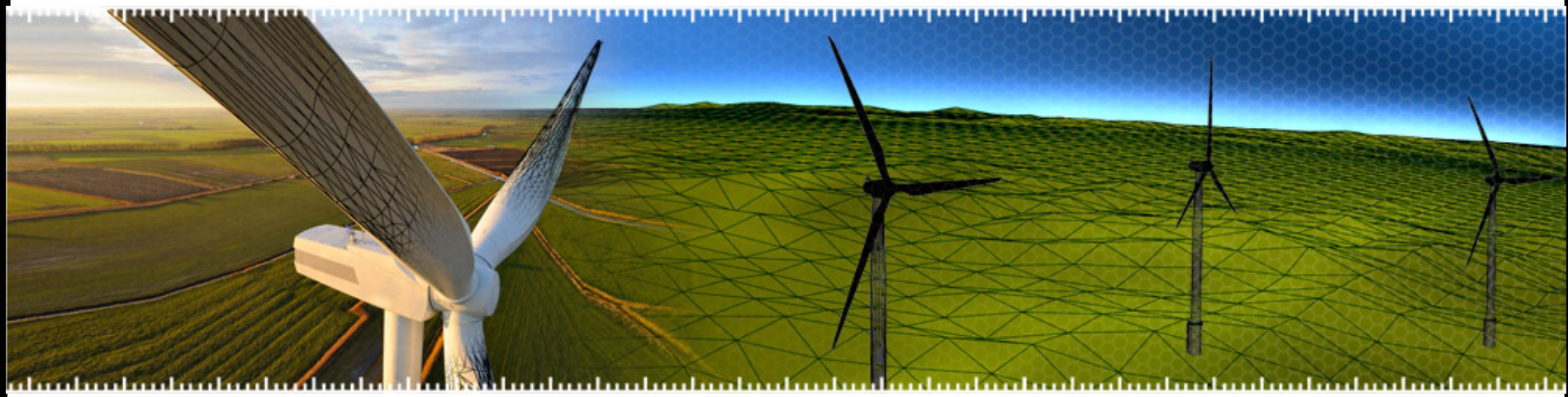
Modelling the Interaction Between Wind Farms and Radar Systems



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Radar Interference 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

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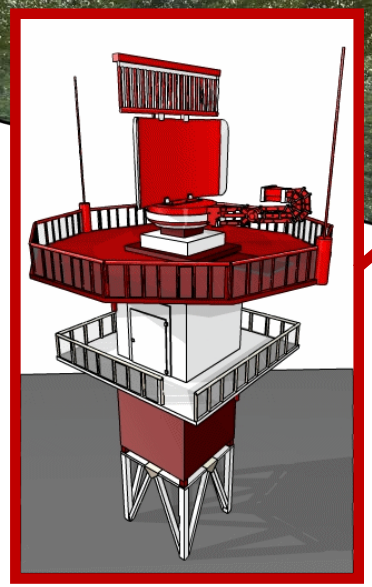
Wind Farms and Radars

Wind turbine



ATC Radar

marine radar

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Modelling Challenges

- A simulator is needed to model the effect on radars before the construction of a wind-farm, such that the effects of different turbine design and farm layouts can be considered
- The model must provide accurate predictions of the scattering behaviour of turbines individually and the wind farm in totality
- HOWEVER:
  - Physical size is big, electrical size is huge!
  - The interaction might be different for every wind turbines, wind farms layout, radar and location
  - Pseudo random nature of the blade rotations in the wind farm makes it difficult to predict all possible outcomes
  - Various external parameters affecting the interaction
  - Interaction with local environment

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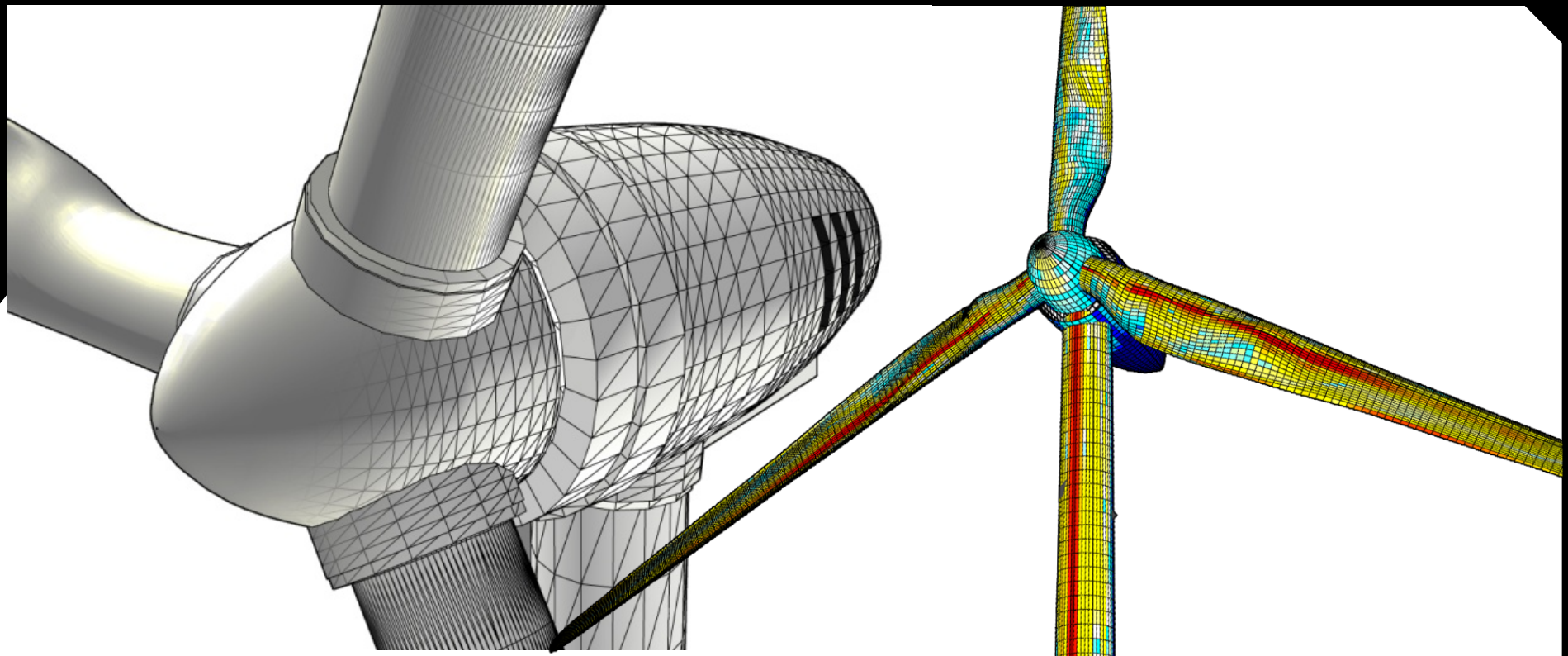
Wind Turbine Radar Scattering



