WINTUR

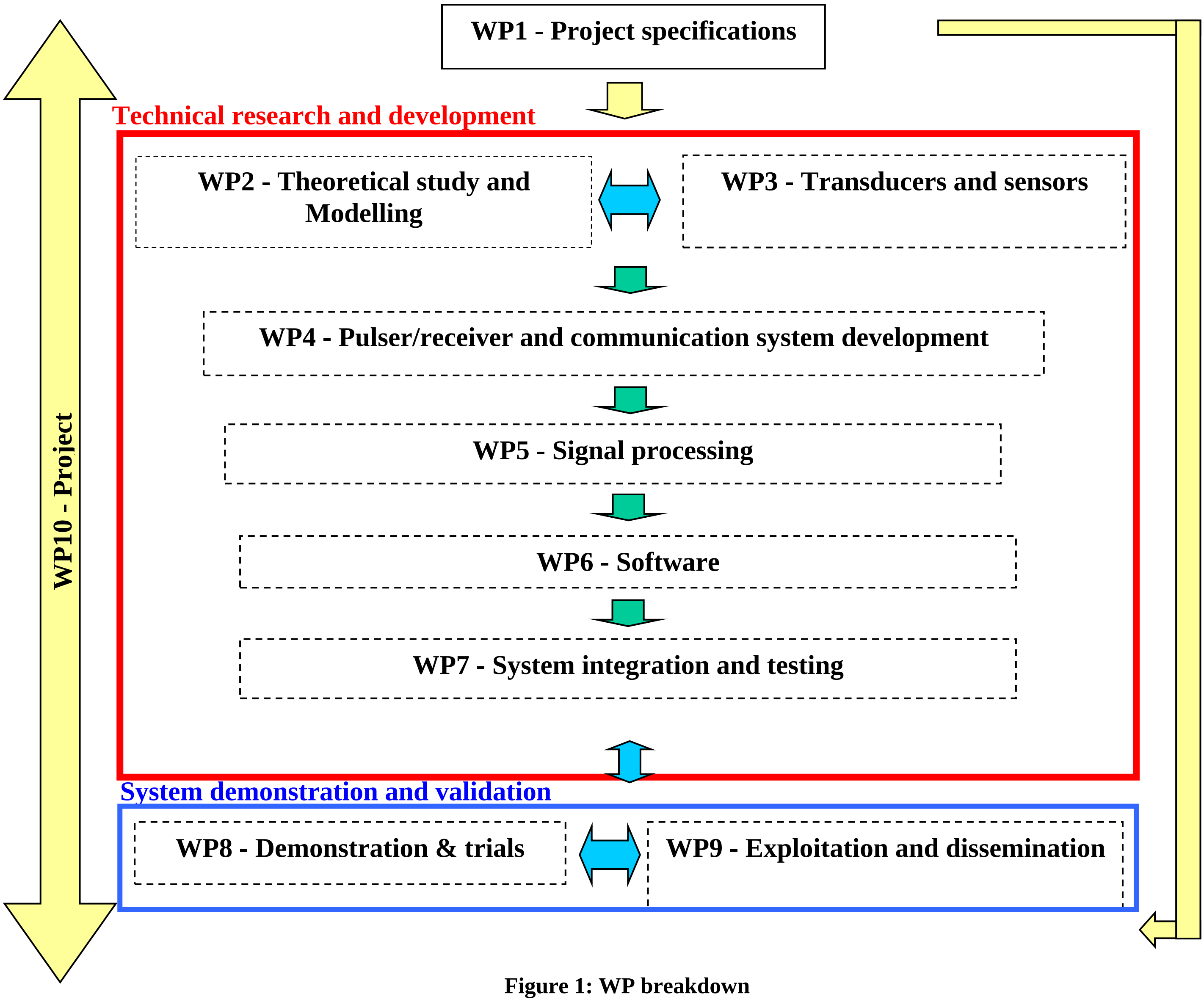


Figure 1: WP breakdown

Site	WTG No	Description	Date	Turbine Type	WTs	Repair/replace
Braes of Doune		No Failures		Vesta V80	36	
Hadyard Hill		No Failures		Siemens 2.3	52	
Artfield Fell		No Failures		Siemens 1.3	15	
Ardrossan	WTG003	Nick in leading edge of blade approx 10 meters from tip. Constructional damage from crane sling. Fibre patch over damaged area. New fibre smoothed in, and painted over	01/03/04	Vestas V80	12	
Ardrossan	WTG010	Small hole in tape on leading edge of blade approx 10 m from tip. Damaged patch of leading edge tape removed and edges painted over. No replacement tape installed.	01/08/05	Vestas V80		
Bindoo	WTG007	Cord wise blade crack	03/11/08	GE 1.5	32	Temporary Repair
Bindoo	WTG013	Cord wise blade crack	03/11/08	GE 1.5		Temporary Repair
Bindoo	WTG015	One zig zag crack @ 6-8m and one cord wise @ 14m	16/10/08	GE 1.5		Permanent repair
Bindoo	WTG017	One crack @ 6m going cord wise from pressure side through leading edge and onto suction side	04/10/08	GE 1.5		Permanent repair
Bindoo	WTG021	Cord wise blade crack	07/11/08	GE 1.5		Permanent repair
Bindoo	WTG023	Cord wise blade crack	23/11/08	GE 1.5		Permanent repair
Bindoo	WTG030	Cord wise crack @ 5m and another @ 12m	16/10/08	GE 1.5		Temporary Repair
Bu	All	Blades damage due to corrosion caused by sand and other debris in the air	27/06/05	GE 900	3	The blades of all three turbines were repaired in situ by a German company WKA Fehrman
Bu	All	The joint where the two sections are glued together to form one blade where cracked and open	24/06/05	GE 900		This was a result of the transport from Brazil the blades of all three turbines were the same and were repaired in situ by Tecsis from Brazil
Coomatalin:	T1&T7	Blades delaminating, serial batch defect from LM			4	All blades replaced
Corneen	WTG002	Blades changed due to split in one blade, Most likely caused by bullet	26/06/05	GE 1.5	2	
Corneen	WTG001	Leading edge minor repairs and blades cleaned, Normal wear & Tear	01/07/05	GE 1.5		

Corneen	WTG002	Leading edge minor repairs and blades cleaned, Normal wear & Tear	30/06/05	GE 1.5		
