Heckington Fen Wind Park Military Air Traffic Control Radar Position Statement

October 2018

Background

The Secretary of State for Energy and Climate Change granted consent for the Heckington Fen Wind Park on the 8th February 2013. The development comprises up to 22 x 125m tip wind turbines with a maximum installed capacity of 66MW. The consent is conditional on a Radar Mitigation Scheme (RMS) being agreed with the Ministry of Defence for primary surveillance radars at RAF Coningsby, Cranwell and Waddington. The current wording of the consent requires the RMS to be agreed before development commences and implemented before any turbines become operational. However, the MOD has agreed (when consulted by BEIS in March 2015) that the wording of Condition 5 of the Consent could be changed to "No construction of a wind turbine shall commence unless and until a Radar Mitigation Scheme has been submitted and approved", rather than "No development shall commence". This letter is included in Appendix 1.

During the course of 2015 – 2017 Ecotricity worked closely with the Ministry of Defence Wind Farm Team and a leading radar consultant/supplier to assess whether any currently available radar mitigation would satisfactorily address the concerns of the MOD. This work concluded that there were no solutions available at that point in time with a reasonable prospect of addressing the MODs concerns. Since this work was completed Ecotricity has been continuing to investigate alternative potential solutions which were not assessed during 2015-17.

Current Strategy

Since mid-2017 Ecotricity has been exploring the potential of 'stealth turbines' with the defence contractor QinetiQ. In sum incorporating stealth (radar absorbent material) into turbine blades can reduce the effects on radars by up to 90%. QinetiQ has successfully deployed this technology on a 35 turbine/96MW EDF site in France.

Stealth materials, either in isolation or in combination with another technology such as a wind farm filter on the radar, have the potential to deliver an effective RMS for Heckington Fen which is acceptable to the MOD.

Appendix 2 of this note is a report from QinetiQ providing further details of the stealth technology and its application. This information was presented to the MOD in January 2018 and consequently Heckington Fen has developed the following Programme.

Programme

A four stage programme is envisaged:

Phase 1 Feasibility (6 months): Modelling parameters and performance criteria for stealth turbines to be agreed between QinetiQ and the MOD (and/or their representatives). Study to be completed to establish if stealth turbine technology has the potential to reduce radar interference to such a level that additional mitigation is not required for Heckington Fen – (ideally no changes would be required to the MOD's infrastructure). If, however, it is concluded that further mitigation is still needed to meet the MOD's requirements, then the study will identify whether any other technologies could, potentially, in combination with stealth turbines, successfully address the MOD's objection. The study will ultimately determine whether there is sufficient evidence to suggest that a Phase 2A trial will be successful, and thus enable a commercial decision on progressing.

Phase 2A Stage 1 Trial (12 months): An initial trial designed to minimise the risk and cost of a full scale trial. This could involve stealth blades being fabricated by a turbine manufacturer to a specification from QinetiQ and then being installed on an operational site such as Ecotricity's Enercon turbine near Swaffham (Swaffham II – 85m hub, 34m blade and tip height of 119m). QinetiQ and the MOD could then evaluate the performance of the blades (and any other elements of the turbine treated with radar absorbent materials) against the RAF Marham Air Traffic Control Radar (either the existing Watchman or the replacement Thales Star NG). If necessary additional mitigation (such as an Aveillant holographic infill radar or a Thales wind farm filter) to remove any unacceptable residual radar returns could also be trialled.

Phase 2B Stage 2 Trial (12 months): Depending on the success of Phase 2A, Phase 2B may require the full scale testing of stealth blades (and if necessary additional radar mitigation) on a wind farm and radar(s) representative of the Heckington Fen site or, if acceptable to the MOD, on Heckington Fen. It could be that this is undertaken incrementally with one turbine being tested at a time.

Phase 3 Implementation (12-18 months): Any required radar mitigation is fully implemented and signed off by the MOD, having followed a full 'release into service' process. At the end of Phase 3 it is expected that the MOD will confirm that the RMS has been successfully implemented enabling the turbines to become operational in compliance with Condition 6 of the 2013 consent. In addition a lifetime maintenance and monitoring programme will need to be agreed to ensure that the stealth technology (and, if required, any additional mitigation) continually performs to agreed standards. Phase 3 is expected to run either fully or partially concurrent with Phase 2B.

