

# The Impact of Viscoelasticity on Wind Turbine Blade Leading Edge Protection

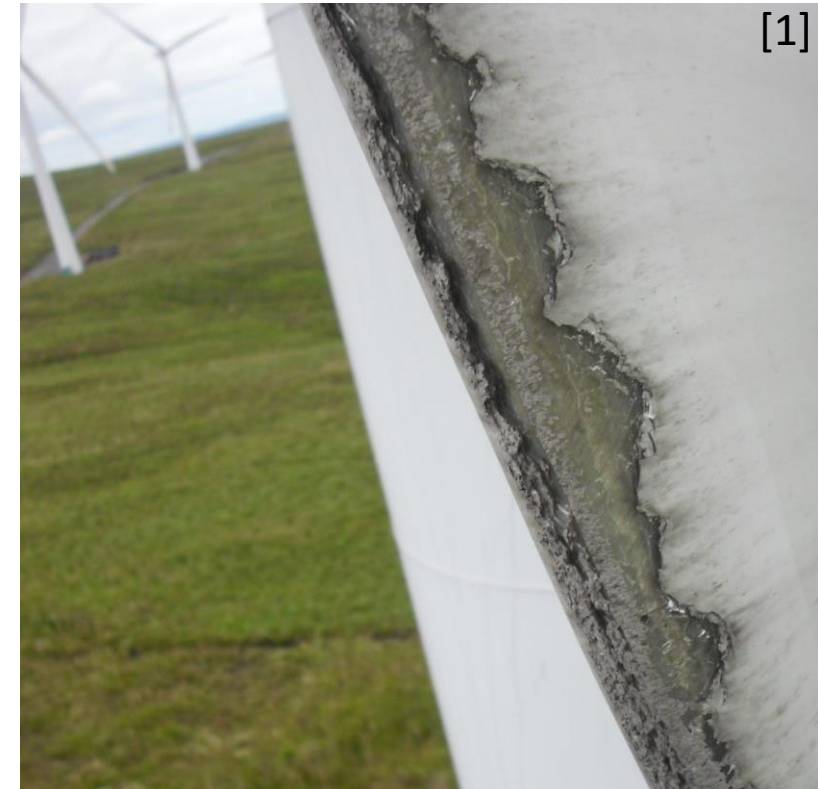
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# Introduction – Leading Edge Erosion

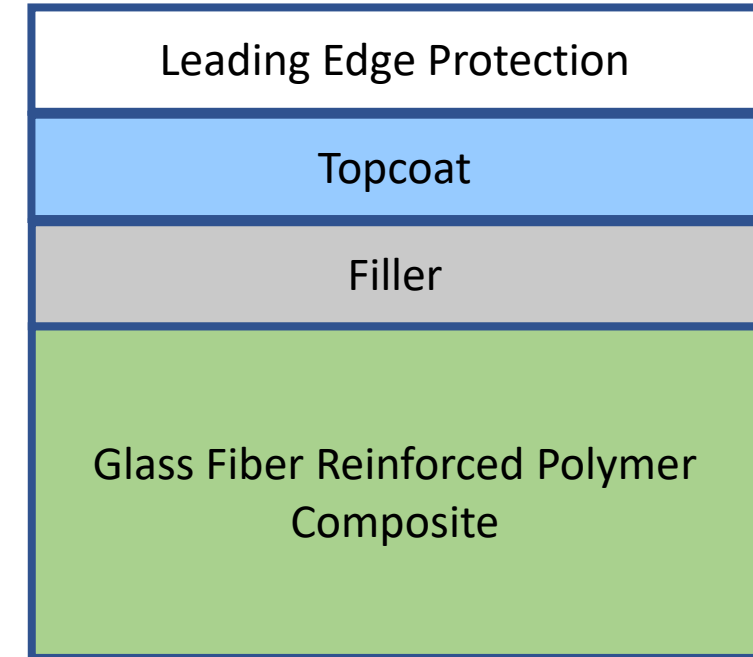
- Leading edge erosion (LEE) is caused by raindrops impacting the leading edge near to the tip of the blade, where local velocity of droplets can be close to 100m/s (225mph).
- It costs the industry in three ways:
  1. Degrades the aerodynamic performance and reduces the energy production of turbine costing the European offshore wind industry between €56m- €75m annually.
  2. Requires regular repairs of the blades costing European offshore wind industry €56m in repairs and inspection annually.
  3. Limits tip speeds to ~100 m/s which is reported to increase the mass of turbine components due to greater loads.



