Wind Turbines and Radar Interaction

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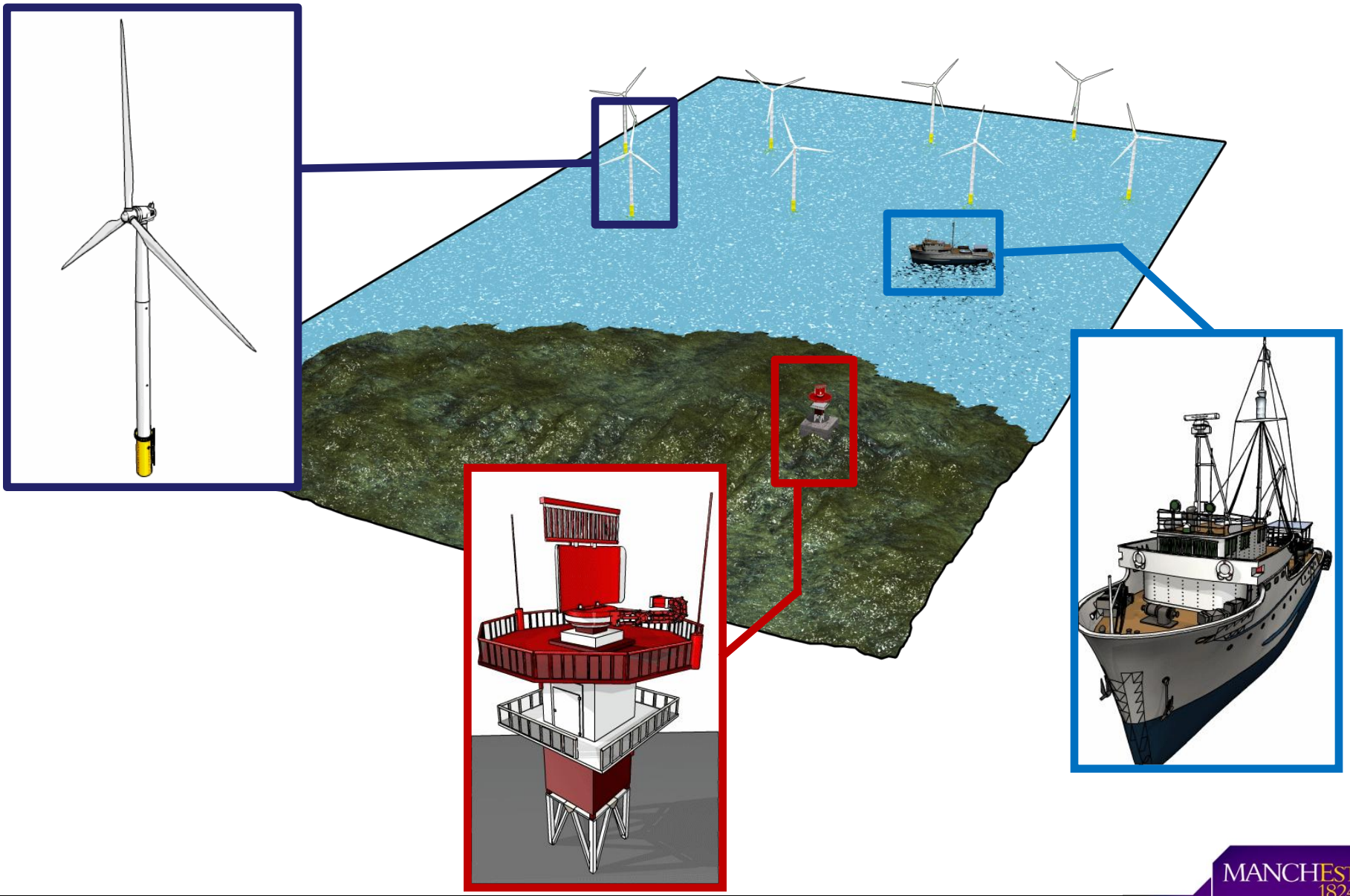
Introduction