The radar scattering models developed within the Supergen Programme uses a simplified yet representative modelling of turbines to give rapid RCS computation.

The models can compute the RCS at nearfield as well as farfield distances.

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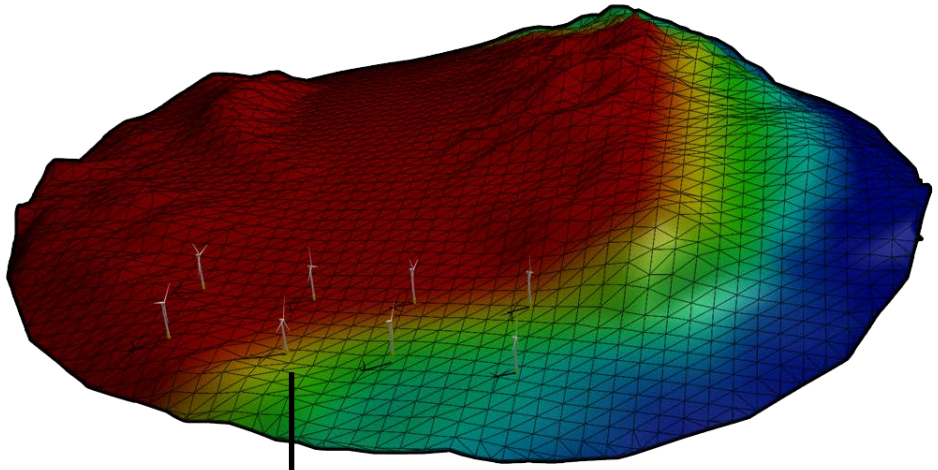
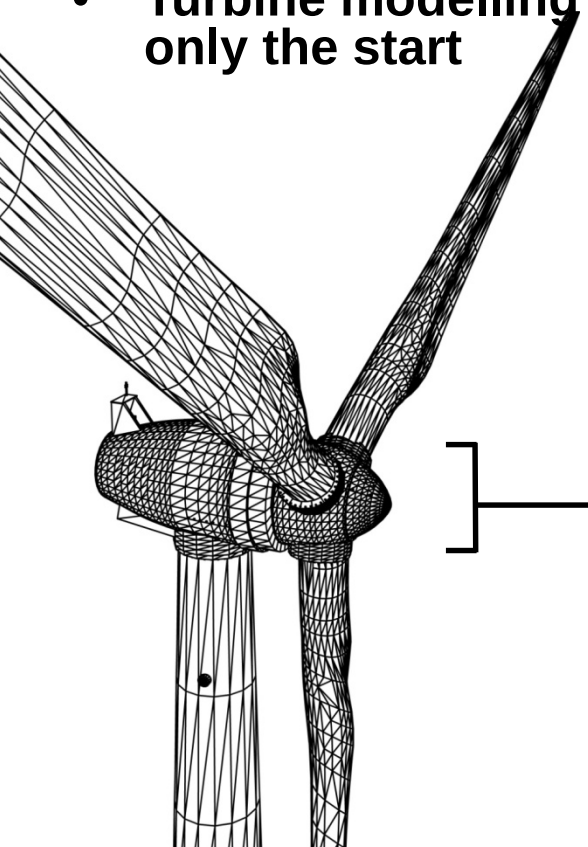
Wind Farm and Radar Modelling

- Accurate turbine geometry for radar scattering modelling was used
- The effect of radar absorbing materials was also investigated
- **Turbine modelling is only the start**





- The aim is to model a complete *wind farm* for site/radar specific assessment
- Environmental and inter-turbine interaction modelling
- Modelling the effects of local terrain
- Computational efficiency for rapid assessment of possible impact