[1]

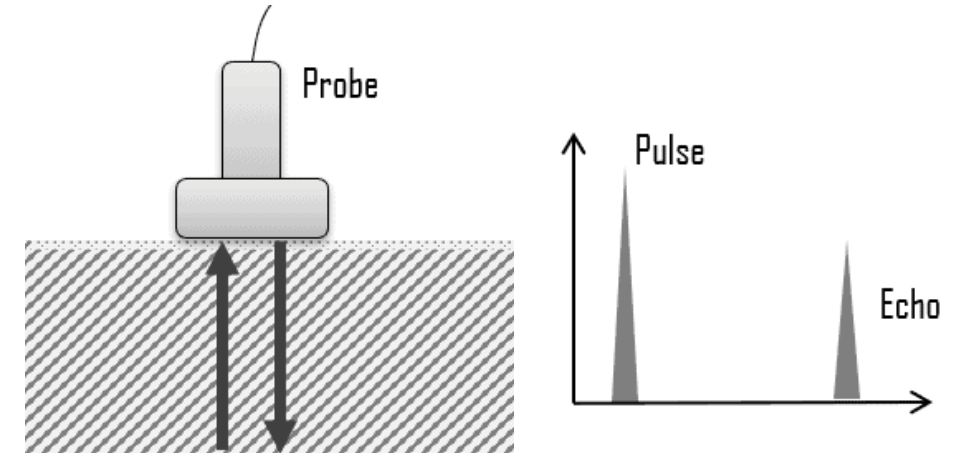
# Introduction – Existing Solutions

- Existing protection solutions are typically multi-layer and do not last the lifetime of the turbine and require regular repair or replacement.
- The main causes of this are thought to be:
  - Poor manufacturing, introducing defects that act as stress raisers and initiation points for erosion
  - Poor adhesion, causing the protective system to de-bond from the blade surface
  - Lack of knowledge of offshore conditions
  - Poor understanding of material properties and degradation mechanisms**