- Concerns over the interference of wind farms with radar systems is stopping the development of thousands of turbines world wide
- These objections are often raised due to the characteristics of the scattering (radar echoes) from the large rotating turbines
- The interference of wind farms with radars is becoming more of an issue across Europe and world wide
- This may result in failure in meeting government targets for CO2 reductions and the “renewables promise” in the UK

Wind Farms and Radars



Significant and Known

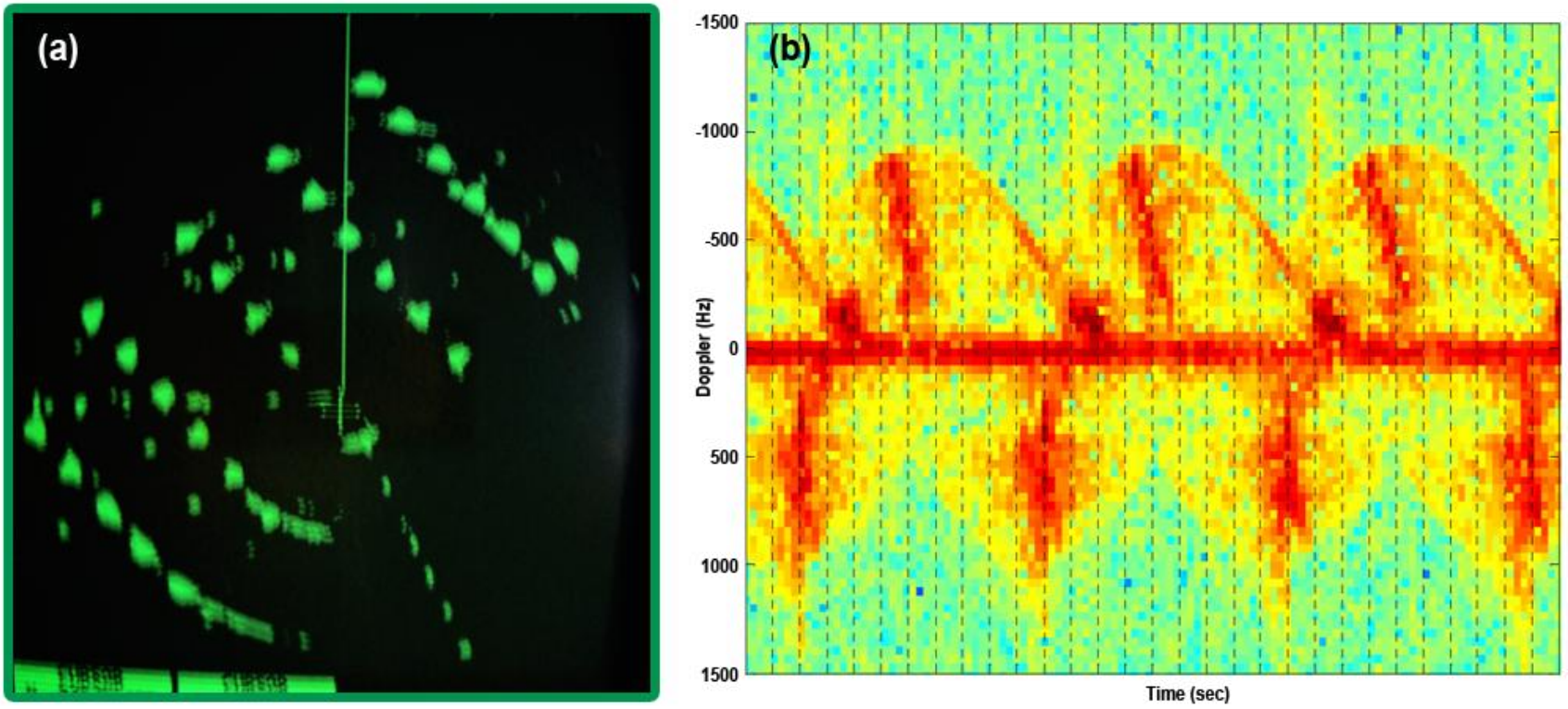
Significant

- The development of wind farms in areas which causes radar interference is seen as a significant threat to safety and security
- Defence and Air Traffic Control (ATC) radars lose sensitivity and the ability to detect objects over the wind farm
  - Due to the large radar echoes
  - Due to the Doppler signature generated by the rotating blades
- Marine radars and coastal Vessel Tracking Systems (VTS) are affected by the large echoes and the multiple reflections of the radar signal within the wind farm

Known

- By identifying the cause of the interference it becomes possible to address these issues
- Mitigation measures becomes available depending on the problem

Measurements



(a) Radar display from a small vessel near the North Hoyle wind farm –it shows target spreading and appearance of ghost targets from multiple reflections

(b) Measured Doppler signature of the Swaffham turbine (source: BWEA Aviation site, measurement by QinetiQ)

Mitigation Options

- The interference of wind farms with radar systems arises when the wind farm is located within a high impact zone (ie, within the line of sight of safety critical radars)
- Through early engagement and discussions with the radar operators and other stakeholders, wind developers can address these issues and possible solutions may be available