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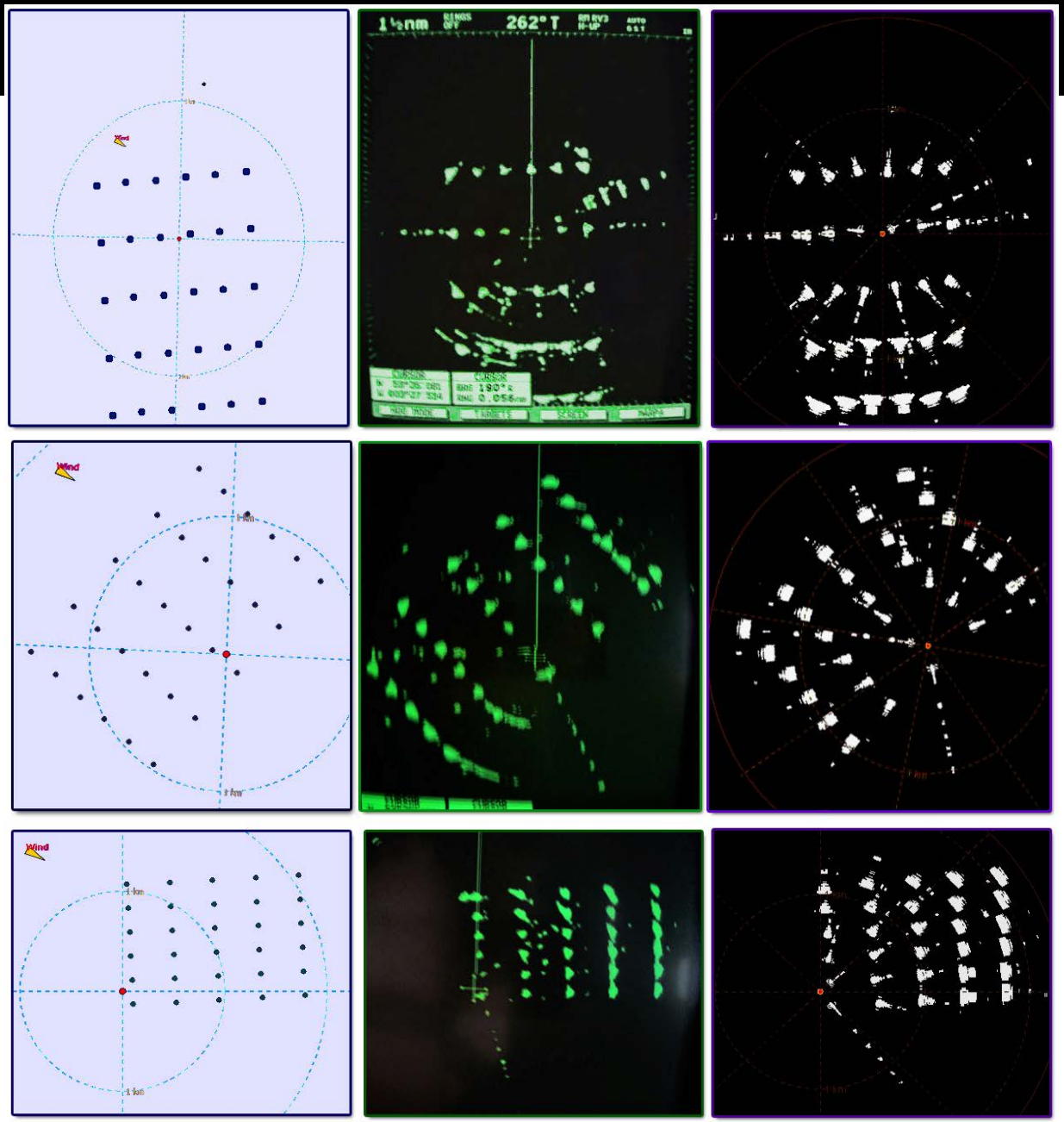

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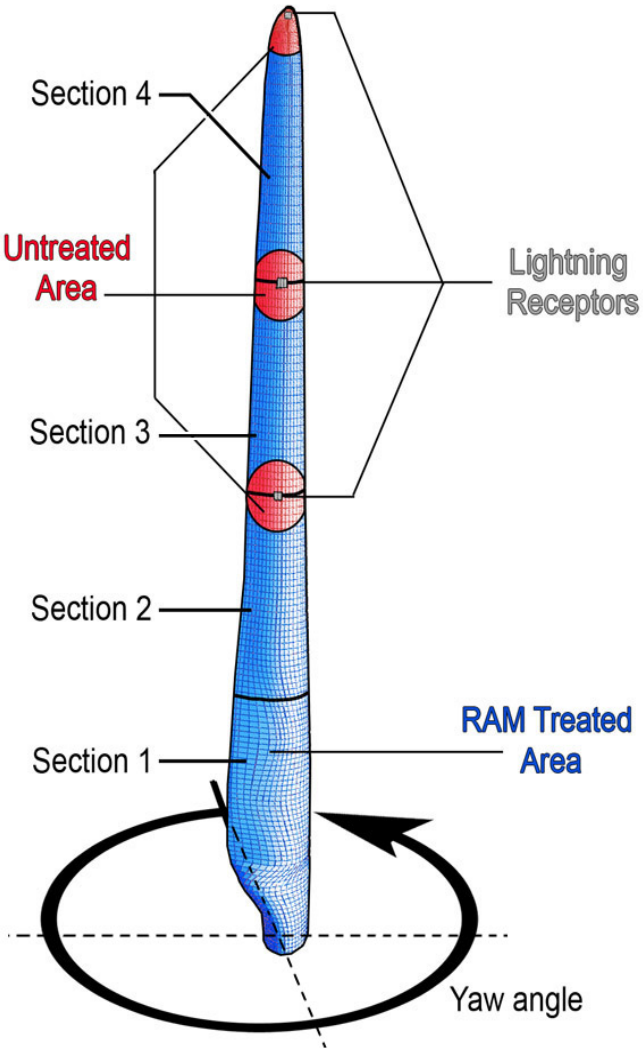
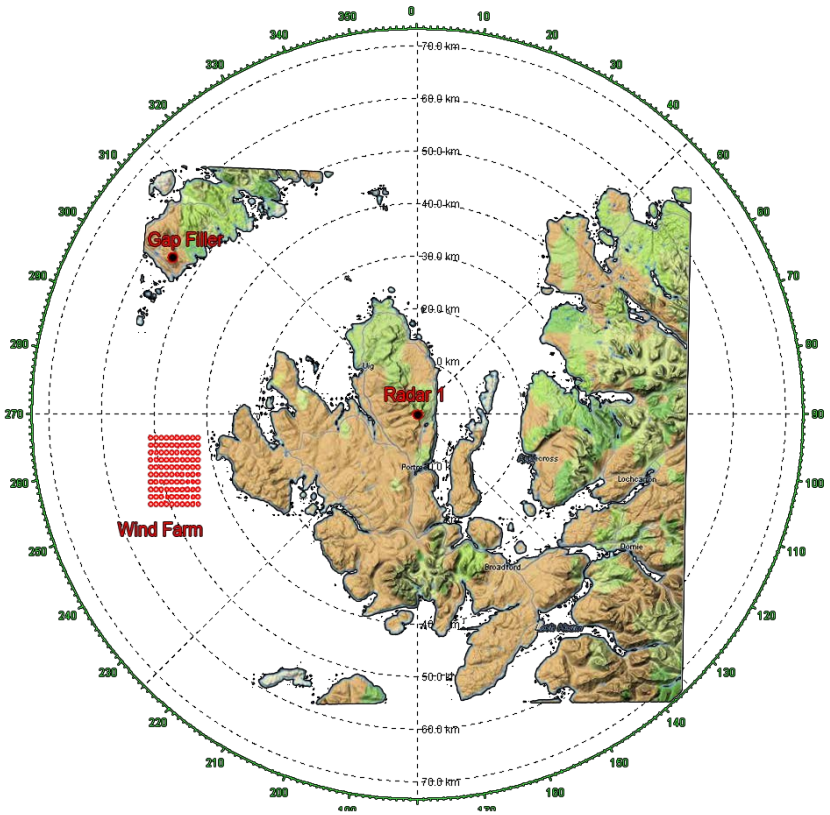
Partial RAM Treatment

