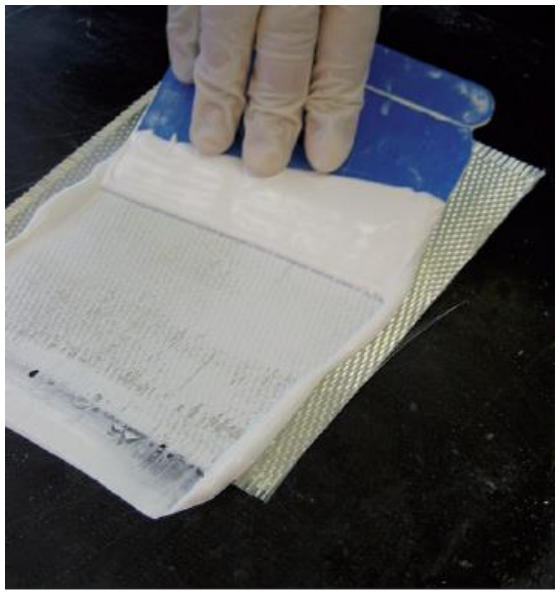
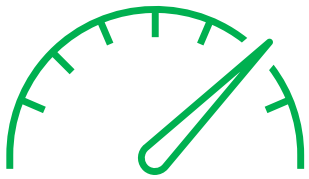
Automated Fibre Placement of Ox-Ox CMCs

Ox-Ox CMCs

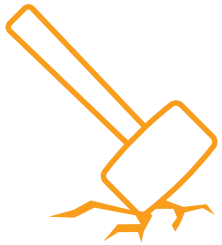




Continuous operation at 1000 °C – no TBCs

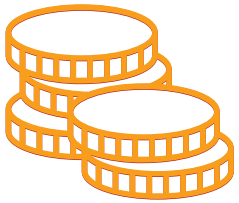
1/3rd density of Nickel superalloys

Low dielectric, low creep, low corrosion



~10% of Ni Superalloys
~4x higher than monolithic ceramics

Manual manufacture
Automated layup



High Cost

NATIONAL COMPOSITES CENTRE

CATAPULT
High Value Manufacturing

New Material - 3M Towpreg

- All Alumina: Nextel 610 tows + alumina matrix
- Room temperature stable
- Matrix contains <1% water and additives for tack (12% total)
- Stated width: 6.34 +/- ~1.2 mm
- 40-45% fibre volume expected
- Max continuous temperature use = 1000 °C
- No recommended processing conditions

Outputs and Deliverables

Outputs

- Get the UK ready for a non-US Ox-Ox CMC
- Adaptation existing AFP equipment for CMCs
- Understand the relationship between key processing variables (KPVs) and the CMC
- Demonstrate benefits of automation – increased control and repeatability
- Assess the CMC-AFP supply chain