- Depending on the nature of the objection, the issues may be overcome through simple and cost effective solutions
- The nature of these mitigation solutions can be categorized into a technical intervention and a non-technical intervention

Non-technical Mitigation Measures

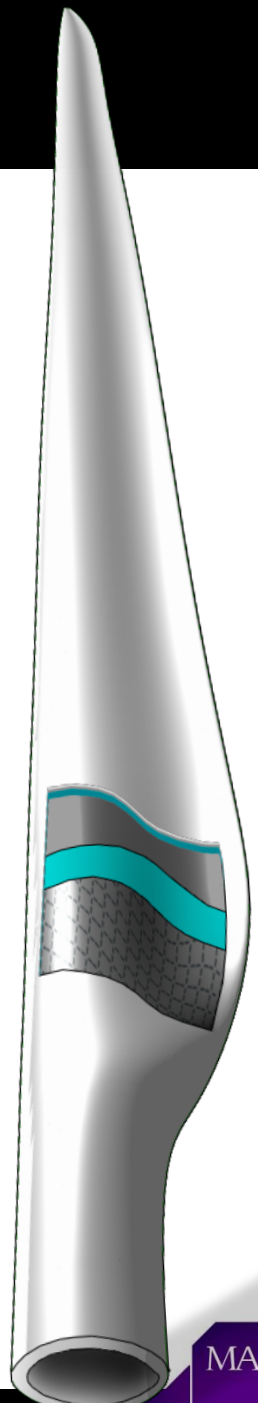
- This can be achieved through careful siting of wind turbines with respect to safety critical radars
- The layout of the wind farm and the inter-turbine spacing may have a significant impact on the radar
- Modification of the radar line of sight through applying a slight tilt up may cause the radar to over look the farm
- Installation of additional (gap filling) radars may compensate for the performance degradation of affected radars

Technical Radar Mitigation Solutions

- The unwanted returns from wind farms may be reduced using “advanced digital filtering” kits which are aimed for large ATC and defence radars
- Such technical solutions are generally aimed at large Doppler based radars such at ATC and defence radars
- Data fusion from multiple radars may also benefit ATC and defence radar networks
- Other radars such as VTS and marine radars, which are cost driven does not employ Doppler processing or data networking
- Such solutions can be of limited use for less complex radar systems

Technical Turbine Mitigation Solutions

- The scattering from a wind turbine can be reduced by modifying the characteristics of the turbine
- This can be achieve through careful shaping of the tower and nacelle to direct the radar echoes away from the radar
- Shaping can not be applied to blades!
- Introducing Radar Absorbing Materials (RAM) may be considered as a possible option
- RAM must be compact and light-weight