Culliagh	ALL	3M Protection Tape mounted on all leading edges	28/06/05	Vestas V47	18	
Drumderg		No blade issues		Siemens 2.3	16	
Meentycat	WTG38	Blade damage due to lightning, 100MM burn on leading edge	23/11/08	Siemens 1.3	15	Permanent repair to be done blade repaired in situ by Siemens
Meentycat	WTG15	Blade damage due to lightning, 50MM burn beside tip conductor	26/11/05	Siemens 2.3	23	Permanent repair done blade repaired in situ by Siemens
Midas	M6	Edge wise vibration due to cracks on trailing edge and shell	01/11/07		23	All blades replaced
Midas	M2	Cracks on trailing edge				Two blades repaired in situ
Midas	M8	Cracks on trailing edge				One blade repaired in situ
Midas	M3					Vortex generator replaced
Midas	M1	Damage due to impact caused during work				One blade repaired in situ
Midas	E1	Internal damage due to debris in the blade				One blade repaired in situ
Midas	M7	Trailing edge cracks, cause to be determined				Equipment and personnel currently on site awaiting a weather window for repair, inspections ongoing
Minsca	WTG04	Blade Balance Retrofit	01/04/09	Siemens 2.3vs	16	Weights Fitted
Mullananalt	WTG001	Grinding dust on blades. Resulting from where they were stored on docks	01/07/08	GE 1.5	5	Cleaned
Mullananalt	WTG002	Grinding dust on blades. Resulting from where they were stored on docks	01/07/08	GE 1.5		Cleaned
Mullananalt	WTG003	Grinding dust on blades. Resulting from where they were stored on docks	01/07/08	GE 1.5		Cleaned
Mullananalt	WTG004	Grinding dust on blades. Resulting from where they were stored on docks	01/07/08	GE 1.5		Cleaned
Mullananalt	WTG005	Grinding dust on blades. Resulting from where they were stored on docks	01/07/08	GE 1.5		Cleaned
Richfield	T15	Leading edge cracks due to fault in manufacturing process			18	Three blades repaired in situ
Richfield	All others	Some minor cracks reported				Awaiting report and course of action from LM/GE
Spurness	WTG01	Lightning damage to tip, trailing and leading edge split open 42 - 45mm.	15/05/08	NM80 2.75MW	3	Repairs carried out by Total Wind Blades for Vestas
Spurness	WTG01	Eroded gel coat caused by sand and salt content in the air.	16/05/08	NM80 2.75MW		Repairs carried out by Total Wind Blades for Vestas

