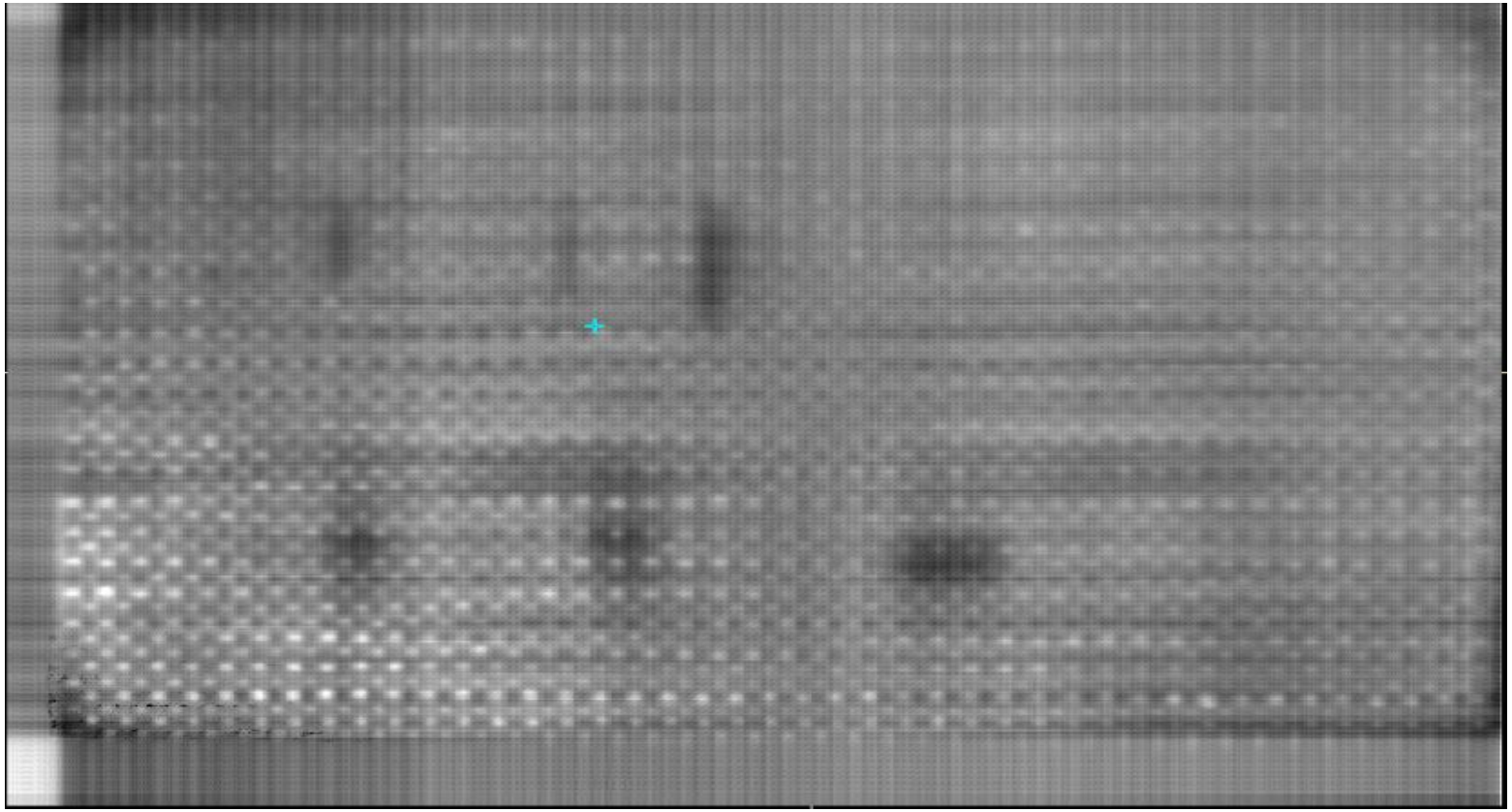
4mm Sample with surface notches

2MHz Pencil Probe at 4MHz 0.25 mm resolution (164215)



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Approach

- Application of Magnetic flux leakage to retrieve high-resolution signals from carbon fibre surfaces

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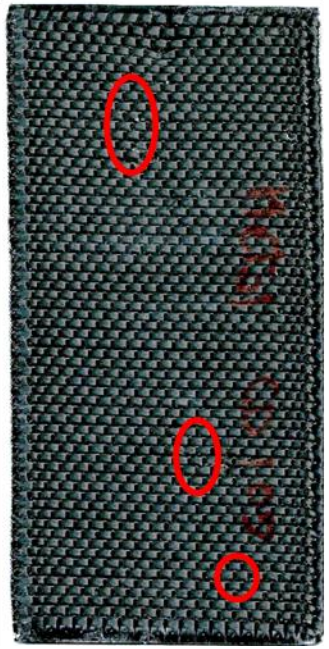
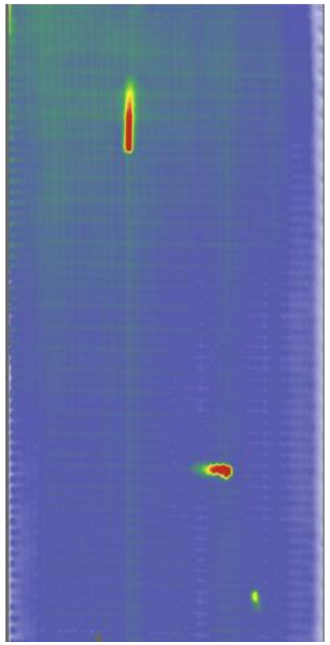
Quarter 1-3 : Preliminary Tests (MFL)

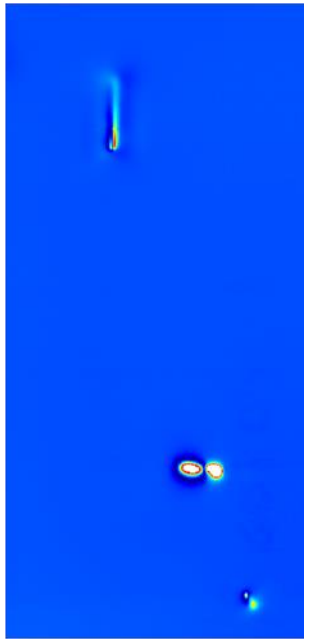
- A flaw in a material causes a deflection of the magnetic field which is detected by the sensor
- **Only occurs** if permeabilities are significantly different as in the case of any ferromagnetic metal



CD107
(Metal Fragments)



Eddy Current Measurement [TWI]



MFL Measurement [AHS]