# Introduction – Existing Method

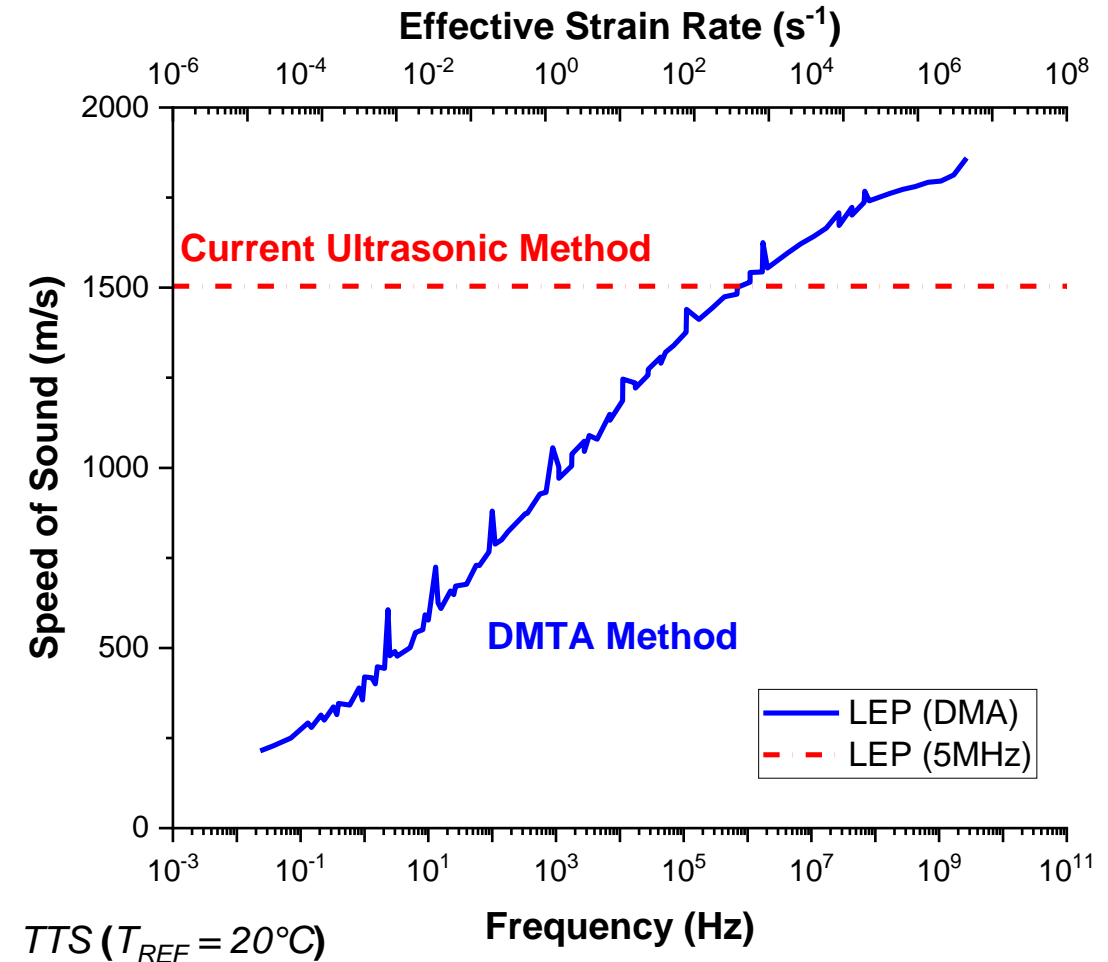
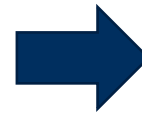
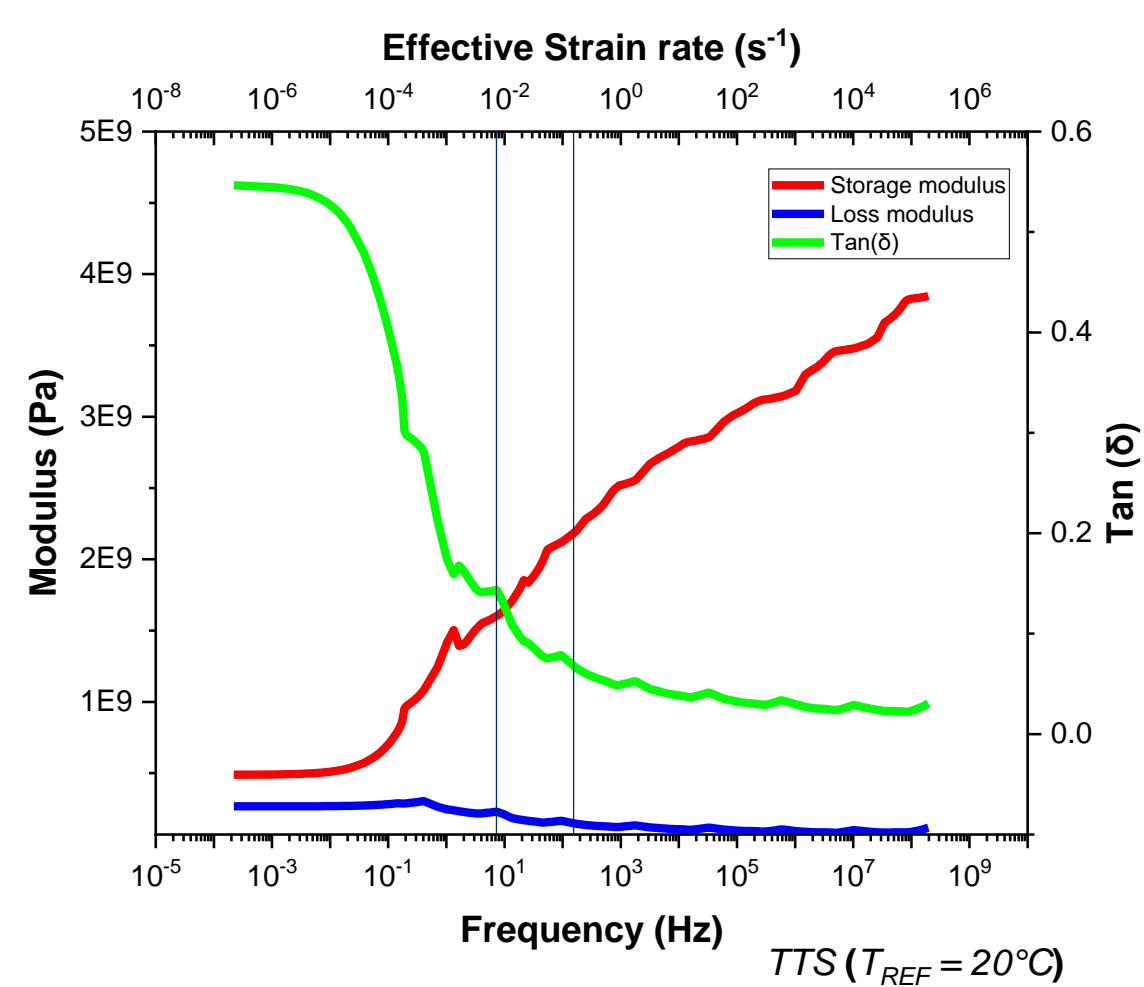
- Current lifetime prediction of coating uses speed of sound of material as a key input.
- Current standard (DNVGL-RP-0573) utilises a pulse echo technique to measure the speed of waves propagating through a medium
- Current materials are polymer based and have viscoelastic characteristics. Meaning material properties are a function of strain, strain rate and temperature.