Spurness	WTG02	Open tip end due to lightning	23/04/08	NM80 2.75MW		Repairs carried out by Total Wind Blades for Vestas
Spurness	WTG02	Eroded gel coat caused by sand and salt content in the air.	23/04/08	NM80 2.75MW		Repairs carried out by Total Wind Blades for Vestas
Spurness	WTG03	Eroded gel coat caused by sand and salt content in the air.	23/04/08			Repairs carried out by Total Wind Blades for Vestas
Tangy	WTG009	Blade tip blown off (1250 mm section) due to direct hit by lightning	11/11/06	Vestas V52	15	Blade removed from hub by Vestas service technicians + repaired on ground by Vestas blade technicians - new blade tip fitted
Tangy	WTG008	Whistling noise from blade	01/07/08	Vestas V52		Pinhole found on blade surface (pressure side) - repaired from access platform (in situ) by Vestas blade technician
Tangy	WTG014	Whistling noise from blade	05/06/09	Vestas V52		Unknown - Vestas have still to visit site to determine type of repair required

Figure 2: SSE wind turbine failure log

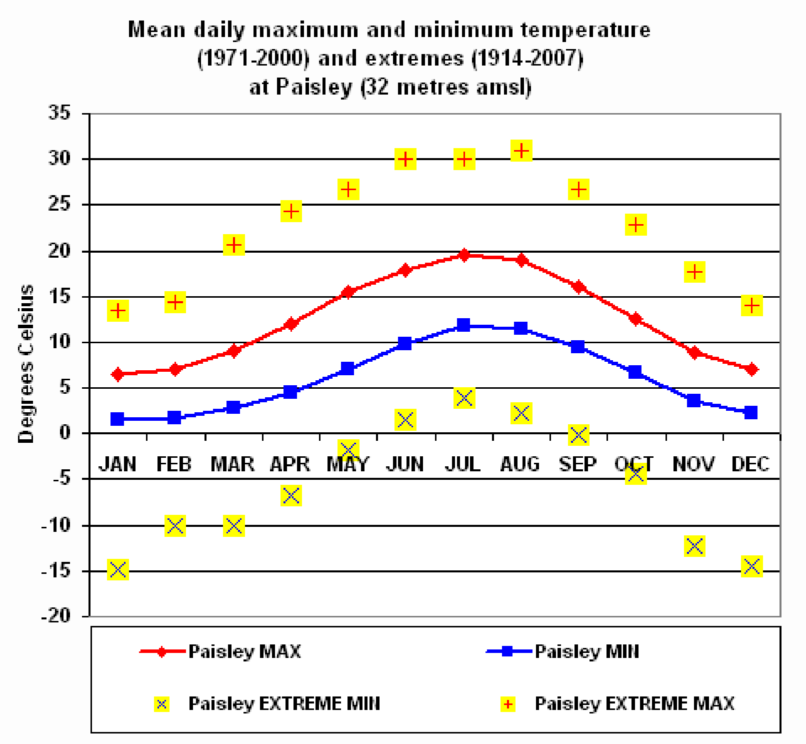


Figure 3: Typical yearly temperature profile for SSE on shore wind turbines. Approx 30 miles from Hadyard Hill wind farm