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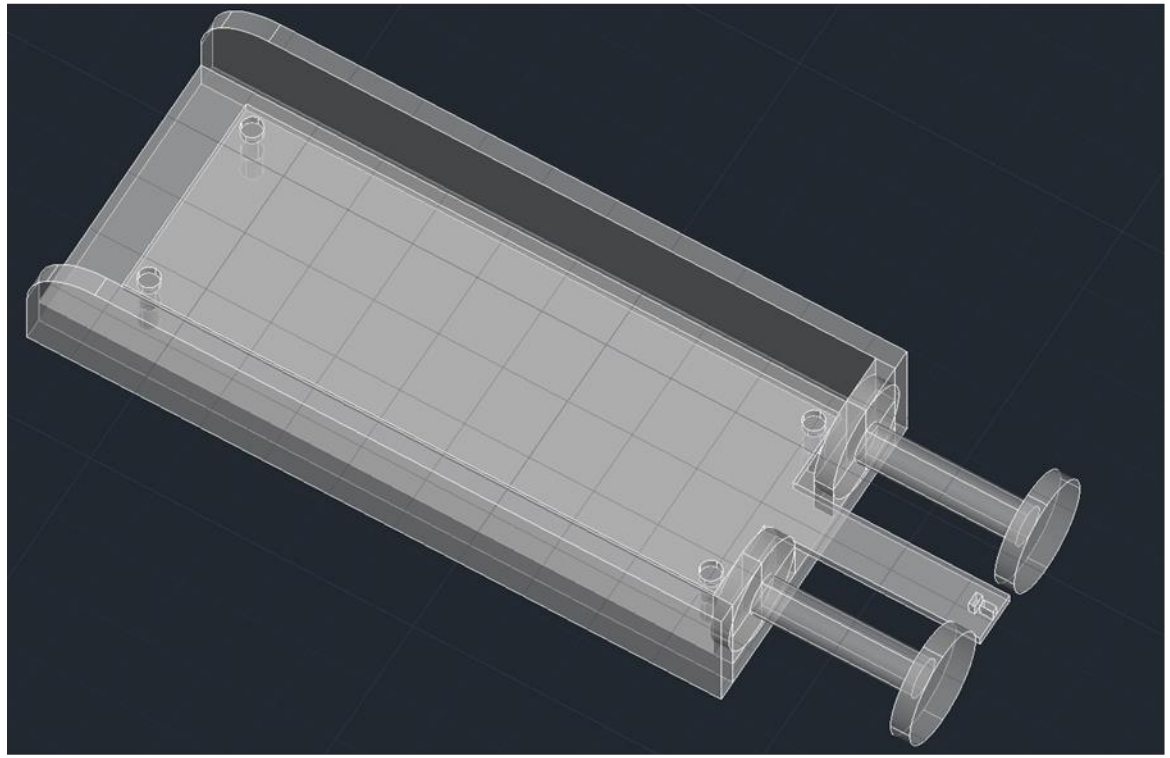
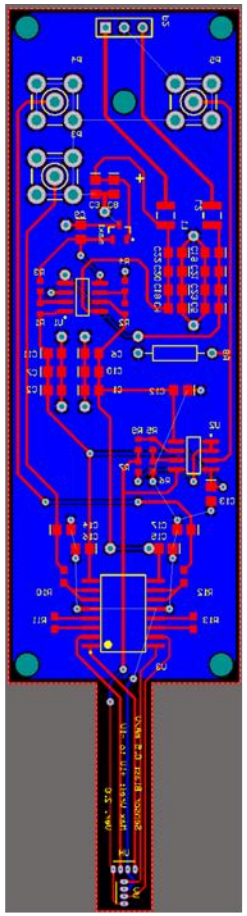
Quarter 4 : High-Frequency Probe Gen 1

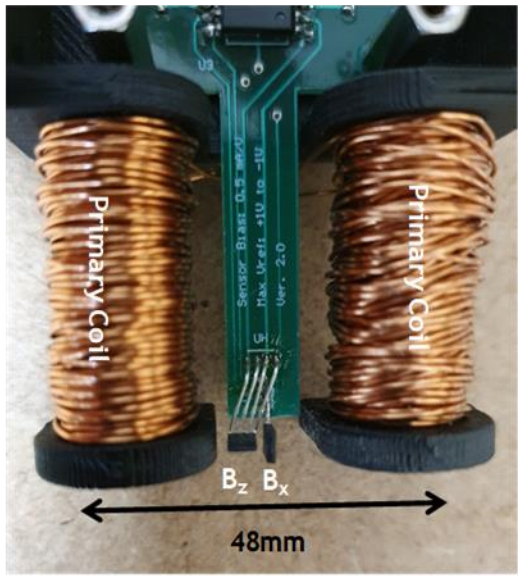




Frequency Range: 100-700kHz

No of sensor: 2 (B_x and B_z)

Field Strength ~1µT (500kHz)



Probe dimension: 135.5mm × 48mm × 15mm
Coil dimension: ø17mm x 25mm (300 Turn each)
Sensor to single-coil centre horizontal distance: 13.5mm

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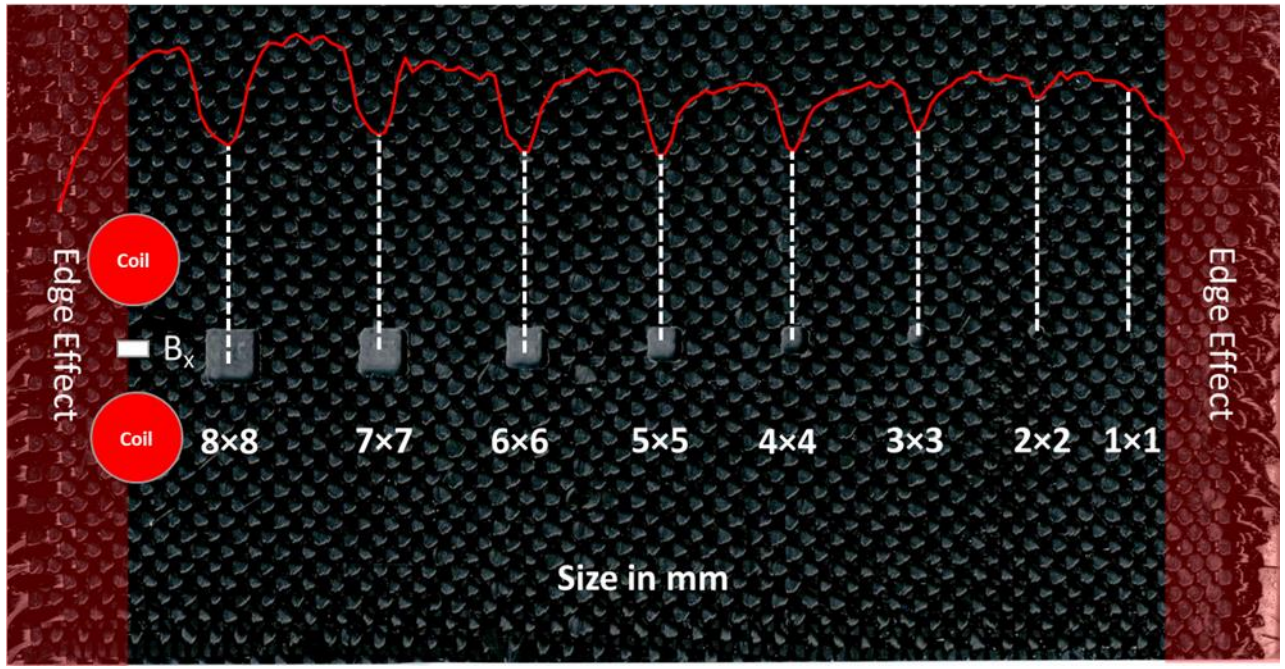
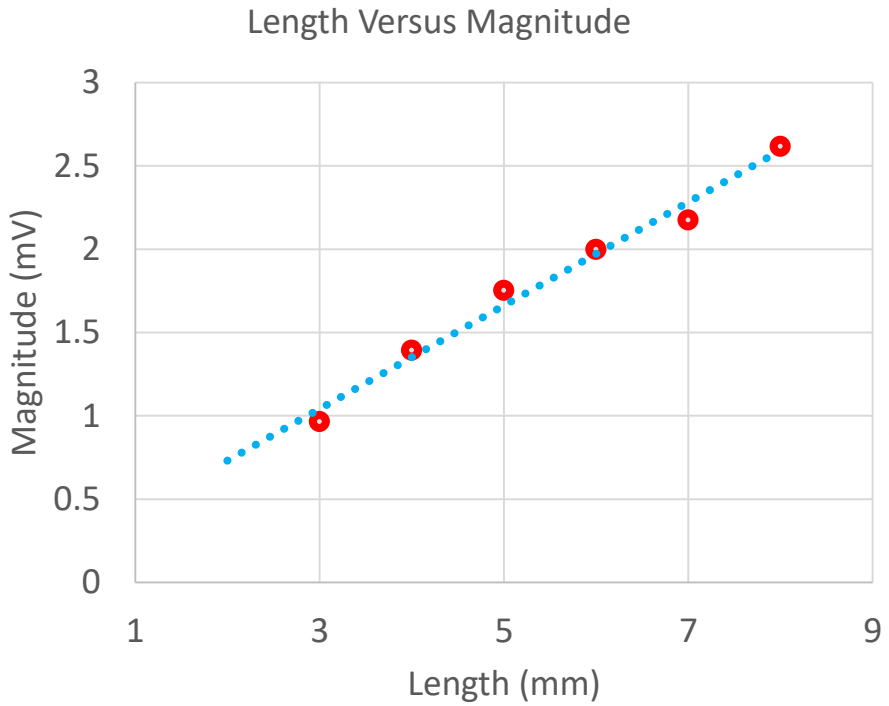
Quarter 4 : Sample 1 – Flaw Size