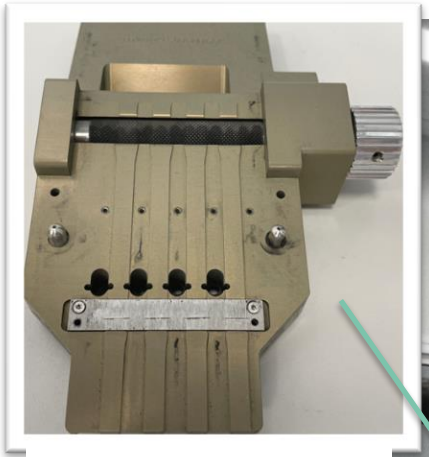
Deliverables

- Project report with processing parameters
- Summary project presentation

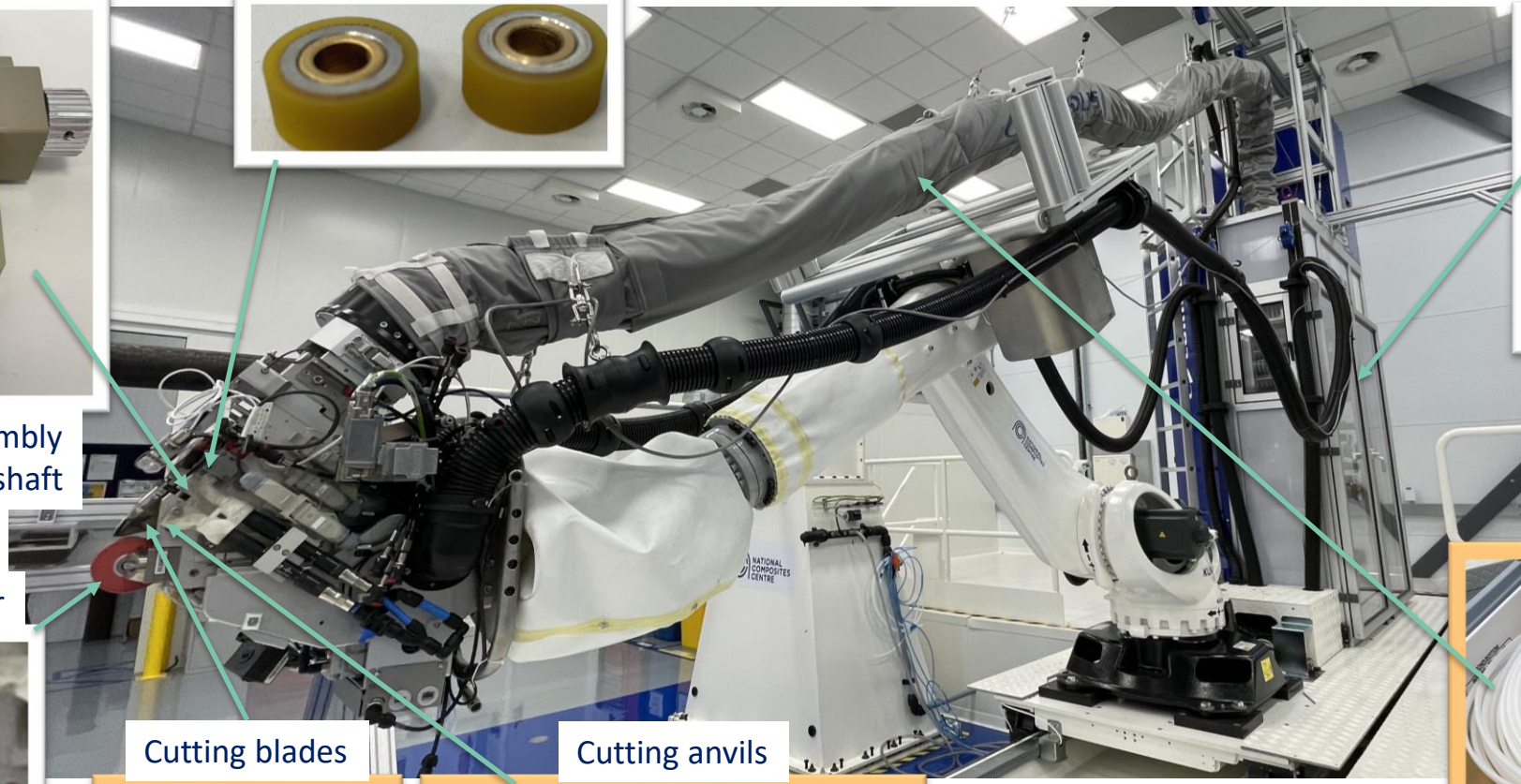
Objectives Completed
+ Semi Complex demonstrator