- A receptor based lightning protection system is assumed where lightning receptors are placed at the middle, three-quarter point, and at the tip of the blade
- The blade is then fully covered with RAM while leaving a clearance area around the metallic receptors
- The clearance radius around the receptor is assumed to be 1.5m
- The tip is untreated



Wind Farm Siting Analysis



- The radar site location and height is identified along with the system specifications
- Specify the location, layout of the proposed wind farm and the turbines size and geometry if available
- Perform radar coverage analysis for the area of interest
- Gap Filling radar location is noted for use in next slides

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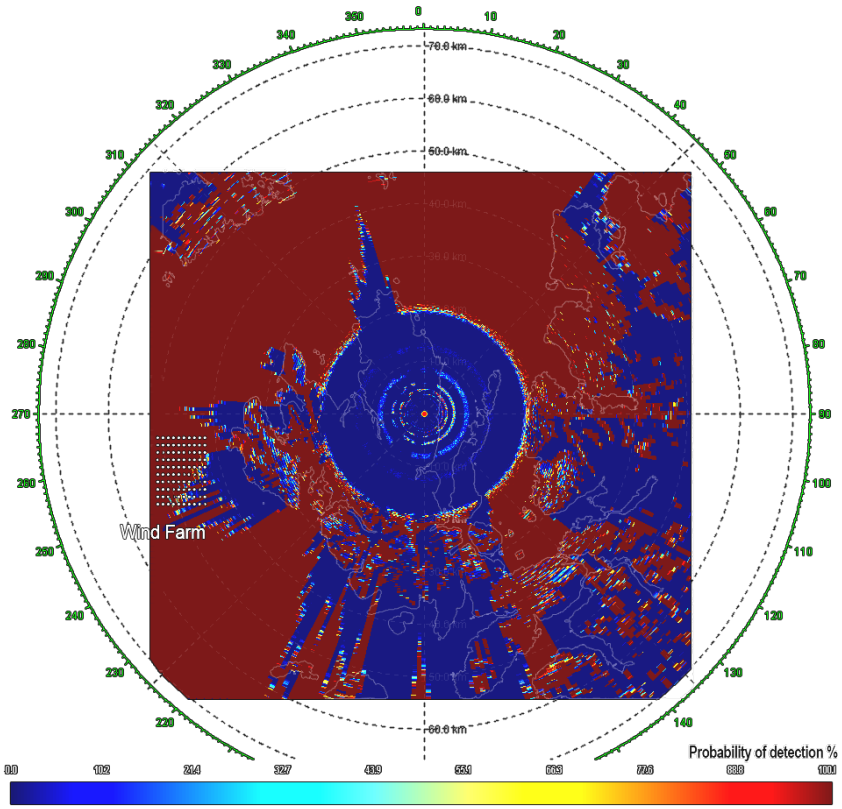
Wind Farm Coverage Analysis



- The radar coverage depends on a number parameters, which include the type and geometry of the turbines used
- The (Exemplar 2MW) blade tip height and radar cross section is used in this modelling scenario
- Coverage diagrams show the area of interest with the probability of the radar detecting the blade tip (at maximum tip height)