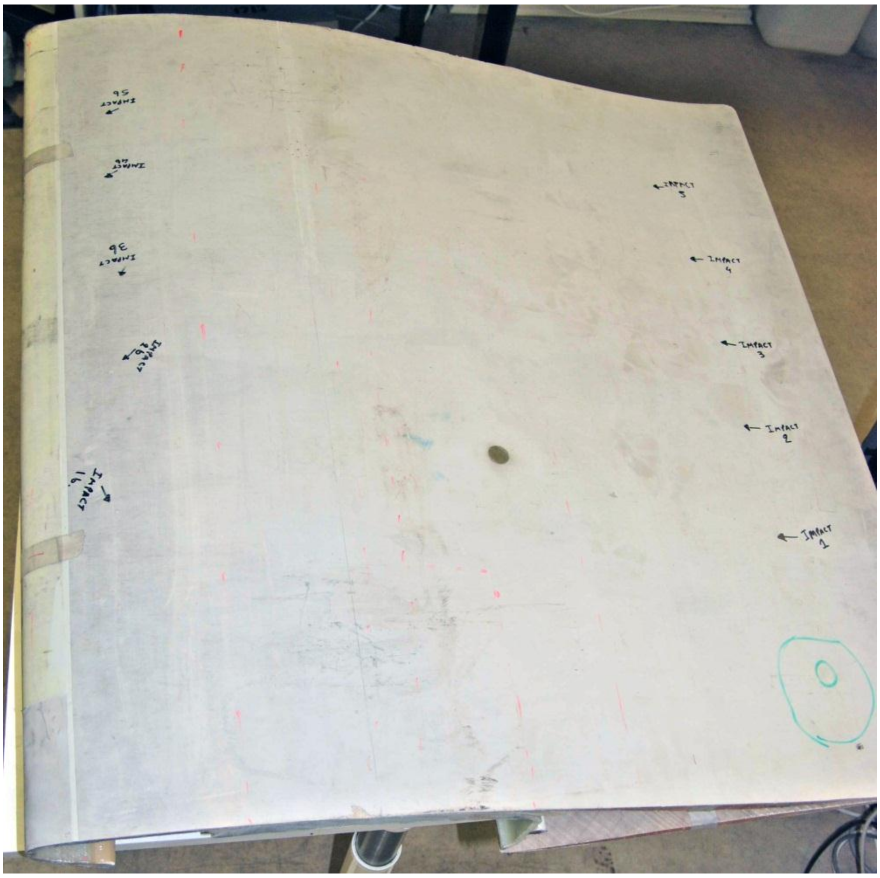
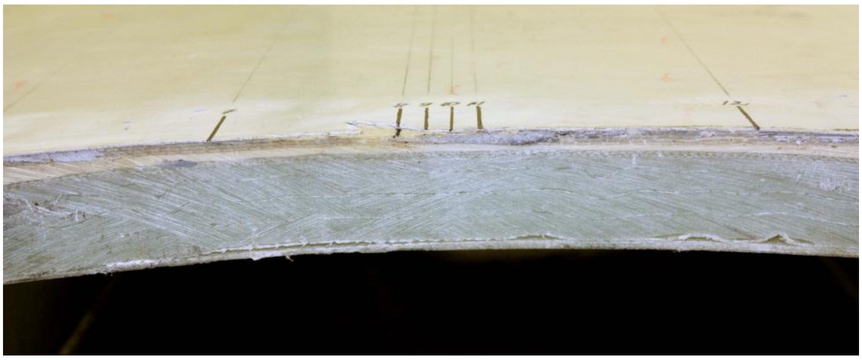


Figure 4: Wind turbine blade test sample

a



b

c

Figure 5: Different structures of composite materials used: a & c – "sandwich" structure; b – laminate structure