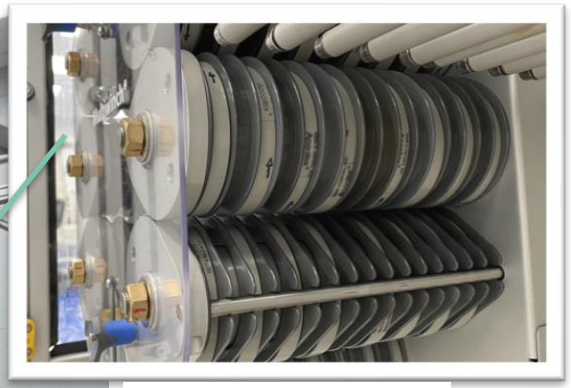
Machine Modifications

Feed rollers



Guide plate assembly incl. driven feed shaft

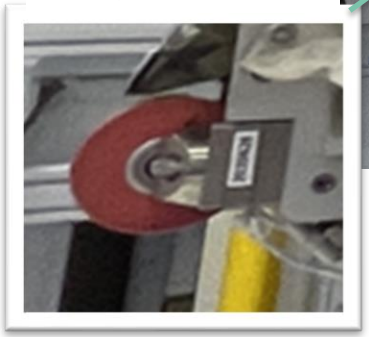




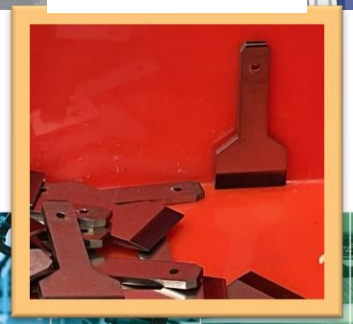
Multiwinch system