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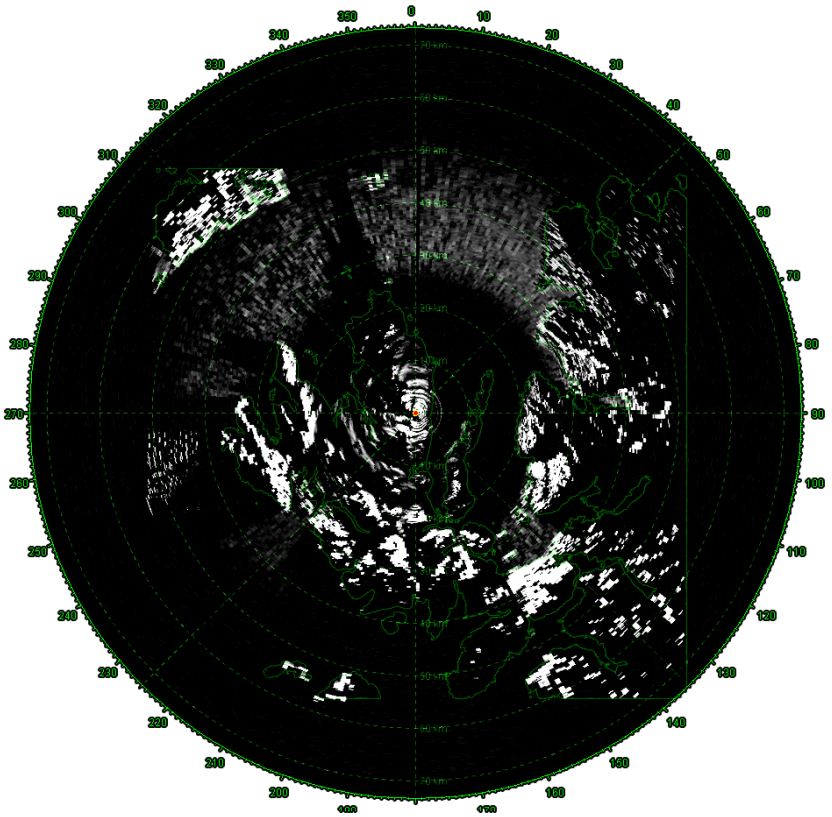
Radar output Analysis



- Modelling of the radar output (display) is also possible to help radar operators and developers understand the possible issues that may arise from a particular wind farm
- This helps to identify the areas of the wind farm that may still produce unwanted radar returns
- Gap filling radars are often suggested as a possible mitigation option

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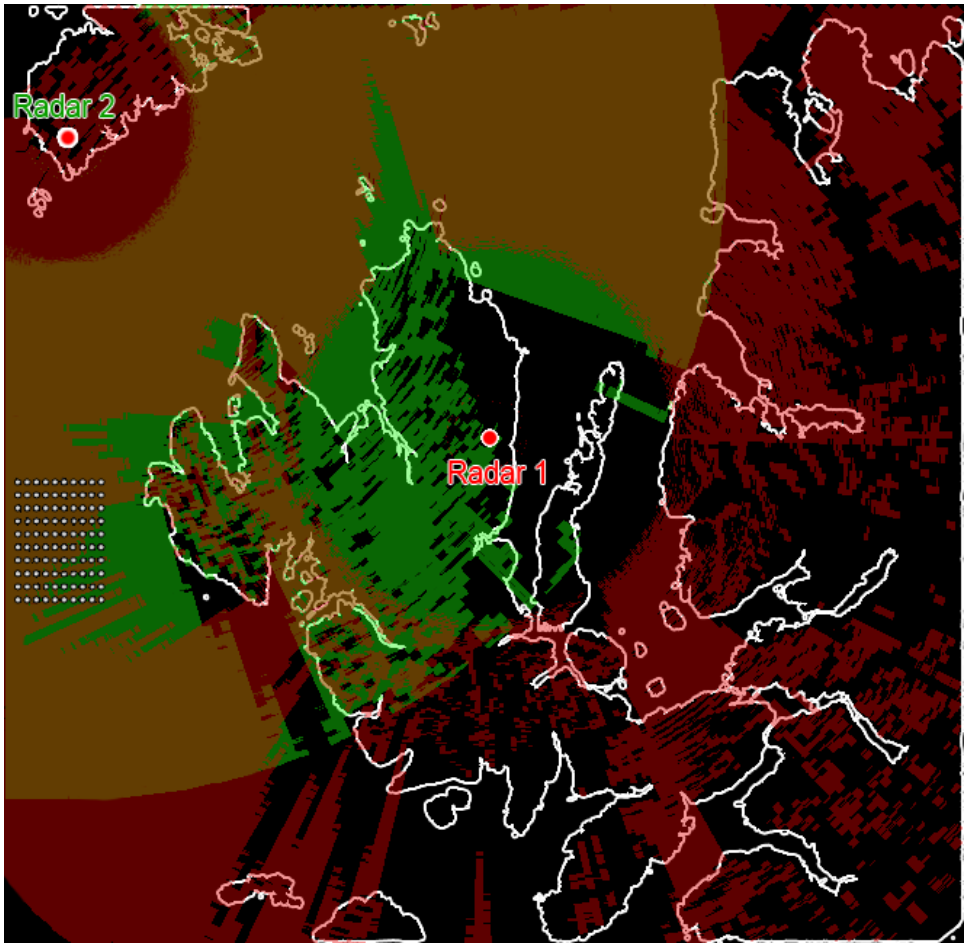
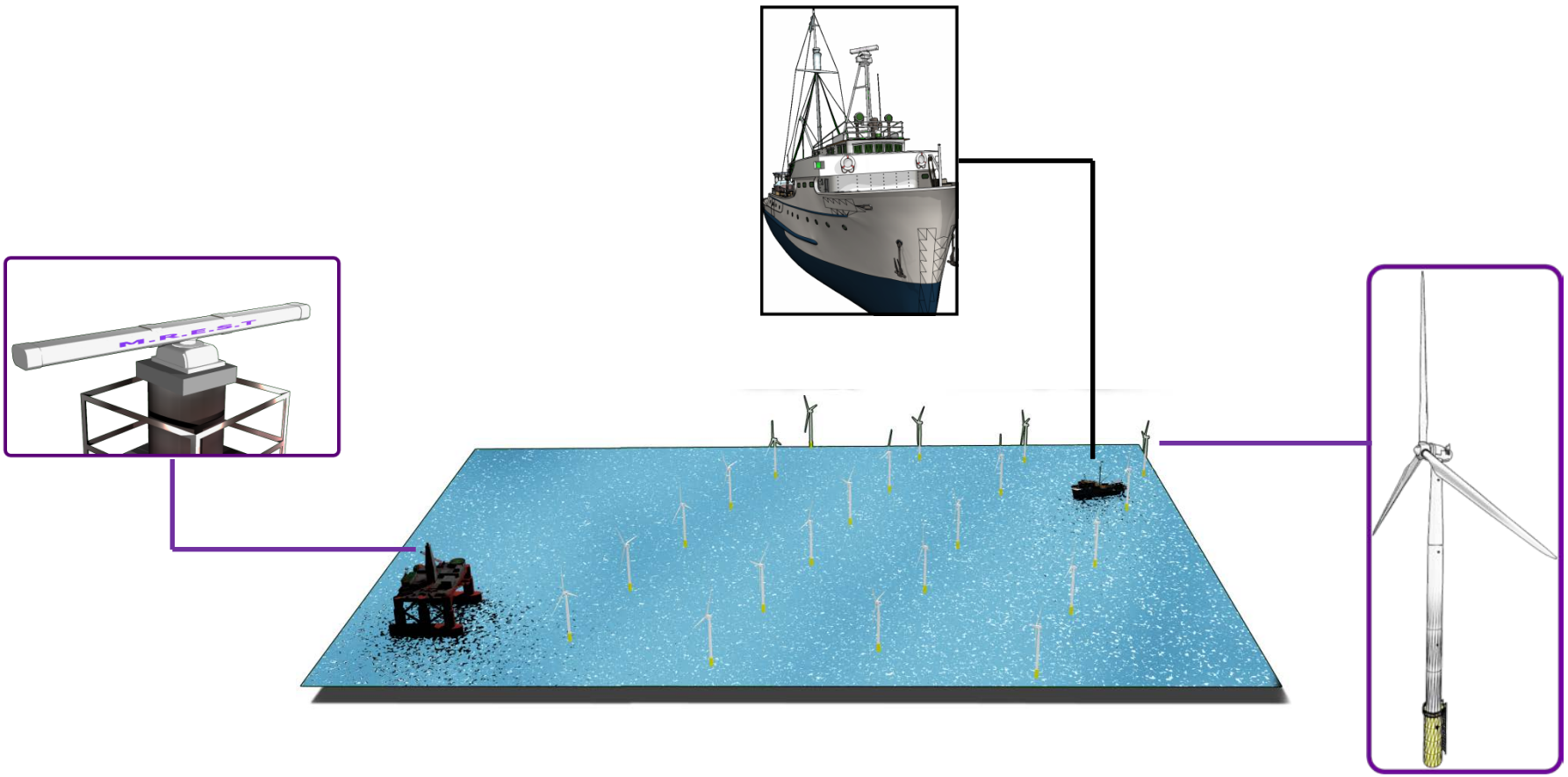
Study of Gap Filling (Netted) Radars