Stealth Vs Lightning Protection

- Most compact RAM solution requires a thin conductive layer
- Applying RAM to the blade may degrade the efficiency of the lightning protection system
- Careful design and coverage is needed in order to effectively apply RAM to turbine blades
- The study and modelling of RAM teated blade were undertaken

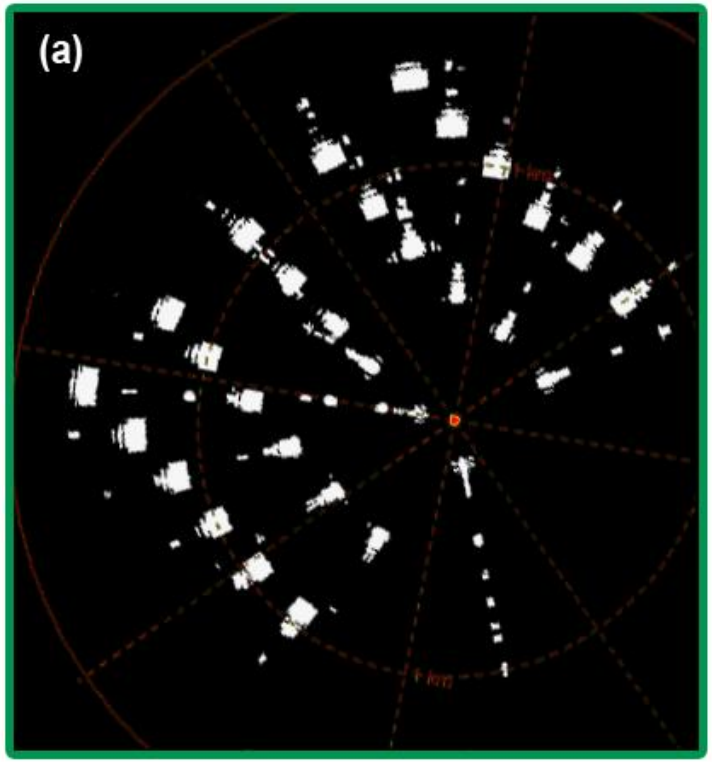
Interaction Modelling

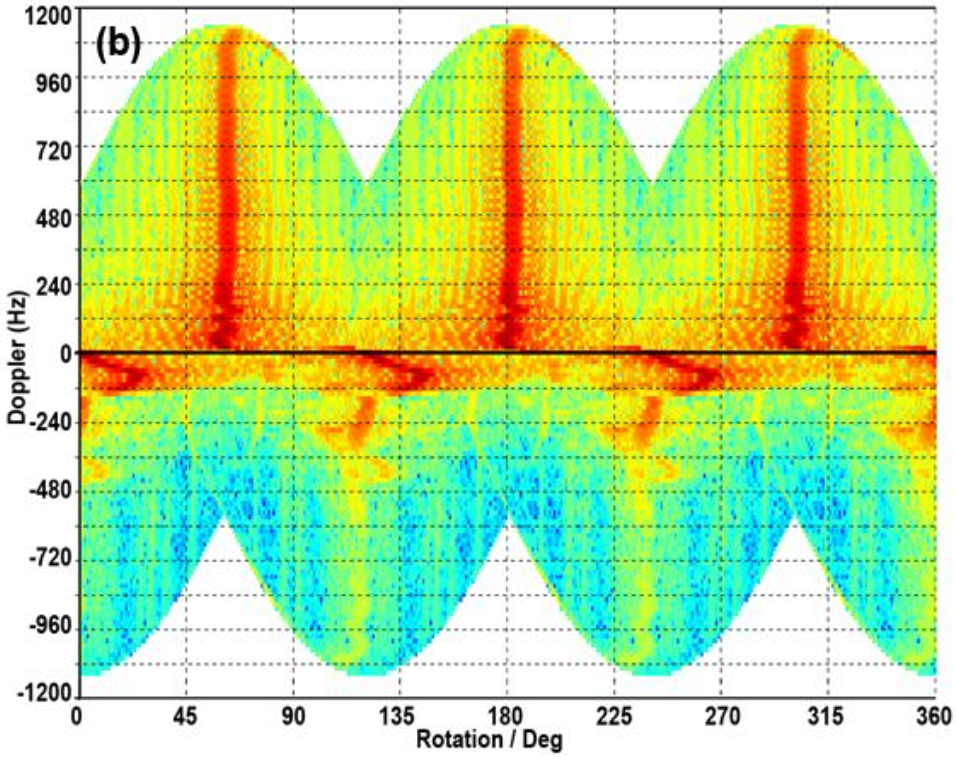
- To achieve feasible and cost effective mitigation measures a comprehensive understand of the issues and the main factors affecting the radar interference is needed
- This is achieved through liaising with radar operators and wind developers to share their practical experience
- Detailed modelling of the radar interaction with turbines can be used to identify the key parameters that would reduce the impact
- Radar modelling and wind farm modelling is required