Fibre guide tubes

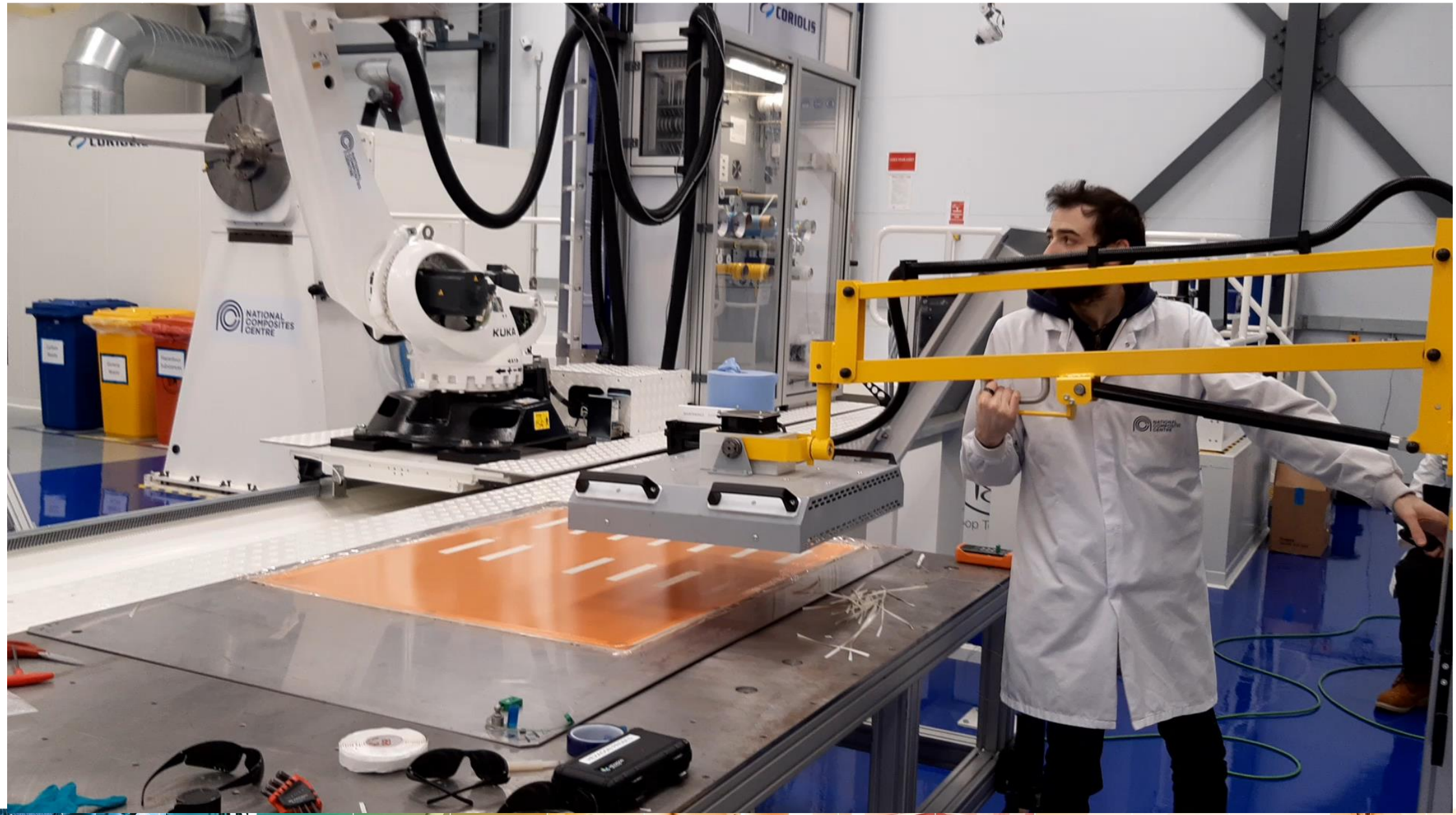
Compaction roller



Cutting blades



Cutting anvils



WP3 - AFP KPV Study

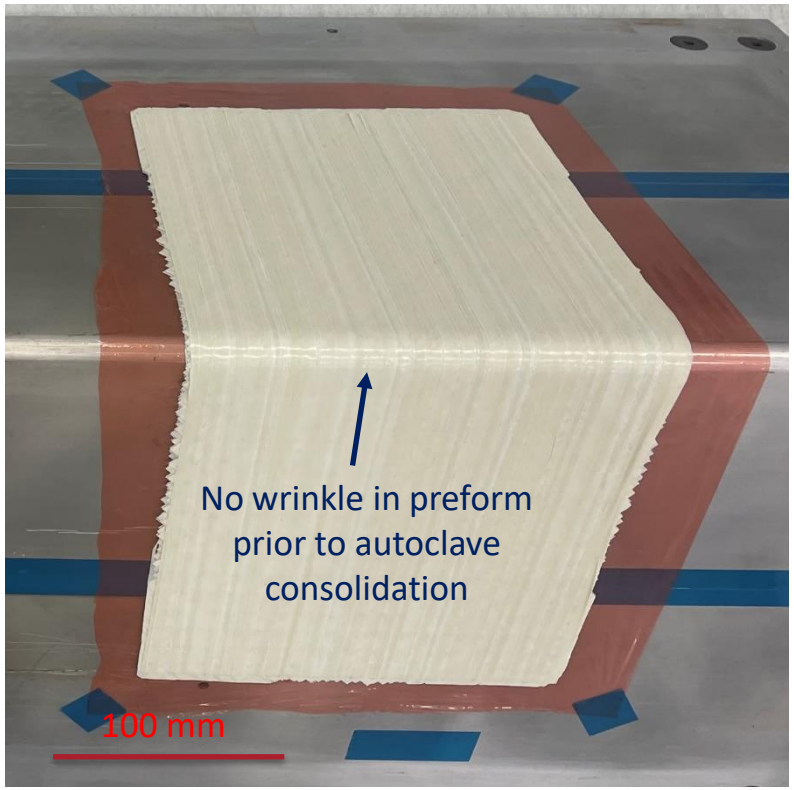
Sample	Layup Speed (mm/s)	Tool Temp (degC)	Compaction Force (N)

