Autowinspec (status at May 2016)

The failure of wind turbine blades is not uncommon (there are an estimated 3800 failures globally per annum[1]) leading to obvious safety issues and wind turbine down-time. A large number of these failures can be prevented through repair or pre-emptive blade replacement, underpinned by scheduled in-situ inspection programmes.

Blades are currently inspected for damage by teams of operators accessing the blades via cranes and rope access. The inspections are visual and by means of a "tap test". The method of access and the means of inspection both have failings:

- Operator rope access is inherently slow, expensive and dangerous.
- The inspection means is imprecise and subjective.

Autowinspec addresses these failings:

- An autonomous robotic crawler is used to perform the blade inspection.
- The inspection uses acousto-ultrasonic (AU) sensing to determine the overall blade structural health. The inspection data is recorded and then assessed in a consistent and repeatable manner.

Target Benefits

- Improved safety because an operator is no longer needed to traverse each blade.
- Lower inspection costs with less operator time needed for inspections.
- Improved inspection means, leading to a lower number of blade failures, improved environmental safety and reduced wind-turbine down-time.

Autowinspec is a 2-year research project part-funded by the EU, running to the Summer of 2016. The project includes a number of research partners (TWI, Innora and InnotecUK) and also a number of SME's – Spectrum, Robotnik and Stirling Dynamics, who act as the lead exploitation partner.

The Prototype System

The prototype crawler is shown below. It moves to a number of locations on the blade to take measurements with the AU sensors. At each location the crawler uses suction pads to secure itself to the blade. The prototype has a mass of 30kg and is placed onto the blade with the assistance of a crane at the wind turbine nacelle.

The largest turbines employ CFRP, but most turbines use GFRP and this has been assumed as the blade material for the project. Some of the most damaging defects are delaminations or disbonds between the skin and spar cap and these have been the focus of the inspection system.

The initiation and propogation of critical flaws in GFRP structure are not well understood. Conventional inspection methods like manual ultrasonic testing, thermography, and tap testing are only sensitive once flaws reach a certain size and this may not be sufficient to predict blade failure reliably. The AU technique employed here uses advance signal processing techniques to measure the <u>effects</u> of flaws, regardless of their exact nature and size. For example, flaws like distributed micro cracks and more general structural weakening can only be detected by AU techniques.

In the sensor pack, there are two pairs of probes (a pulser and a receiver). Broadly, structural degradation and other kinds of small distributed flaws between the two probes are identified with higher attenuation of the transmitted signal.

