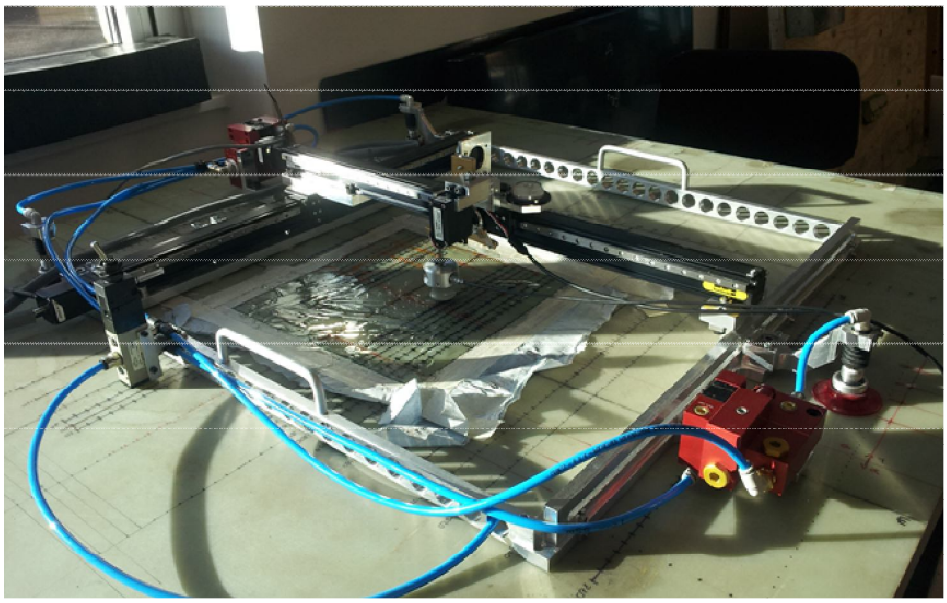

Figure 1 The prototype scanning system showing, the frame, linear axes, servo assembly, ultrasonic transducer/holder, X, Y, Z movement motors, suction cups holding the frame to the blade and other system components e.g. vacuum trap

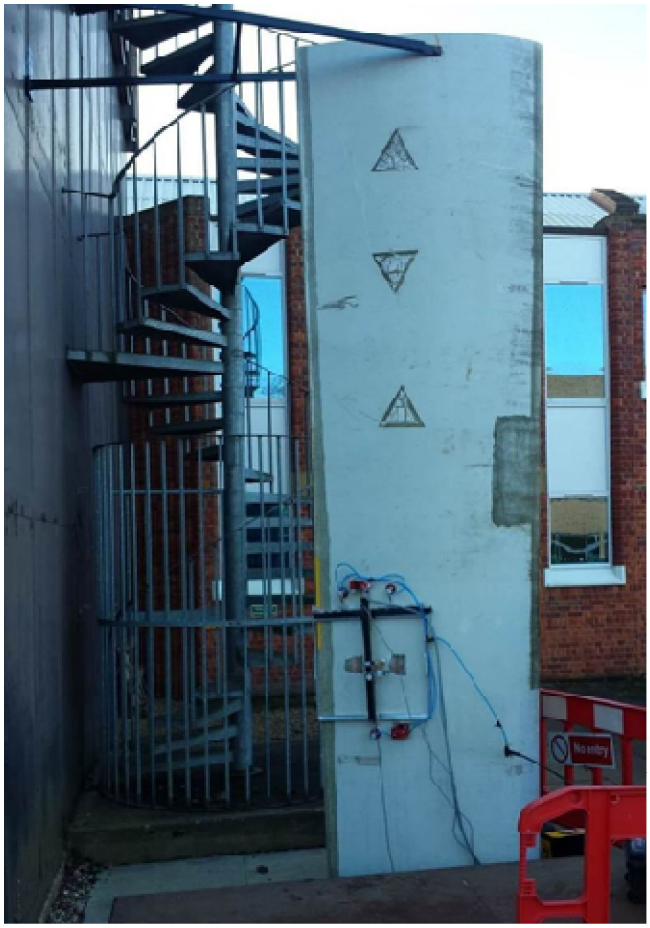

Figure 2 Automated inspection device mounted to vertical turbine blade section at TWI (5m x 1.2m)