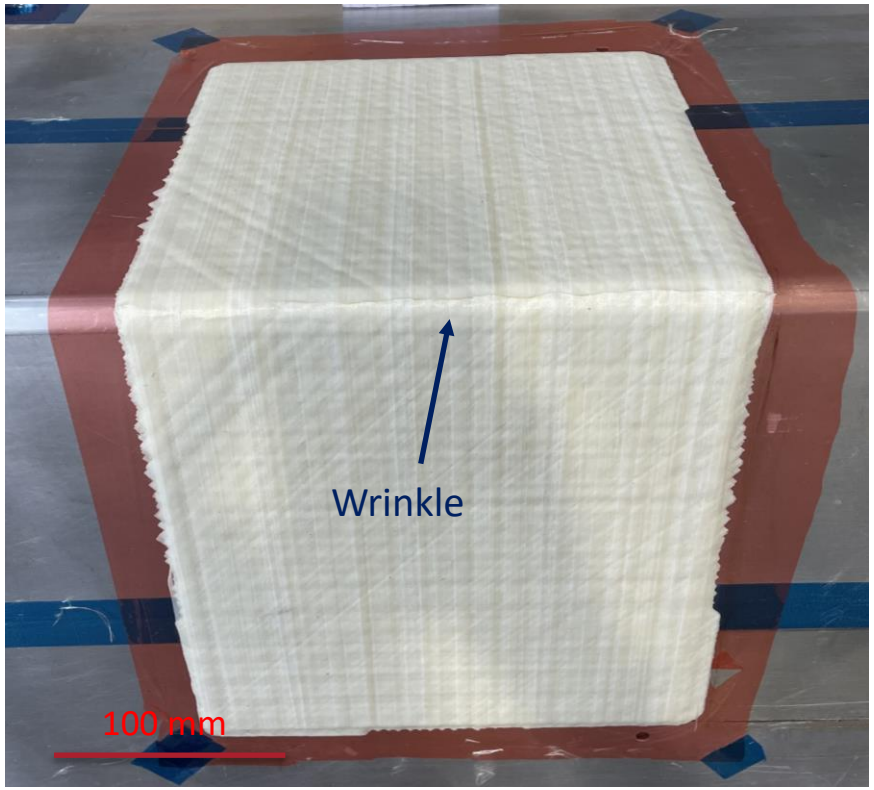
KPV Study

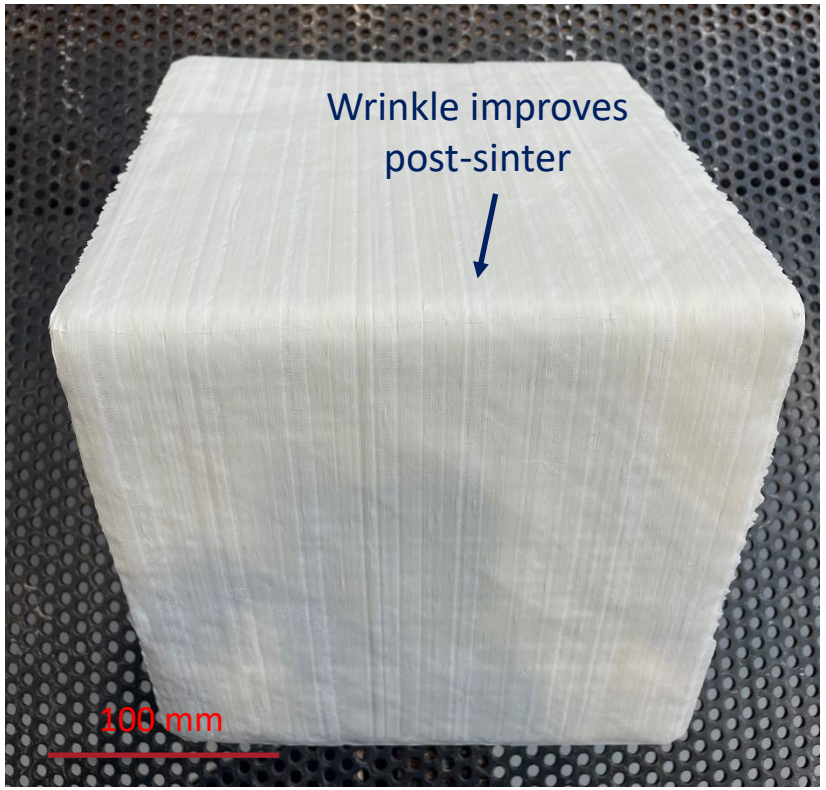
- 15 KPV samples
- 4 ply thickness (0.44 mm)
- Inspection using metrology arm
- Best parameters used to manufacture 16 ply thick demonstrator
- NDT also conducted on demonstrator