Wind turbine and Wind Farm Modelling

- Due to the physical size of the turbine relative to the radar wavelength modelling scattering from a wind turbine is a computationally challenging task
- Although it is possible to compute the scattering from a single turbine using commercial Computational Electromagnetic (CEM) tools, it requires LARGE computational resources and prolonged run times
- The modelling of a WIND FARM is more complex and adds to the computational requeirments
- Research within the Supergen programme aims to find new methods to model the turbine as an entity and the wind farm in totality in a computationally efficient manner

Modelling Results



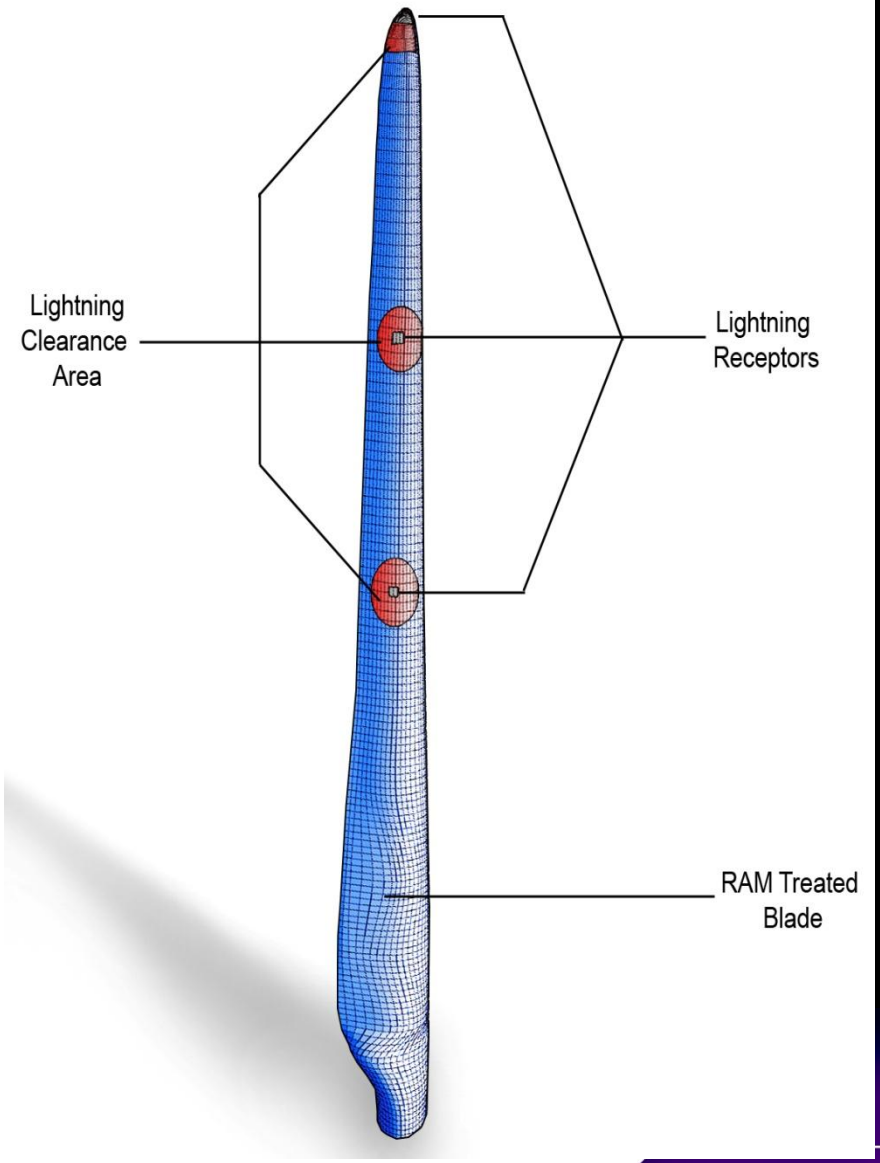


(a) Wind farm modelling using the developed tools (run time: 33 mins)

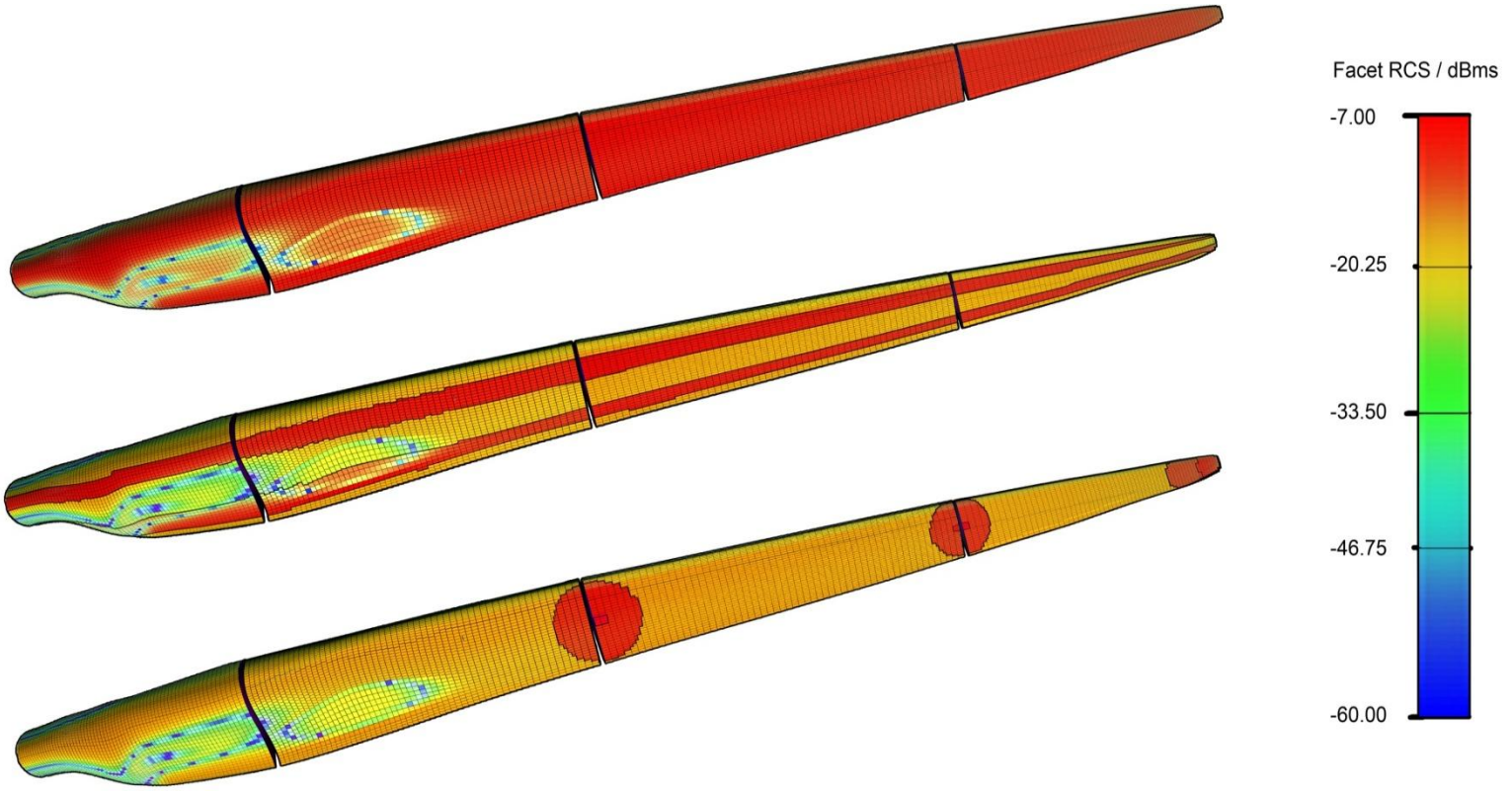
(b) Doppler signature modelling for generic turbine (Exemplar 2MW)