Radar Early Warning Systems (REWS)



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Radar Early Warning Systems (REWS)

- REWS are highly complex and highly automated systems that relay on detection and tracking vessels near offshore oil and gas platforms
- REWS are mainly used monitor and protect offshore assets from collision with errant vessels
- REWS are used to detect and track all vessels on the radar horizon.
- REWS has preset collision alarm rules.
  - Typically, an Orange alarm is raised if a collision course is detected with Closest Point of Approach (CPA) of 0.5 NM or Time to Closest Point of Approach (TCPA) of 35 minutes
  - Red alarm is raised if the CPA is 0.27 NM or TCPA is 25 minutes.
- Should a vessel breach these rules an automatic alarm is raised to alert the operator.
- REWS uses complex filtering, thresholding and tracking techniques.
- REWS may also integrate AIS data to complement radar data

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REWS vs Wind Farms : Potential issues

- The list of detected targets are transmitted to other assets including nearby Emergency Response and Rescue Vessels (ERRVs) via ultra high frequency (UHF) radio links.
- UHF links use a low-bandwidth telemetry system and have a limit on the total number of tracks that can be transmitted. Overly large targets list may need extended time to be transmitted and may cause untimely update of the radar feed.
- Degradation of target detection due to:
  - Shadowing
  - Target masking
  - Increased threshold
- Degradation of tracking performance due to the above and also due to the varying turbine returns which may generate false tracks.