Table 1 Laser Sources and Parameters used for Processing GFRP

		UV-laser	VIS-laser	NIR-laser	MIR-laser
Wavelength	λ	355 nm	532 nm	1062 nm	9250 nm
Pulse frequency	f	80 kHz	45 kHz	30 kHz	110 kHz
Laser power	P_L	28 W	14 W	42 W	48 W
Pulse duration	τ	38 ns	16 ns	240 ns	100 ns

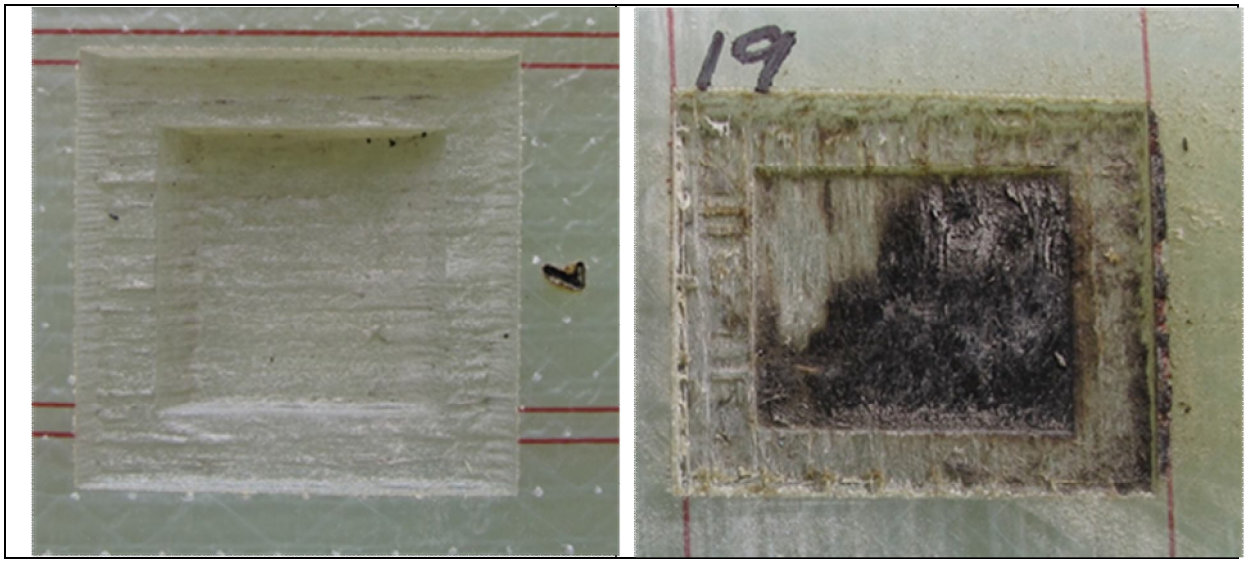

Figure 3 Results for laser ablation using UV-laser (left) and VIS-laser (right)

Table 2 Summary of Laser processing of wind blades

Maximum dimensions of the area to be treated		
DoW Specification for Laser processing	***Expected results***	
	Laser processing	***Semi-automated mechanical milling***
Length (X): 100cm. Width (Y): 100 cm.	*Unlikely without robotic arm*	*Length>1m Width> 1m*
Diameter of material to be removed: 20cm	*Yes, but low quality*	*D>50cm*
Thickness of structure: 3mm (i.e. 24 plies)	*Yes, but low quality*	*Yes*
Radius of curvature (single or double) will not	*Yes, but low quality*	*Yes*
Number of stepped layers per side: 24	*Yes*	*Yes*
Minimum width of each step: 5mm	*Yes, but low quality*	*Yes*
Minimum thickness of each step: 0.125mm	*Yes*	*Yes*
Consecutive plies may be of the same or different orientations	*Yes*	*Yes*
Other system requirements		
DoW Specification for Laser processing	***Expected results***	
	Laser processing	***Semi-automated mechanical milling***
Laser Scanner easily mountable on structure to	*Unlikely*	*N/A*
Lightweight overall system configuration.	*No*	*Yes*
Flexible part of minimum 5m cable.	*Yes (only for certain laser configurations)*	*N/A*
Grinding should be performed in either circular	*Yes*	*Yes*
Scarfing instead of stepping should be considered.	*Yes*	*Yes*
Main innovations introduced by the new laser device		
DoW Specification for Laser processing	***Expected results***	
	Laser processing	***Semi-automated mechanical milling***
High automation of the process, to avoid human and positioning errors.	Yes *	Avoidance of human and positioning errors is achieved in an alternative way
High repeatability of operations.	Yes *	Yes
Geometry introduced via software, so the accuracy of the operation is guaranteed.	Yes *	Accuracy is achieved in an alternative way
High automation of the process, to avoid human and positioning errors.	Yes *	Avoidance of human errors is achieved in an alternative way
High repeatability of operations.	Yes *	Yes