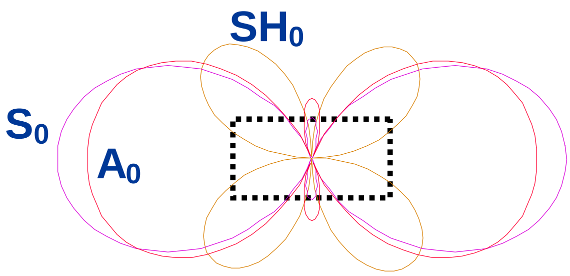


Figure 6: Field pattern of MFC sensors

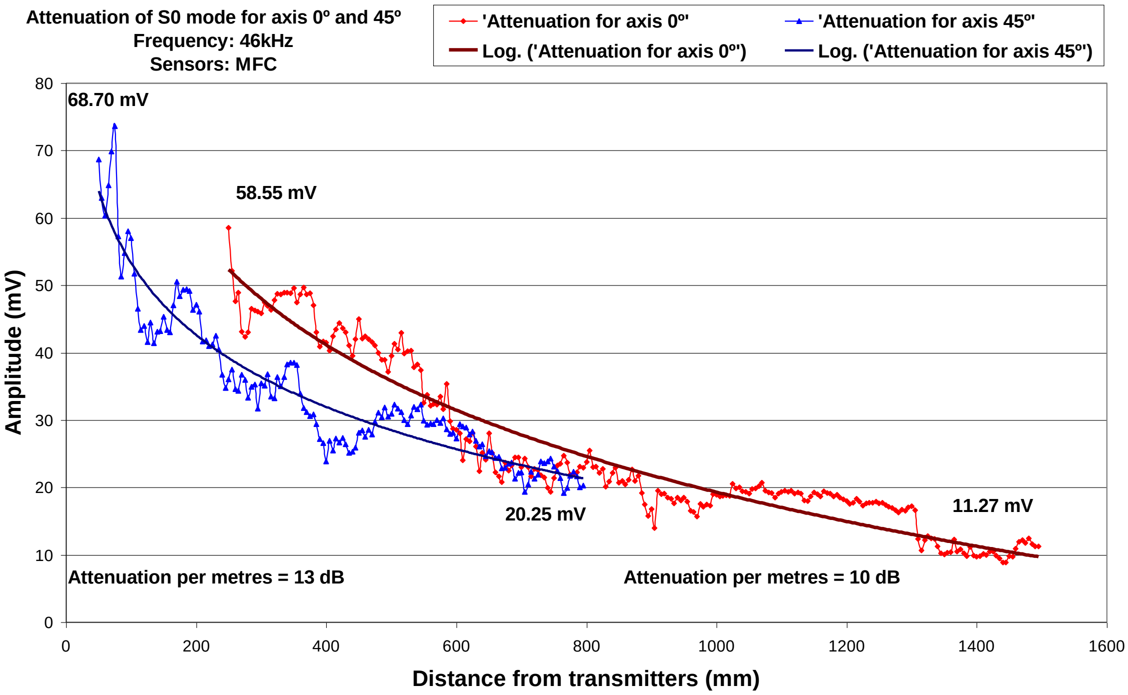


Figure 7: Attenuation rate on 0º and 45º fibre axis for S0 wave mode

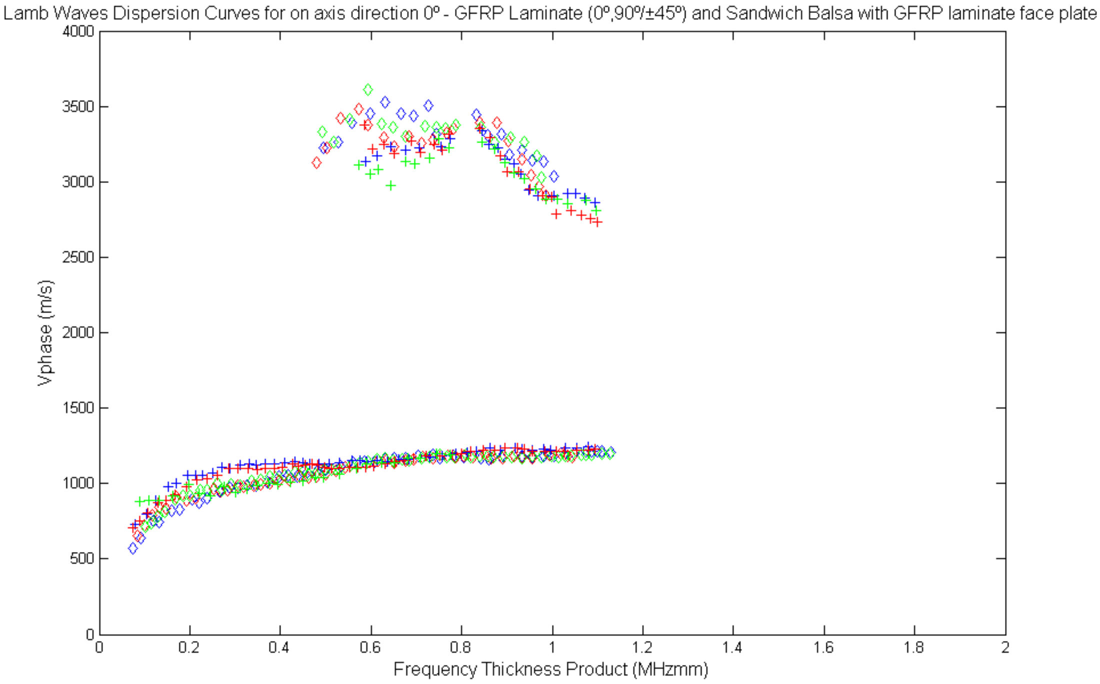


Figure 8: Comparison of S0 and A0 between their propagations in laminated and sandwich structures