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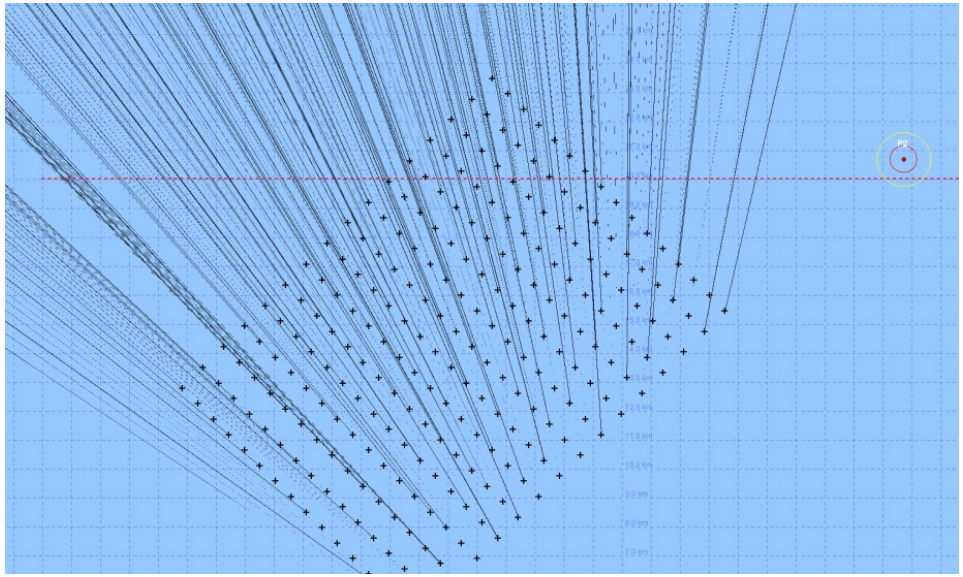
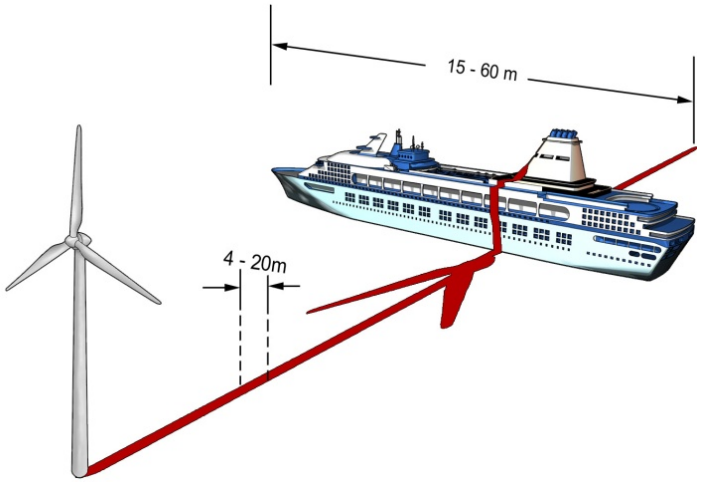
Modelling radar shadows for vessel detection

- Large vessels in excess of 1,000 Gross Tons (GT) are typically the main concern to the safety of the offshore platforms
- Vessels that are rated at 1,000GT and above can vary significantly in length (typically 15 – 60m).
- The length of the vessel is important to consider when assessing the effects of partial shadowing.
- A vessel with a length of 25m and RCS of 35 dBm^2 is considered.
- Partial shadowing may occur





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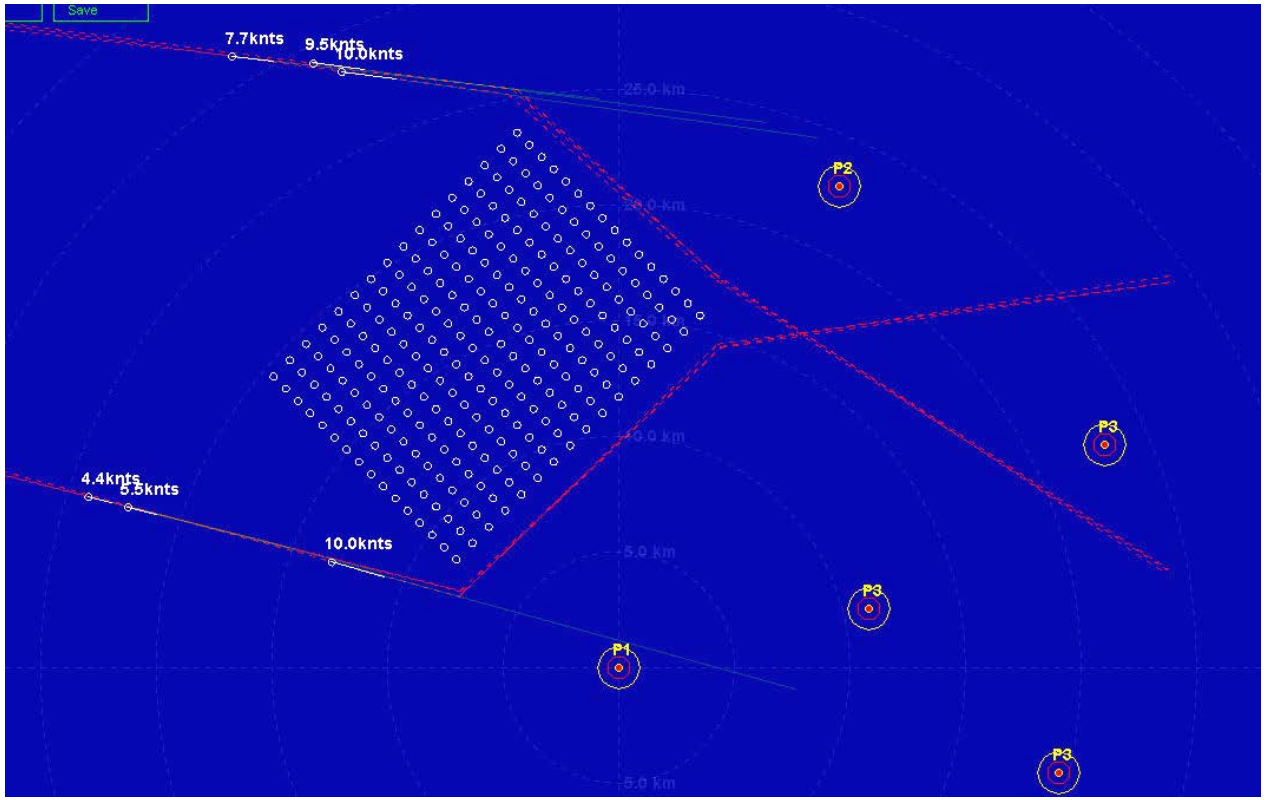
Modelling rerouted traffic around wind farms