Lightning Protection Vs RAM

- In Supergen Phase 1, a partial RAM treatment of the blade was presented
- The proposed solution leaves a clearance area around the lightning receptors to maintain efficiency
- Using new modelling techniques, the impact of partial RAM treatment of blades on the scattering and Doppler can be investigated in detail



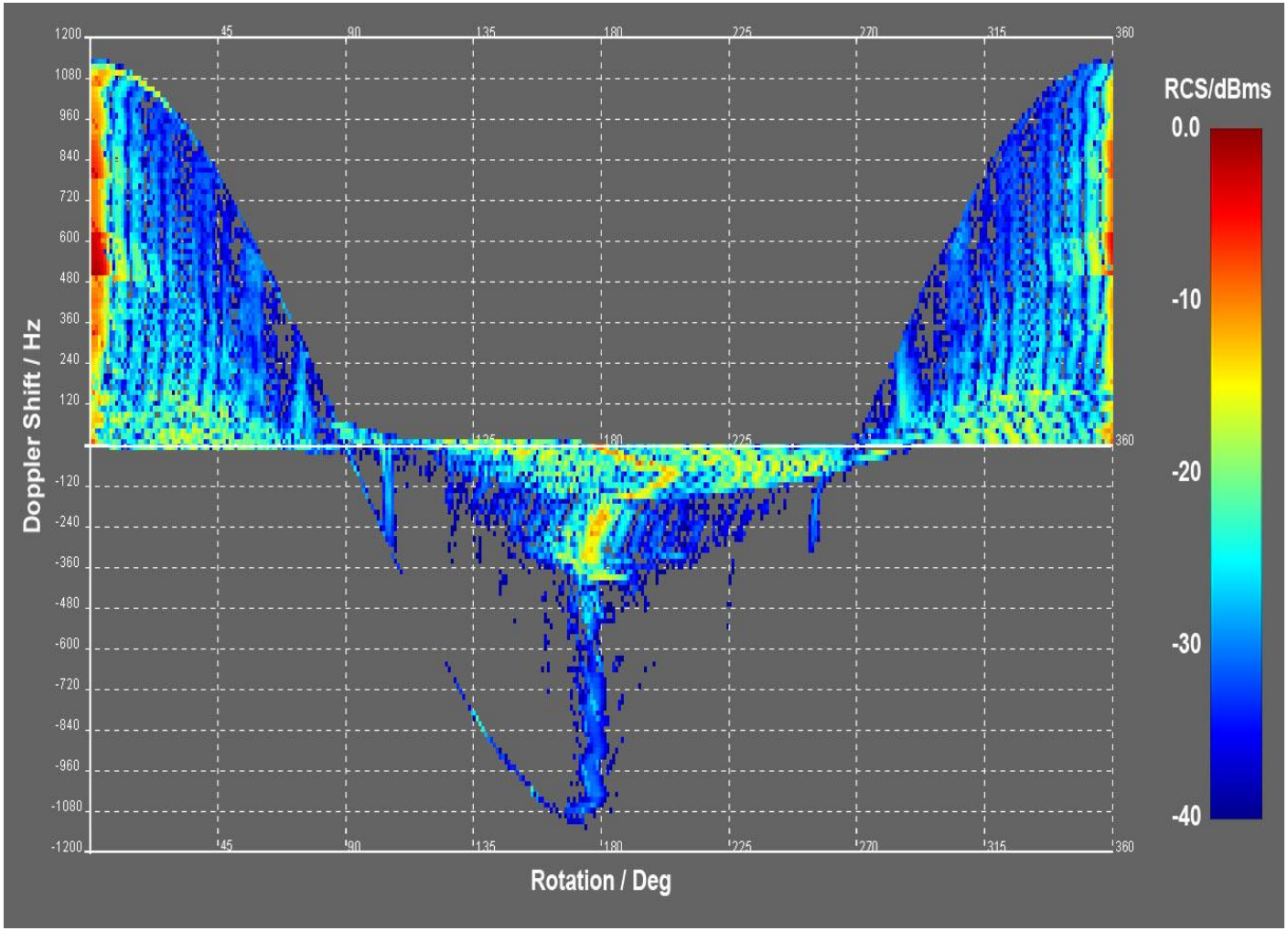
Surface Scattering

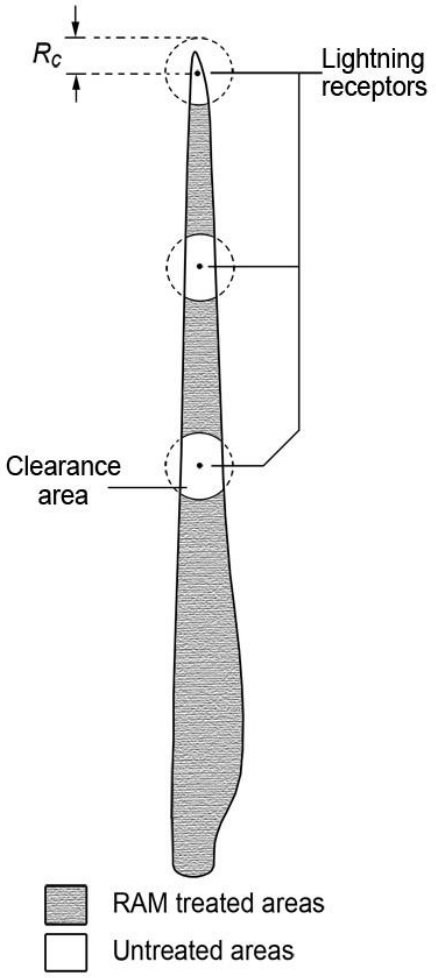


The regions of high scattering from a blade can be identified and treated with RAM

This allows for efficient RAM coverage of blades to reduce the cost and weight penalties

Doppler of Partially Treated Blade





Conclusions

- The interference of wind farms with radar systems is global issues and is slowing the development of wind farms
- A number of mitigation solutions are available to the developers depending on the objections raised
- Through modelling and understanding the factors causing the interference, the interference issues can be resolved through cost effective measures
- The current research programme aims to deliver a detailed model that would be used as tool to help developers and radar operators over come the interference
- Identifying the problem is key to finding a solution

Investigate – Simulate – Mitigate

Questions