Prototype Performance

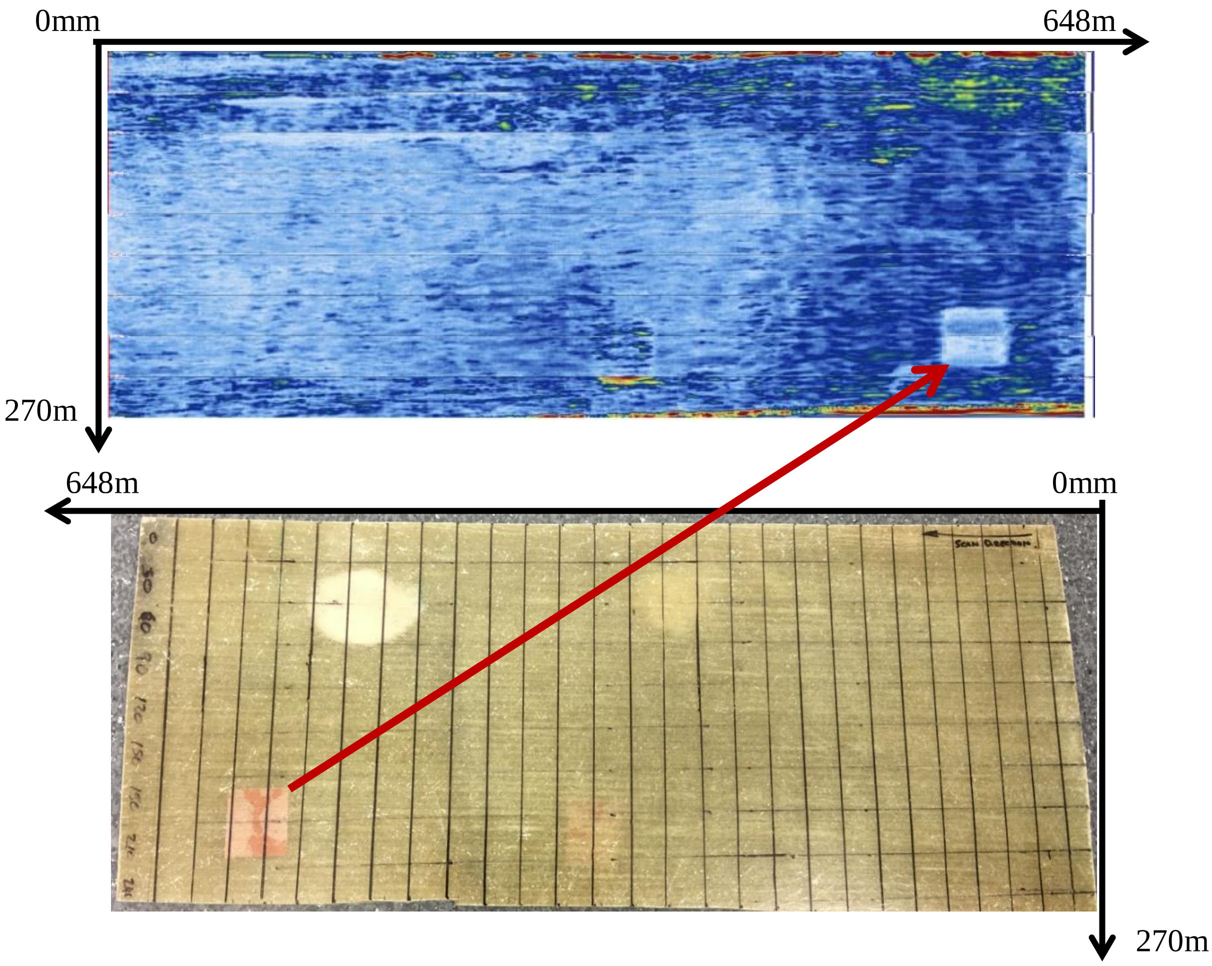
<u>Speed of measurement</u>

Each measurement takes 10 seconds. With a distance between measurements of 10cm along the span and 2 chordwise measurement locations then 50 minutes of measurement time is needed to scan both sides of a blade over a spanwise distance of 7.5m*.

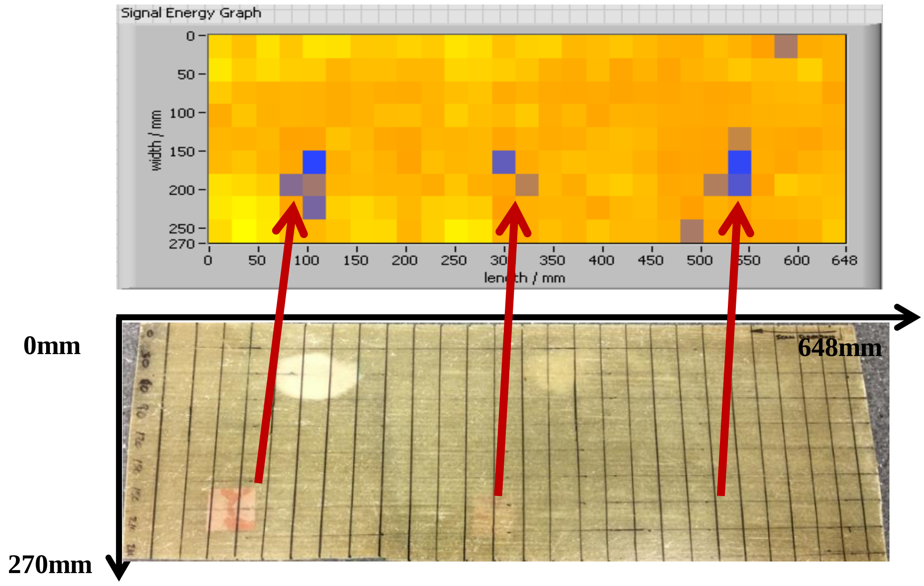
* 30% of the span for a typical medium-size wind turbine with blades of length 25m.

<u>Inspection performance</u>

In one test, a GFRP sample plate with six artificial flaws was analysed. The six features were three teflon inserts (to represent disbonds) and three circular regions seeded with impurities to represent diffused damage. With ultrasonic phased array techniques, only one of the teflon inserts was detected, as shown below.

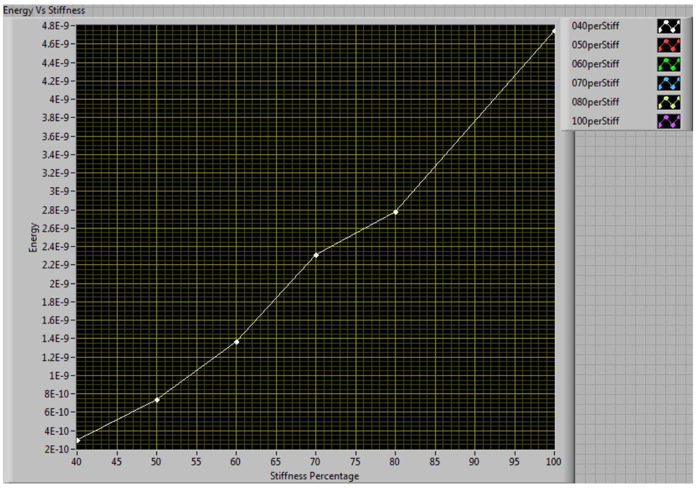


With the Autowinspec AU system, all three teflon inserts were detected:



The circular regions were not detected but it is felt that the impurities may not have actually reduced the strength of the plate in these regions.

More generally the Autowinspec AU system can discriminate different levels of material degradation. One example is shown below where the measured energy increases with the relative stiffness (i.e. the strength) of the structure.



Prototype Maturity

The prototype is not yet sufficiently mature for productionisation.

- Although the prototype is currently undergoing trials on a wind turbine, the safety case for having the crawler on a blade will need further development, with further mitigations in place in case the crawler loses power or malfunctions.
- The move-stop-secure-measure sequence can be speeded up to reduce the overall blade measurement time.
- Currently the measurement data is post-processed for use by the research team. Additional development of user interface software, together with user training, would be needed before the system could be used by maintenance staff.

1. *http://www.windpowermonthly.com/article/1347145/annual-blade-failures-estimated-around-3800*