- Once all the parameters are set for the radar and the wind farm, the models can then be used to assess the detection and tracking of vessels around the wind farm
- The effect of rerouting of traffic on the alarm rates can also be assessed



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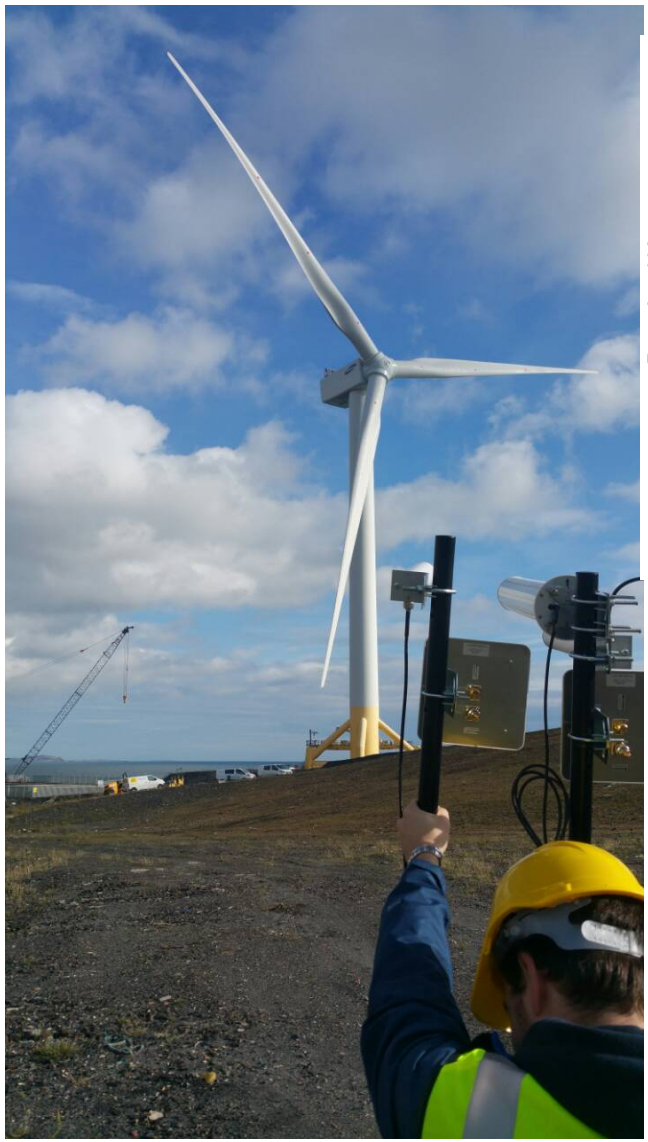
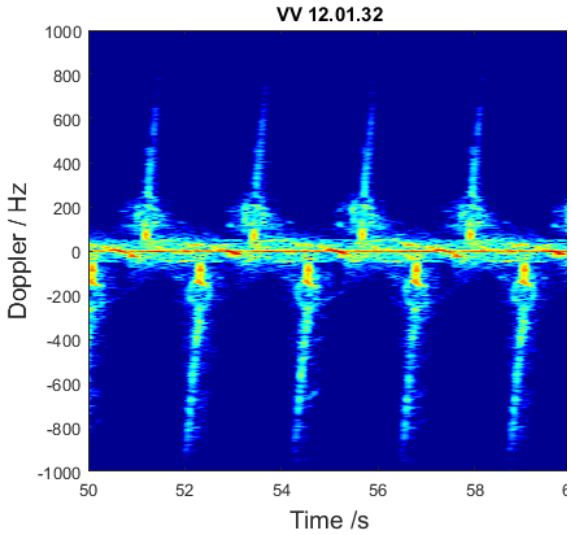
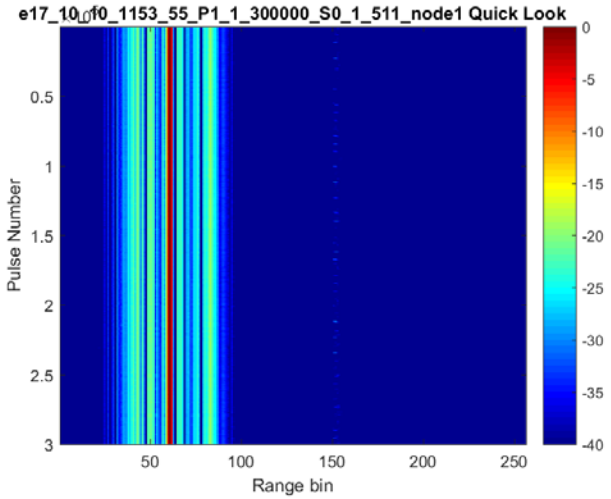
Large Offshore Turbine Scattering Measurements and Modelling







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Impact on Industry

- The research undertaken within the Supergen Programme has already been utilised in collaboration with industry to assess and resolve some of the radar concerns relating to new wind farm developments
- Such developments include
  - Wind farms near the Port of Liverpool.
  - the Morecambe bay region.
  - Hornsea Project in the North Sea.
- The research had a strong impact and ongoing collaboration in industry on real world radar related issues concerning the effects of wind farms on these radars.
- Furthermore, academic outputs on this topic won best propagation paper at the recent EUCAP conference, the leading European conference in antennas and propagation in recognition of the importance and quality of the research and its impact on industry.

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Modelling the Interaction Between Wind Farms and Radar Systems

Questions