Wrinkle – 16 ply component

Before Autoclave → **After Autoclave** → **After Sintering**







	Preform	Consolidated laminate	Sintered laminate
Mean thickness (mm)	1.977	1.566	2.073
Maximum thickness (mm)	5.852	2.032	4.867
Minimum thickness (mm)	0.335	0.387	0.394
Standard deviation (mm)	0.246	0.125	0.534
Bulk factor	N/A	26%	-5%

CT Scan – Side View

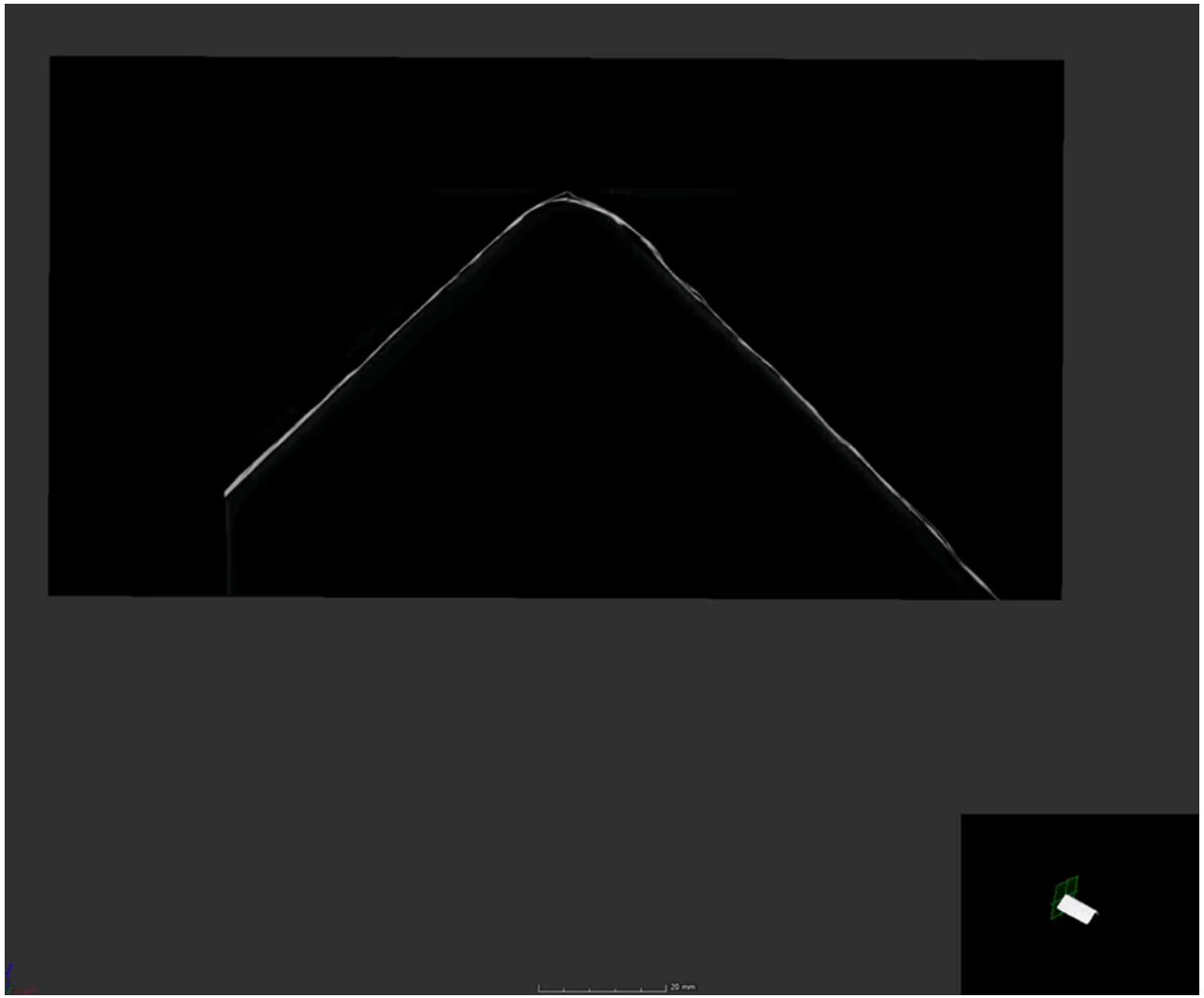
Internal delamination

Possible causes:

1. Variation in material ‘tackiness’
2. Poor thermal management during AFP
3. Insufficient deposition force
4. Damage during removal from tool after autoclave
5. Relaxation of material during autoclave/sintering

Good Matrix Distribution

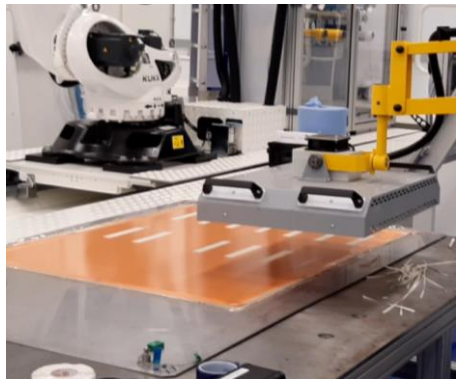
In prepreg materials, the matrix can bleed through to the component edges



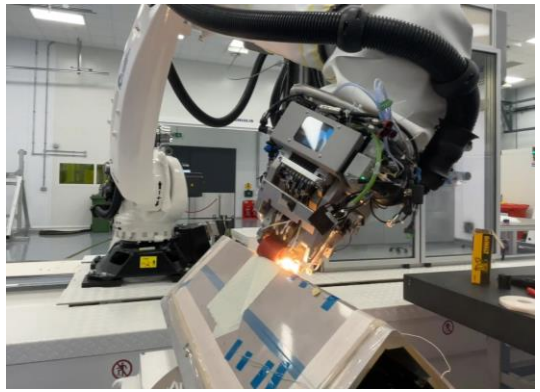
Summary

- Core project has demonstrated Europe's first use of AFP-CMC
- KPV study completed
- 16 ply semi-complex panel manufactured
- Material width variation present ($\pm$1.27 mm, 40% width)
- More heat is required for AFP layup than organic matrix composites
- CT scan and metrology reveal delaminations

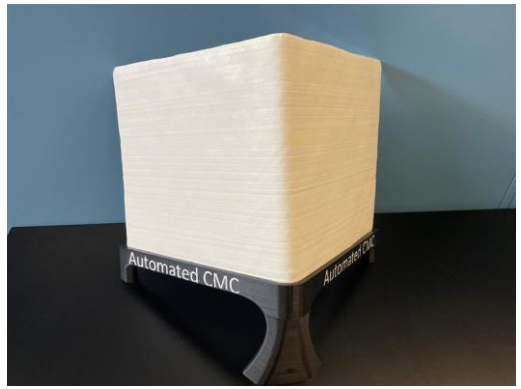
Initial Trials: Single Courses



KPV Trials: Radius Study and Panel Manufacture



Autoclave + Sintering + CT Scan



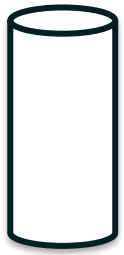
AFP-CMC 2

Rolls-Royce®

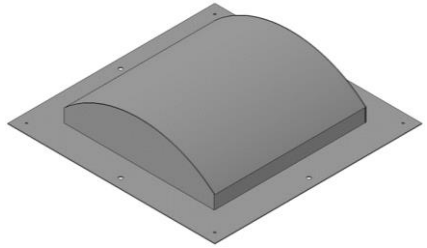
AXIOM MATERIALS

NATIONAL COMPOSITES CENTRE

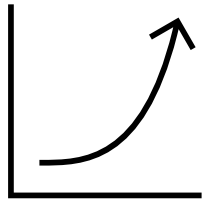
Slit tape



Complex Demonstrator



Materials Characterisation



- Increased application over AFP-CMC 1
- Influence component for AFP-CMC 2
- Regular interaction with 3M