Results Summary :

Eddy currents are disturbed by a flaw → Magnetic Field affected related to Length

Minimum Flaw Size Detected 2mm×2mm

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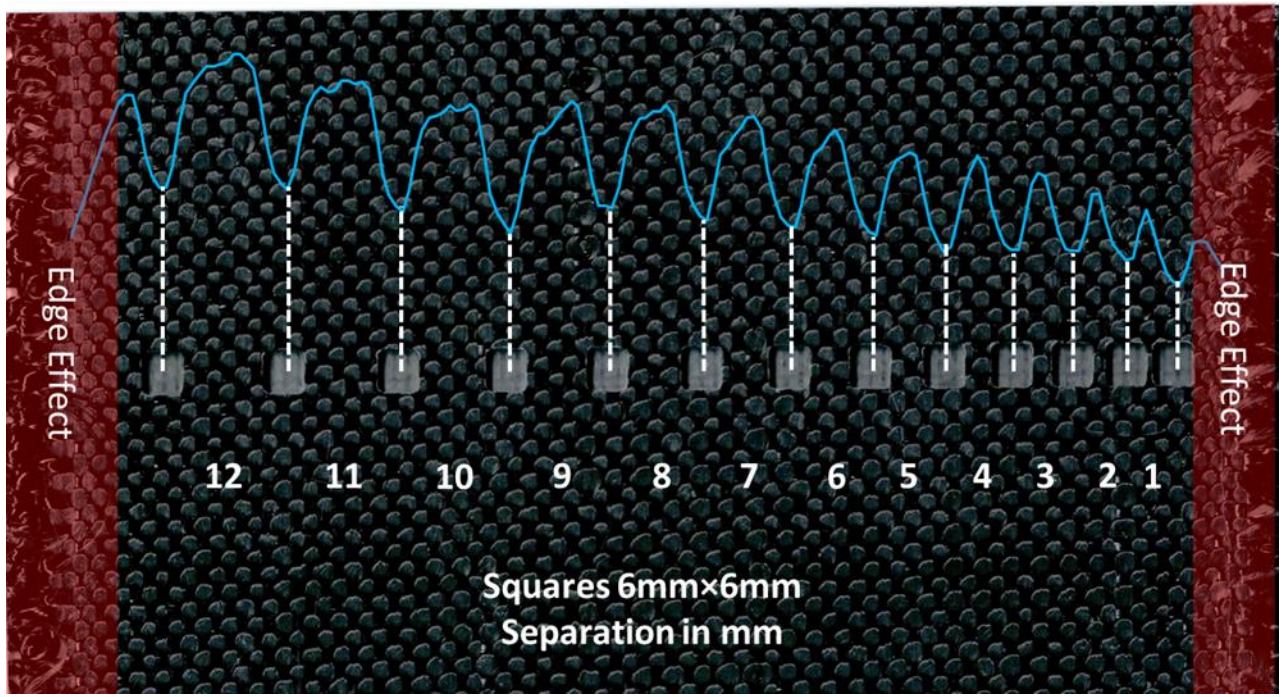
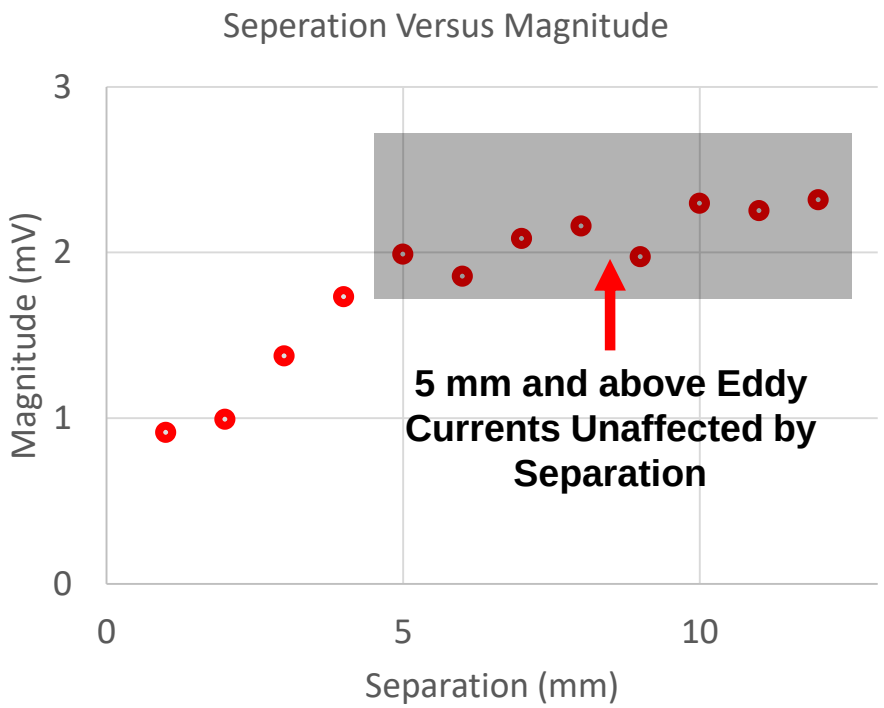
Quarter 4 : Sample 2 – Resolution





Results Summary :

Eddy currents are disturbed by a flaw → Magnitude reduces as separation reduces below 5mm