(*): Subject to quality restrictions

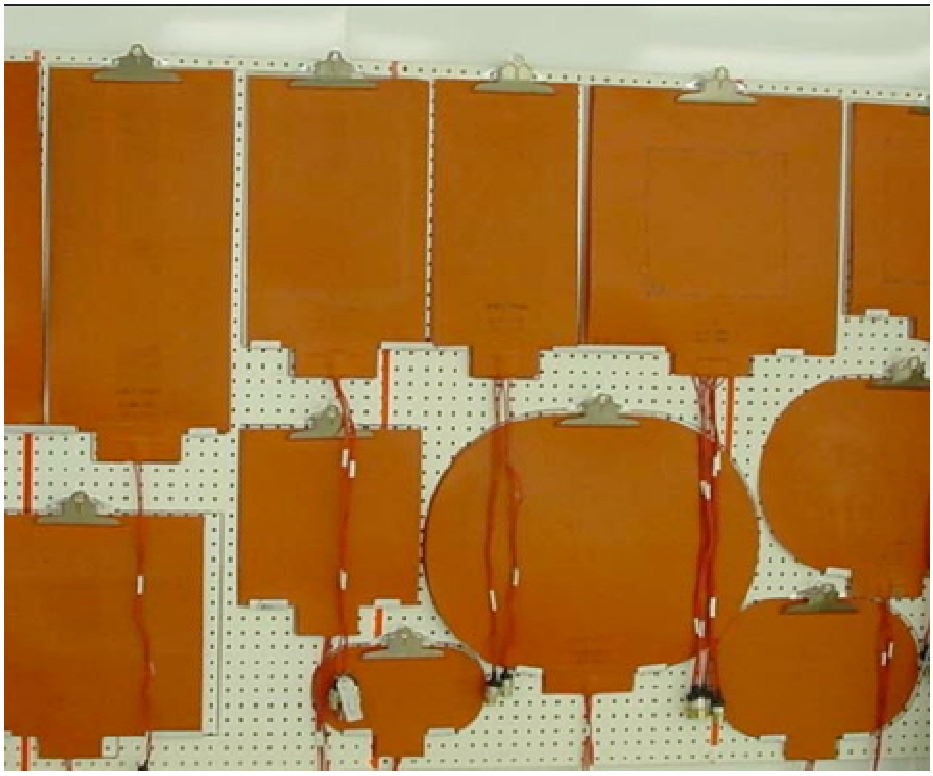

Figure 4 Heating blankets for use with different size and shape damage areas

Figure 5 A 3 meter long and variable width blanket consisting of 2 heating zones, 4 thermocouples and 2 cables for connection of power and thermocouple sensors. The main heating blankets specification is: Operating ambient temperature >0°C, Power density of 2500 watts per square meter and a maximum blanket area of 4 Square meters.

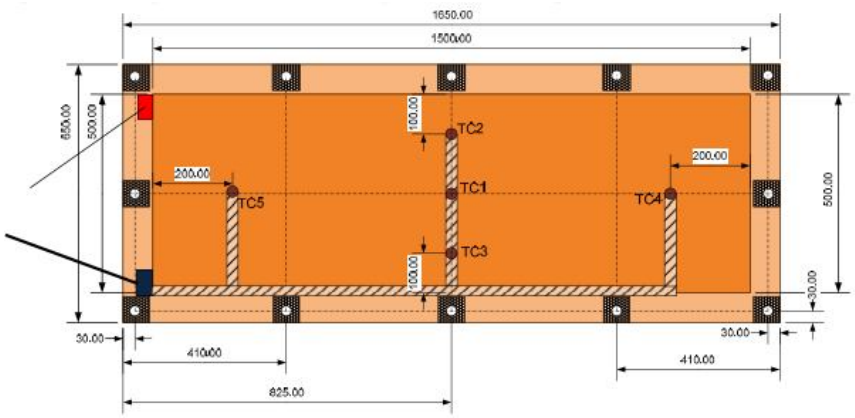

Figure 6 Conductive heating and vacuum blanket with dimensions and thermocouple positioning

Figure 7 Robust, “push-button” conductive heating console for use in-situ repair of wind turbine blades