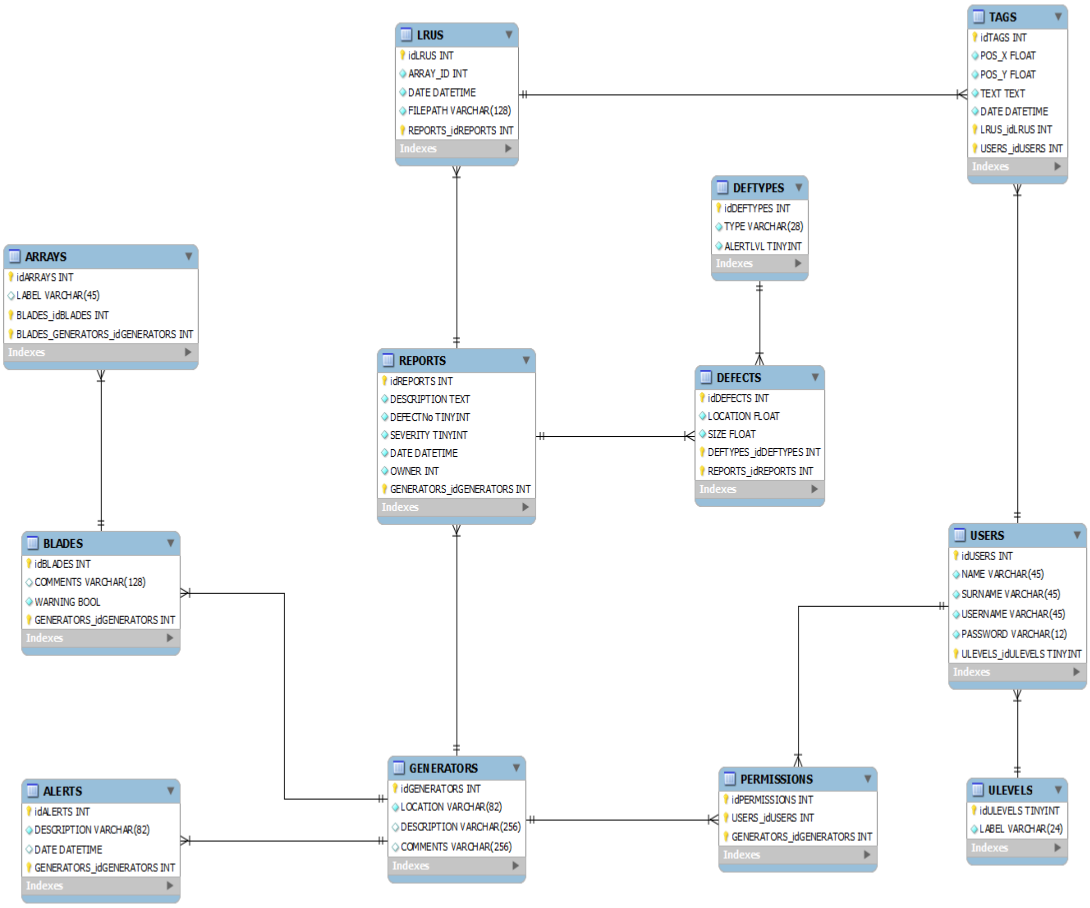


Figure 9: WinTur Remote Database Design

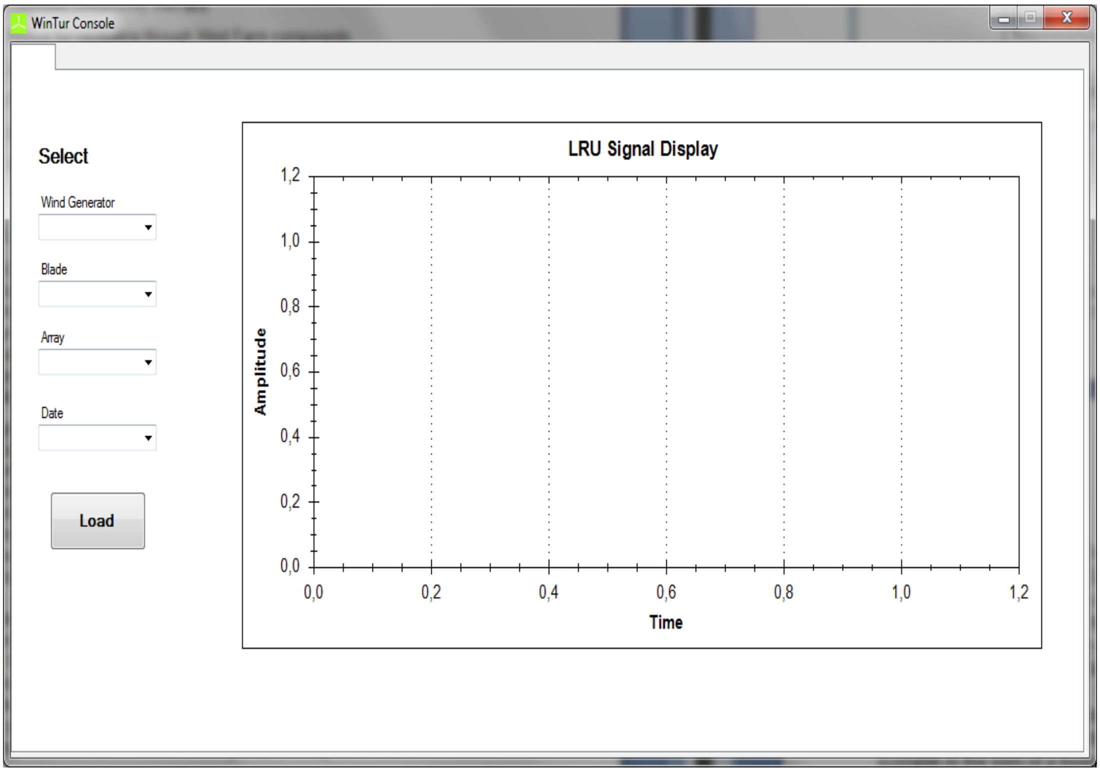


Figure 10: WinTur GUI

Figure 11: WinTur Demo on full length turbine blade

Figure 12: APA sensor on a sub-woofer

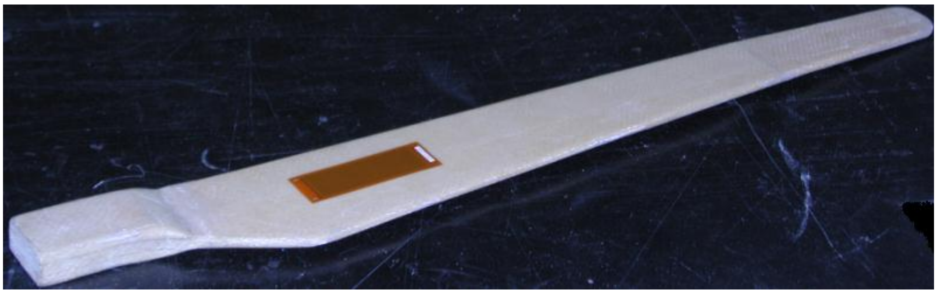


Figure 13: MFC on a 1:14 scaled model of a turbine blade

Strengths (Internal-Consortium)	Weaknesses (Internal-Consortium)
• International industrial contact database • Strong research expertise on different expertise • Interdisciplinary approach • Novel transducer technology • Great experience in risk assessment. Strong risk reflex and ability to react to changing conditions effectively.	• Lack of data and measurements due to limited access to the essential data in wind turbine manufacturing because of high level of confidentiality. • Might not be easy to retro-fit systems
Opportunities (External)	**Threats (External)**
• Big gap in the market for a satisfactory condition monitoring method for the wind turbine components • New possible future collaborations and job openings. • Expansion of the market to similar green energy technology applications. • Requirement for the cost effective and timely detection of degradation due to fatigue or to natural incidents • Fast response to abnormalities on the wind turbines, prevention of serious breakdowns • Opportunities for widespread licensing • Positive contribution to the maintenance and repair time without any interruption to the power generation • Data transfer without any human intervention • Results applicable for other large fiber reinforced composite structures (i.g. trams, trains, ships, aircrafts) • Providing basics for better understanding of failure modes in complex composite sandwich structures • Modular structure of the transducer unit combined with the energy autarkic approach can lead to a cost efficient "plug & run" system	• Decreasing consumer spending due to current economic conditions • Price focused approach • Reduction in R&D budget • Small barrier to entry for competitors • Competing technologies • Lack of real life data from end user • Lack of knowledge (end users & manufacturers) • Fear of something new - resistance to change • Displeasure of blade manufactures to embed additional elements into their laminates for the background of delamination • Bureaucratic process • Time and costs for necessary certification process before putting the whole system into circulation

Figure 14: SWOT analysis for WinTur project