Minimum Flaw Size Detected 1mm

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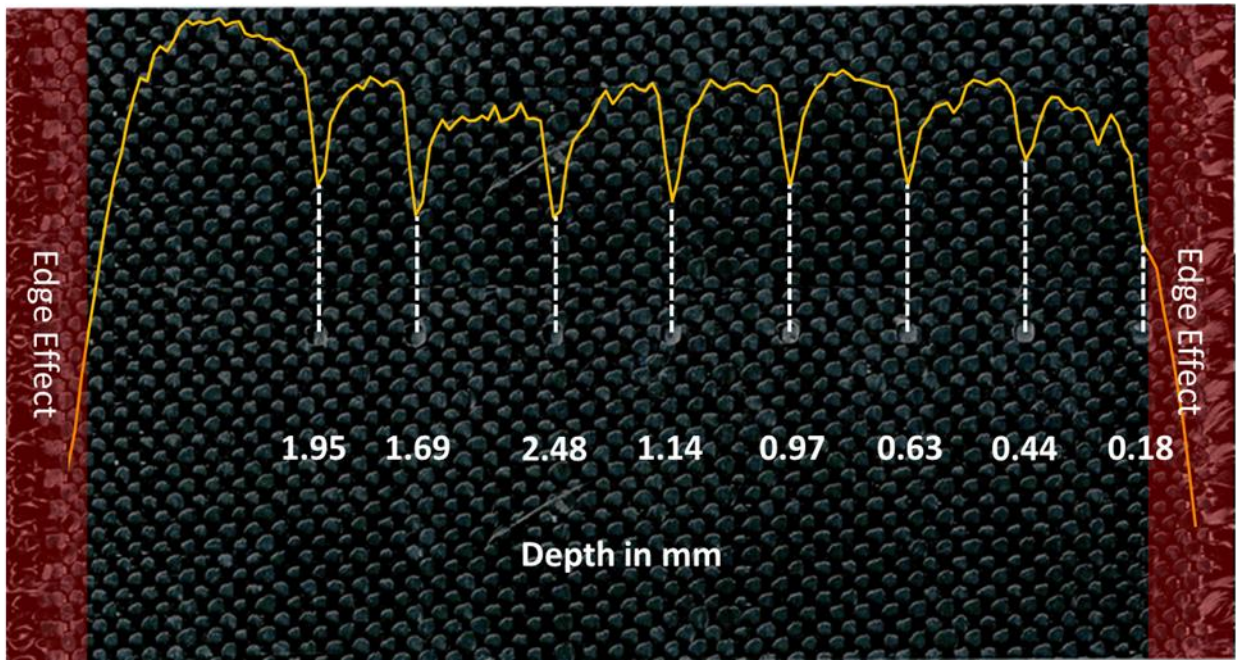
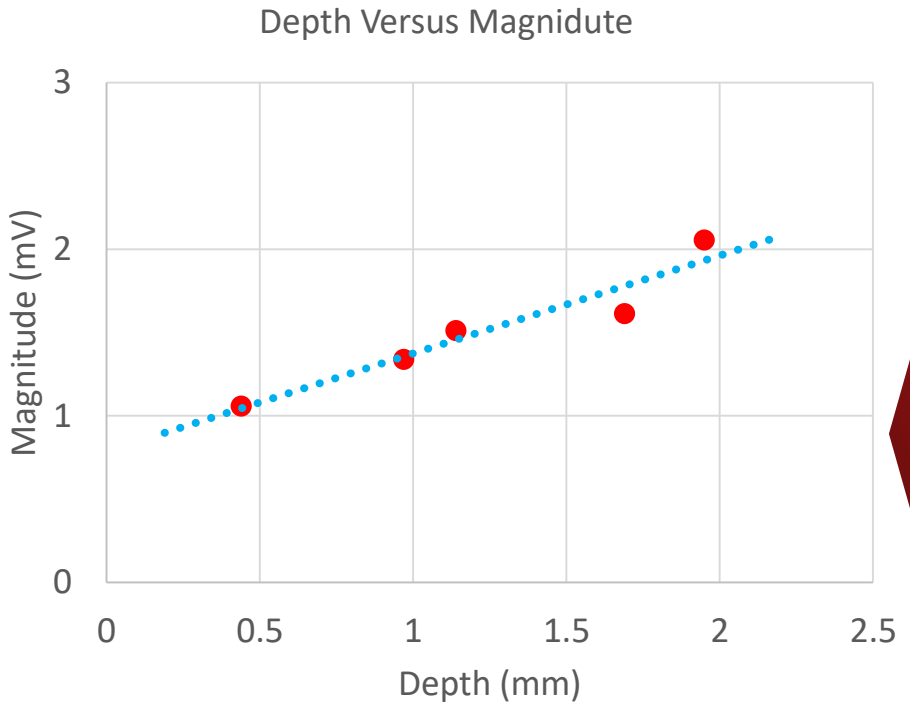
Quarter 4 : Sample 3 – Flaw Depth





Results Summary :

Eddy currents are disturbed by a flaw → Magnetic Field affected related to depth

Minimum Depth Detected 0.44mm

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Approach

- Curved demonstrator (design and tooling), FEA and mechanical testing

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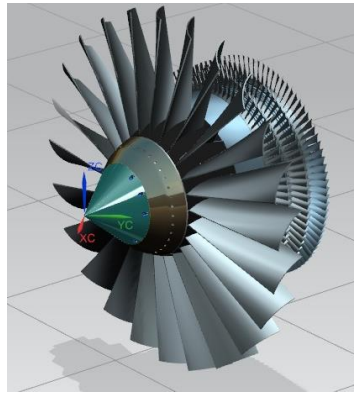
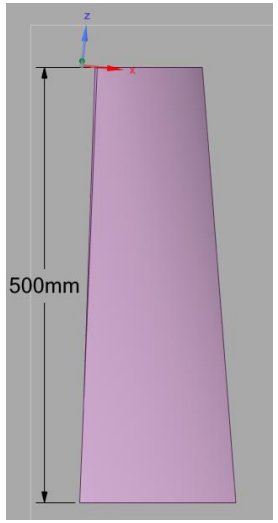
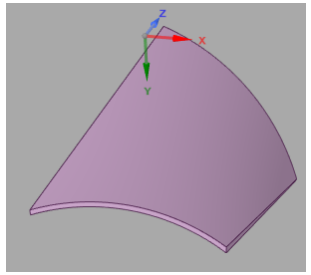
Curved Demonstrator design-FAR

- Our curved demonstrator is a fan blade from a CMF56 engine, which is used in the A320 and A240 aircraft.
    - Minimum radius is 200mm.
- Typical volumetric flaw types can be placed into the part during manufacture
- The demonstrator allows for parts of different thicknesses to be
produced from the same tool.
- We can apply load conditions of bounded at one end, and a point load applied at the other – creating a cantilever load case.