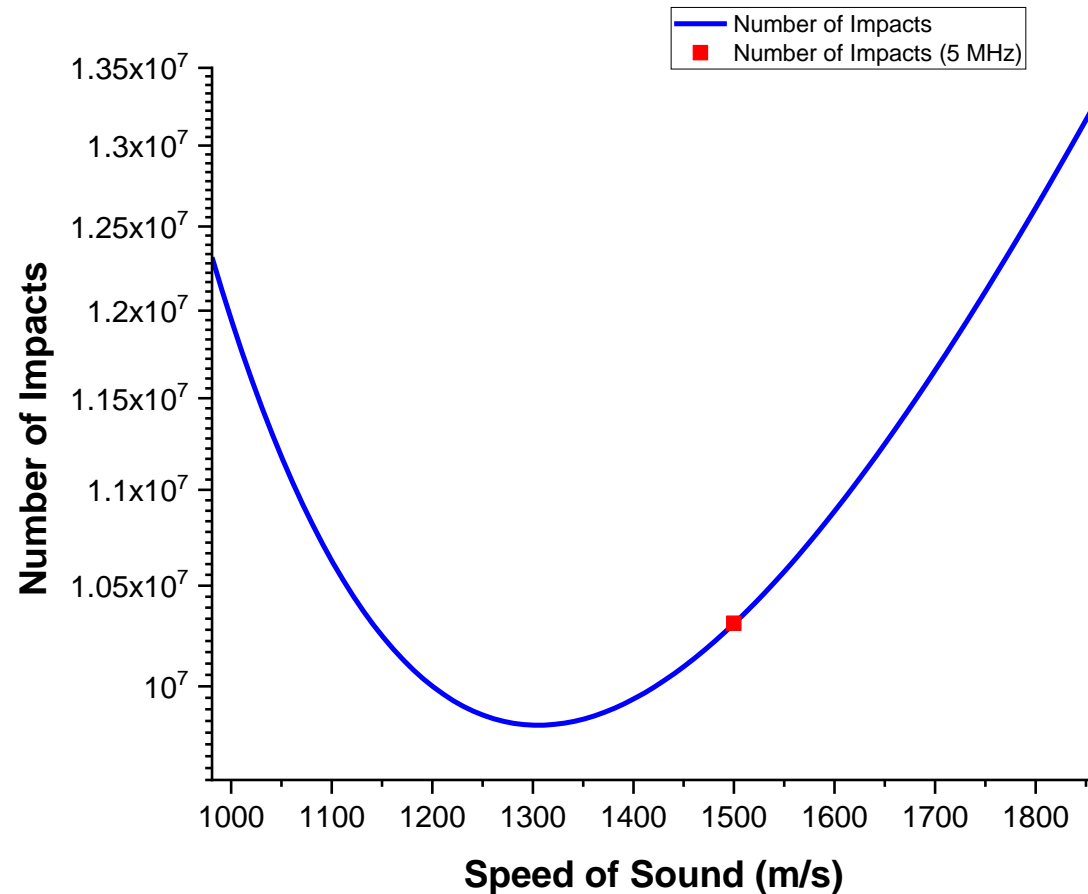
$$\text{Speed of sound} = \frac{\text{Distance travelled}}{\text{Time of Flight}}$$

**Raises the question – is quantifying speed of sound at one strain-rate, and temperature, enough to capture the material response?**

# Results – Material Characterisation



# Results – Material Lifetime



- When comparing the effect of speed of sound differences on the number of impacts at  $T_{ref}=20^{\circ}\text{C}$ .
  - The minimum number of impacts could be **5.1% lower** than the 5 MHz NDT method.
  - The maximum number of impacts could be **22.4% higher** than the 5 MHz NDT method.

Measurment Type	Number of Impacts
Minimum (DMA)	9.81E+06
Measured (5 MHz)	1.03E+07
Maximum (DMA)	1.33E+07

# Summary

- Leading Edge Erosion is one the **biggest problems** the offshore wind market needs to overcome.
- Modern coating solutions are viscoelastic and as result dependant on strain, strain-rate and temperature. These effects are commonly not considered.
- Demonstrated a new method of predicting material properties using DMTA and quantified its effect on the lifetime of a commercial material.
- This work is part of developing a selection of tests to provide a **predictive capacity** to understand material failure and facilitate rapid product development.

# Acknowledgements

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# Thank you for listening

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# References

[1] Five reasons for protecting the leading edge with Belzona, <https://blog.belzona.com/5-reasons-leading-edge-belzona/>