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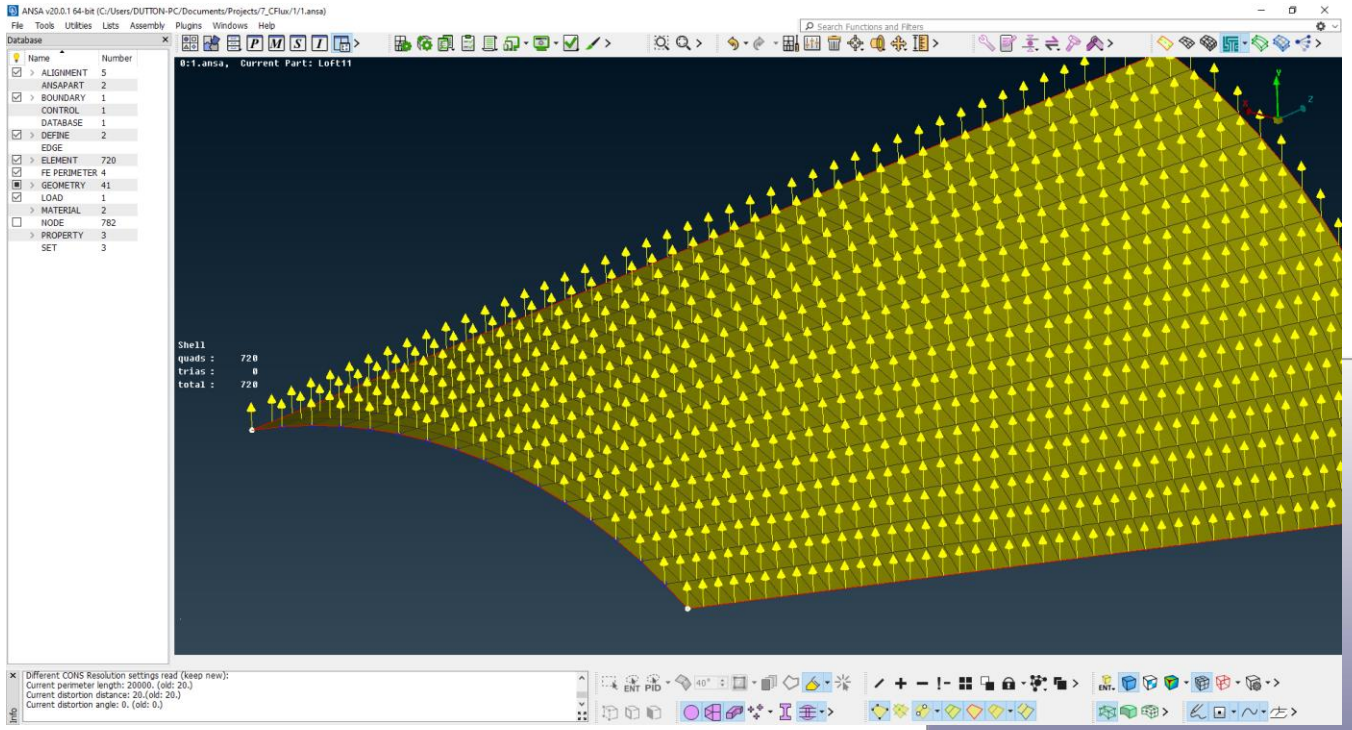
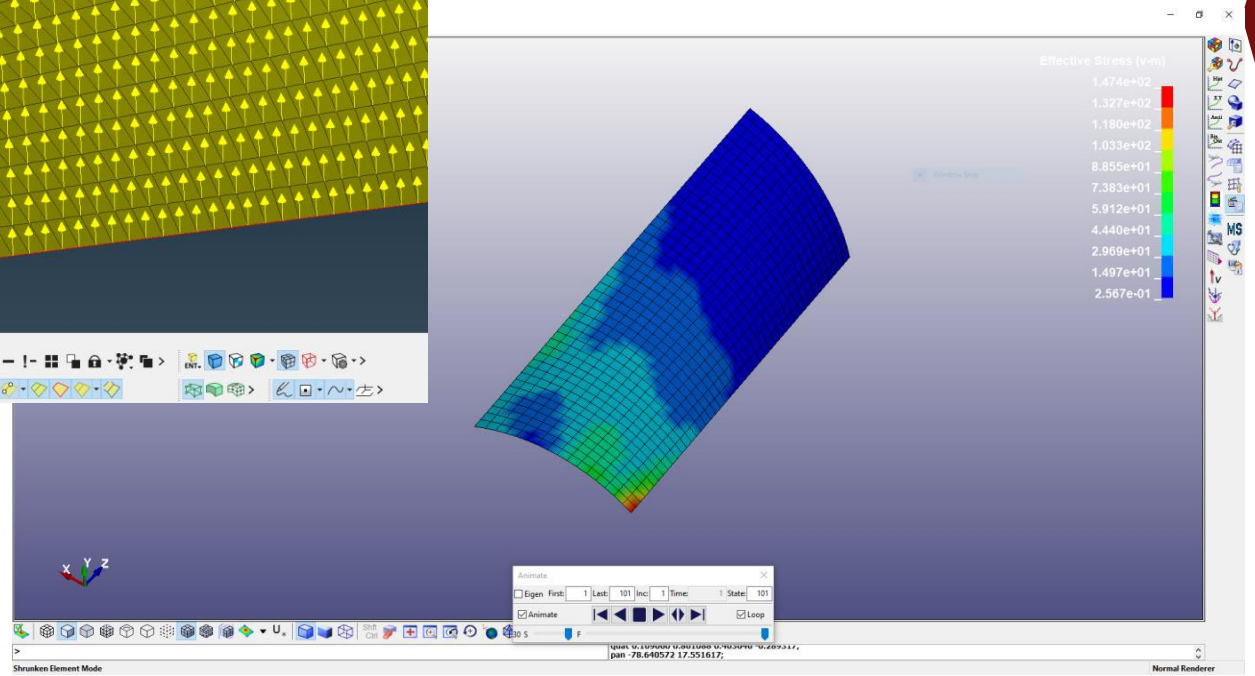
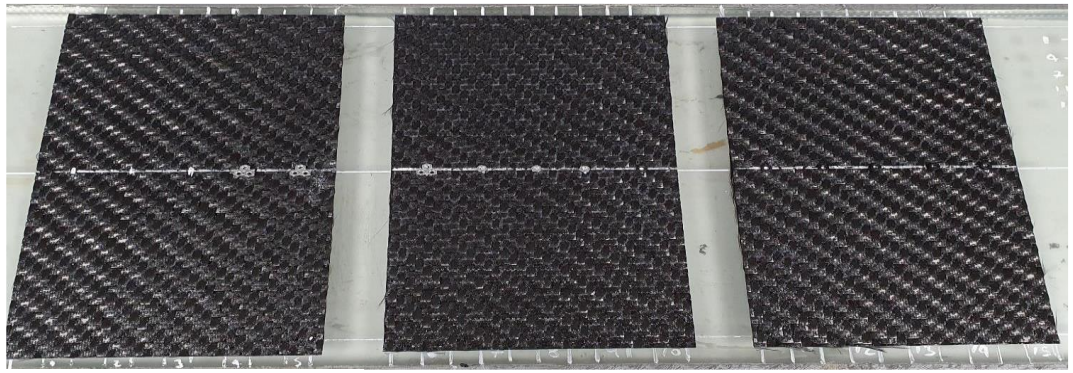
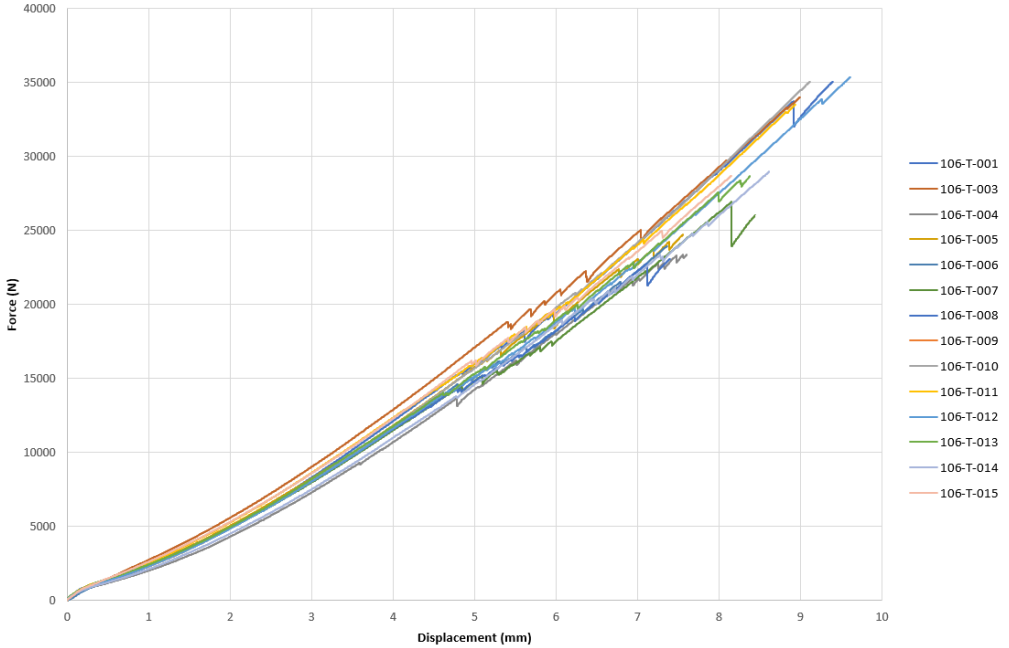
FEA analysis of curved demonstrator

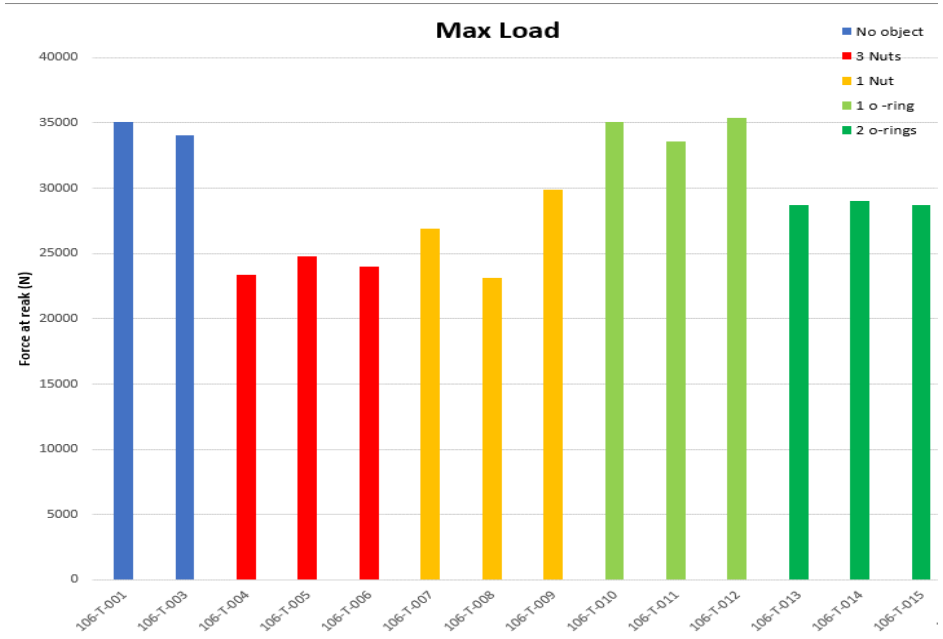




Tensile testing of coupons-FAR







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Building the Eddy current automated prototype

- Systems integration

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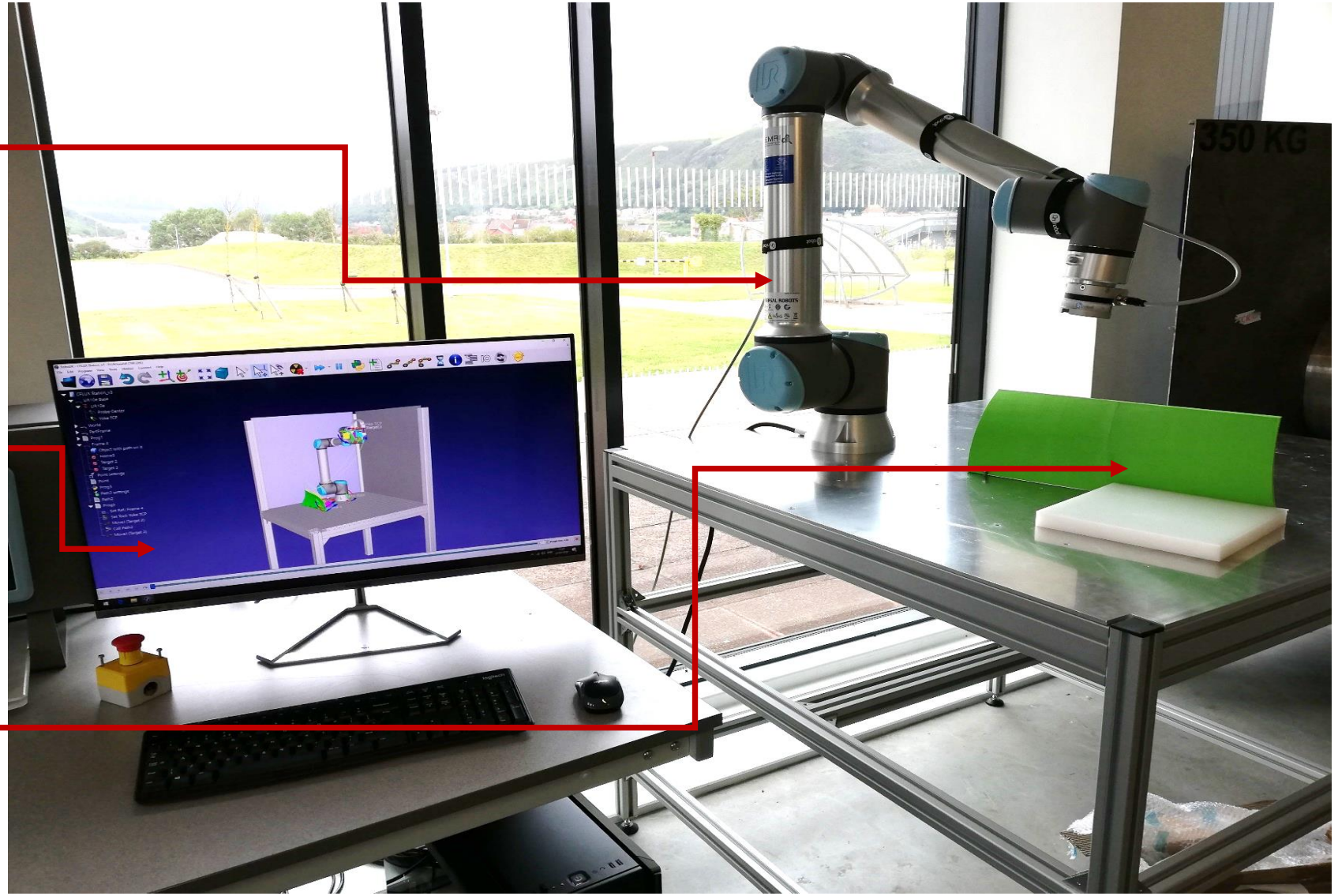
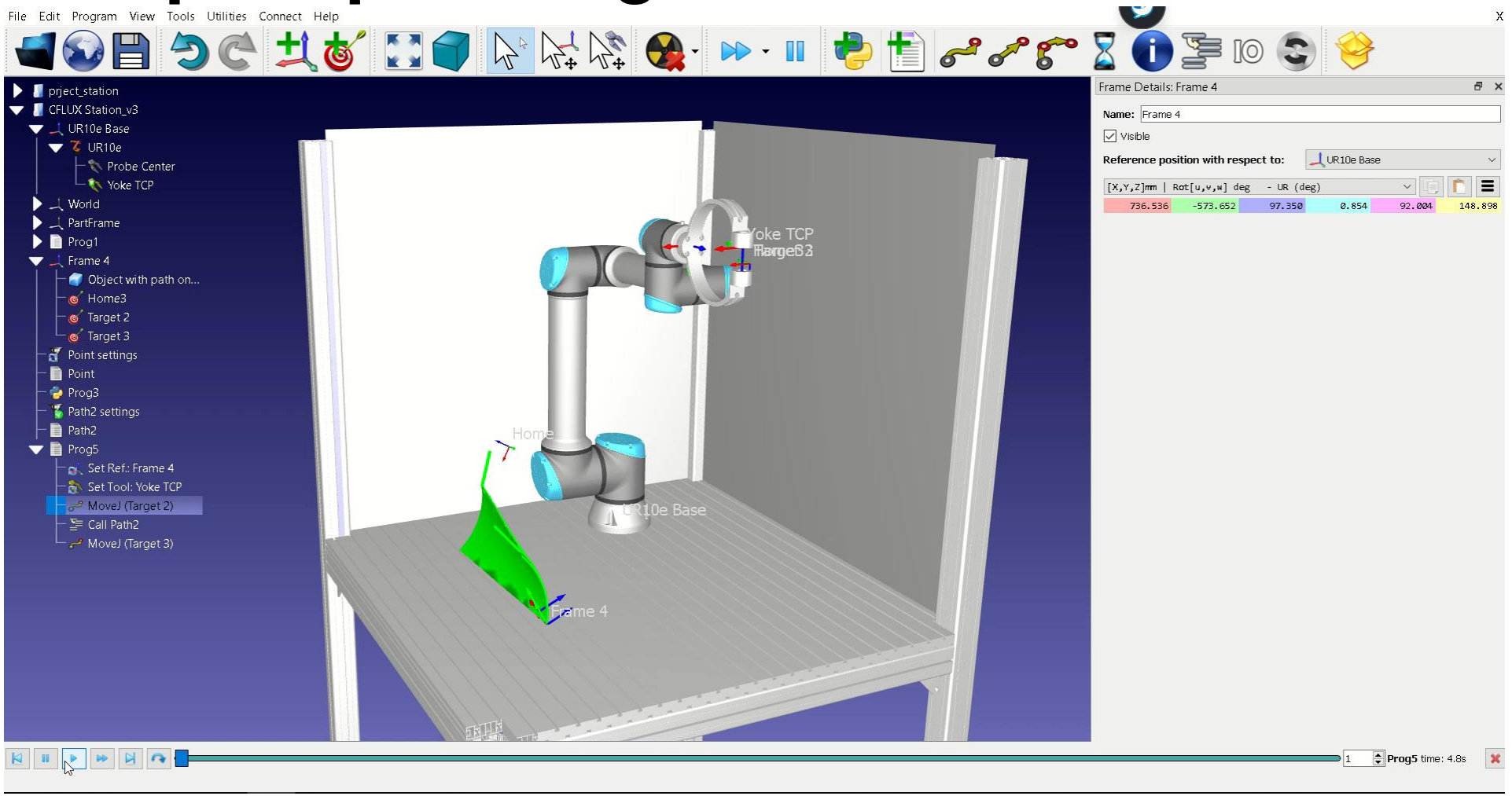
TWI-NDT validation, robot integration Probe assembly design

- Cobot for automatic Scanning of 3D parts
- Offline path Planning via RoboDK
- 3D printed Curved demonstrator, M. Wrights and sons



Cobot path planning on RoboDK software



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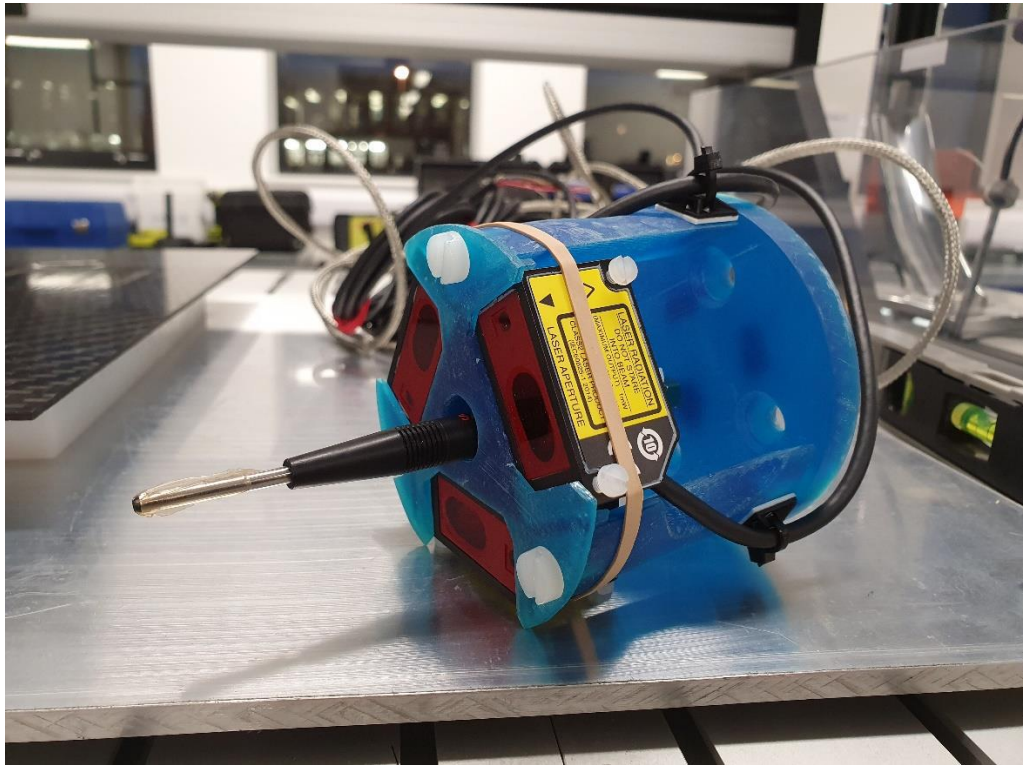
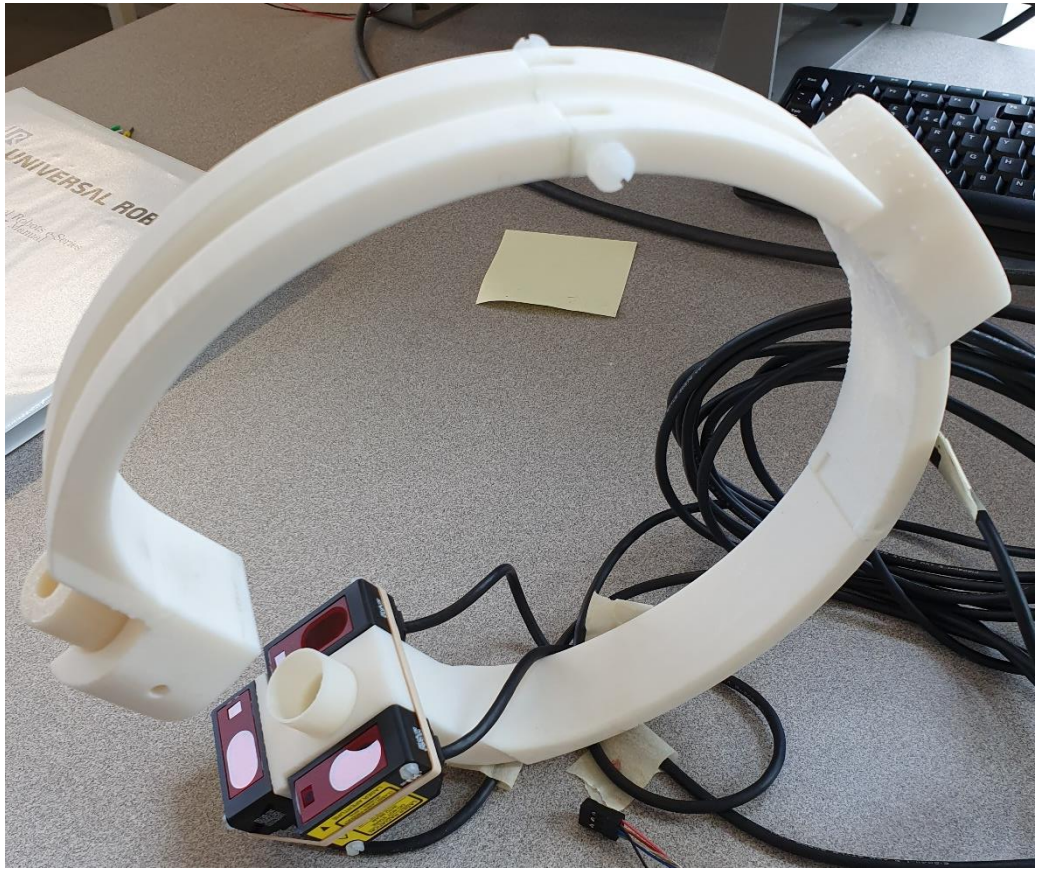
3D printed laser measurement head, with integral Eddy current probe holder, and through transmission version





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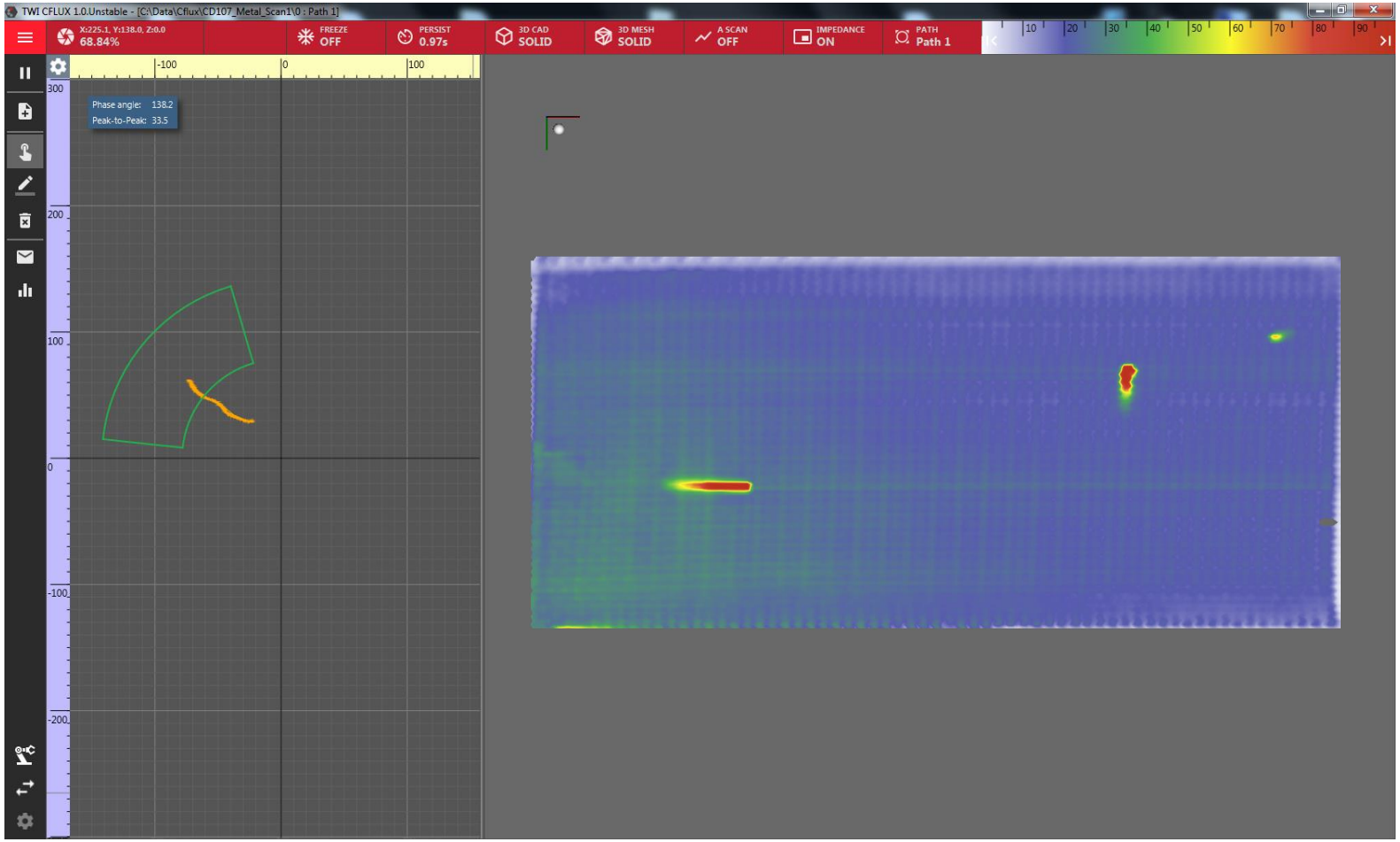
TWI Software



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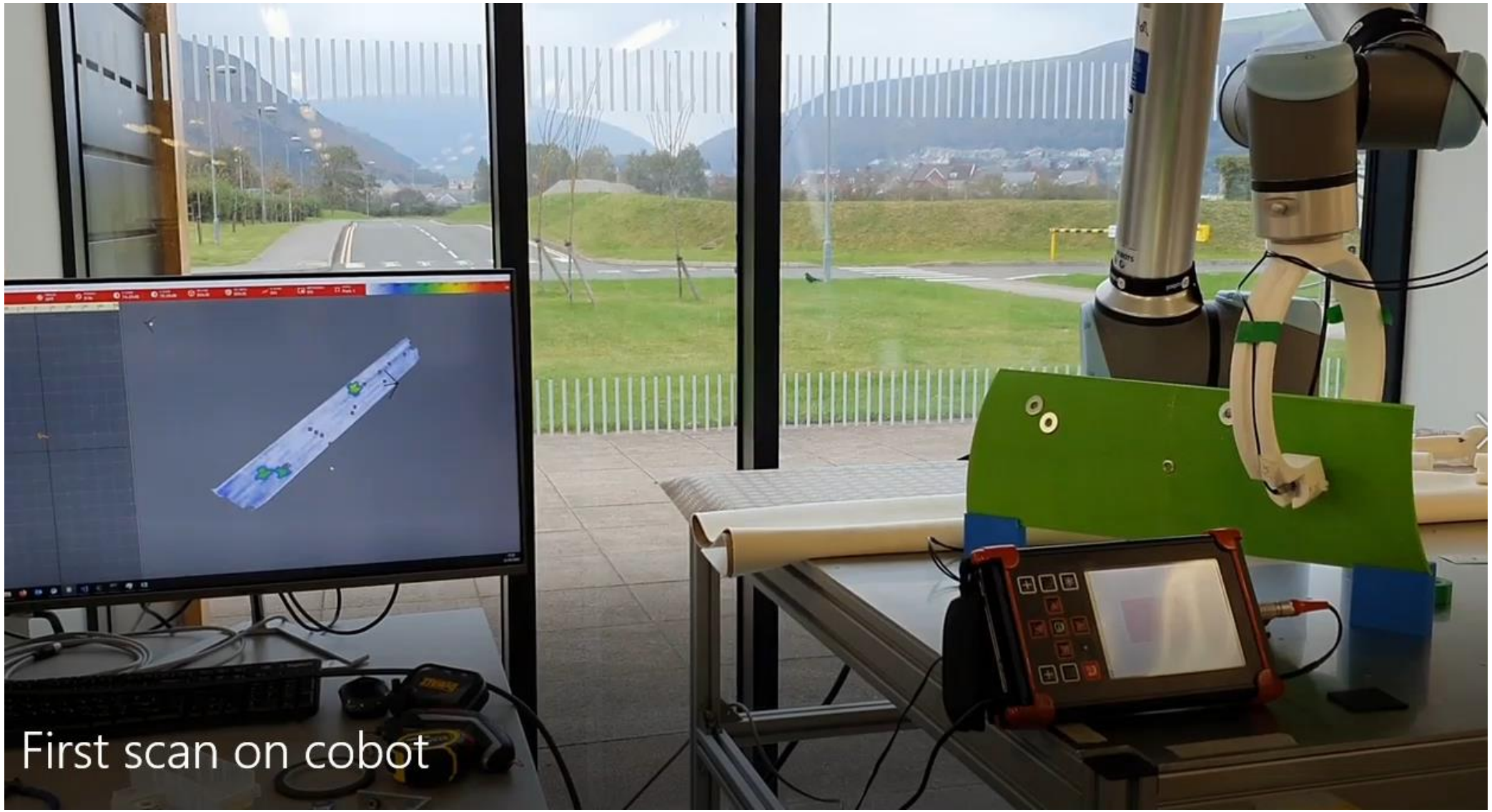

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Conclusions

Where are we now?

- Eddy current systems all proven in principle
- Eddy current probes designed
- 2D thru transmission scanner complete
- MFL system proved in principle
- Curved demonstrator raw materials and tooling available

Next actions for the project

- Create curved demonstrator parts with artificial flaws
- Finalise integration of Eddy current system and optimise and test
- Build MFL system, optimise and test
- Mechanical testing of curved demonstrator parts
- Exploitation of our new technologies

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To find out more information and discuss some possible applications don't hesitate to contact us.

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