Appendix 1

Defence Infrastructure Organisation

[redacted] 7RL

Telephone [MOD]: [redacted]
Facsimile [MOD]: [redacted]
E-mail: [redacted]

Your Reference: Heckington Fen Wind Farm

Our Reference: [redacted]

[redacted]
Department of Energy & Climate Change

20th May 2015

Dear [redacted]

Heckington Fen Wind Farm

<u>Electricity Act 1989 Section 36 (as amended) ("the Act")</u>
<u>Town and Country Planning Act 1990 Section 90 (as amended) ("the Section 90 direction")</u>

Thank you for consulting the Ministry of Defence (MOD) on the application made on behalf of Ecotricity (Next Generation) Limited to vary the consent in respect of the Heckington Fen Wind Farm in your communication dated 26th March 2015.

In light of the proposed variations to the existing consent, the MOD has reassessed the application and has no objection to the following variations:

Condition 1.

> Amend the turbine rotor diameter from 90m to a maximum rotor diameter of up to 103m and allow a 10 meter radius micro-siting allowance around each turbine location where onsite constraints allow, as set out in Figure 3.1;

Condition 5. Amend the wording of the condition to read:

> "No construction of a wind turbine shall commence unless and until a Radar Mitigation Scheme has been submitted to and approved in writing by the Secretary of State, having consulted with the Ministry of Defence and NATS (En Route) plc, to address the impact of the wind farm upon air safety"; and

Condition 7.

> Amend the wording of the condition to remove the words "shown on Figure 4.1" at the end of the second sentence.

In respect of the variation proposed to Condition 5, it should be noted the MOD has commenced discussions with Ecotricity (Next Generation) Limited regarding radar mitigation and it is understood that all parties are in agreement regarding the requirement for mitigation. It is on this basis that the MOD has no objection to the proposed variation to Condition 5.

The MOD has no comment to make on the remaining variations proposed.

The application is for up to 22 turbines at a maximum overall height of 125 metres to blade tip. This has been assessed using the grid references below as submitted in the application.

Turbine	100km Square letter	Easting	Northing
1	TF	19572	46370
2	TF	19586	46048
3	TF	19600	45643
4	TF	19920	45963
5	TF	19933	45564
6	TF	19983	45205
7	TF	20210	46312
8	TF	20237	45901
9	TF	20257	45556
10	TF	20260	45116
11	TF	20622	46522
12	TF	20609	46171
13	TF	20631	45770
14	TF	20597	45416
15	TF	20596	45008
16	TF	20981	46391
17	TF	20979	46055
18	TF	21052	45766
19	TF	20933	45357
20	TF	20902	44899
21	TF	21420	45863
22	TF	21297	45450

I hope this adequately explains our position on the matter. If you require further information or would like to discuss this matter further please do not hesitate to contact me.

Yours sincerely

[redacted]

[redacted]

Defence Infrastructure Organisation

SAFEGUARDING SOLUTIONS TO DEFENCE NEEDS

Appendix 2

QinetiQ Stealth Wind Turbines (SWT) and Air Traffic Control (ATC) Radars

[redacted]

February 2018

Requests for wider use or release must be sought from:

[redacted]
QinetiQ
Malvern Technology Centre
Malvern, Worcestershire
WR14 3PS

Should this document be translated into any language other than English, it should be translated in its entirety to maintain integrity and context. For the avoidance of doubt, the English version should also always be provided as the technical source document with any translated version.

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1 Introduction

1.1 Scope

This technical memo summarises the QinetiQ Stealth Wind Turbine (SWT) technology and discusses the benefits for Air Traffic Control (ATC) radars.

1.2 Background

Wind Turbines have the potential to impact on the operation of radar systems. The impacts include static and Doppler radar clutter, ghost targets, saturation and shadowing. It is assumed the reader is familiar with the impacts and potential solutions.

QinetiQ has developed Stealth Wind Turbine (SWT) technology that reduces the magnitude of radar echoes. The technology has been proven at the 96MW Catalan wind farm, where QinetiQ SWT is used to mitigate the impact of the turbines on an S-band (2.8GHz) weather radar [1][2].

Stealth will also reduce the impacts on other radar systems, either by itself or in combination with other technologies.

2 Slides: QinetiQ SWT summary

QinetiQ Stealth Wind Turbine Technology Summary

Vince Savage and Thierry Le Gall

February 2017

QINETIQ/18/00577/2.0

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QinetiQ

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Introduction to QinetiQ Group

- Provide technology-based services and solutions to the defence, security and aerospace markets
- Provision of technology insertion and consultancy services to commercial and industrial customers around the globe
- The UK's largest research and technology organisation

Our vision: "To be the chosen partner around the world for mission-critical solutions, innovating for our customers' advantage"

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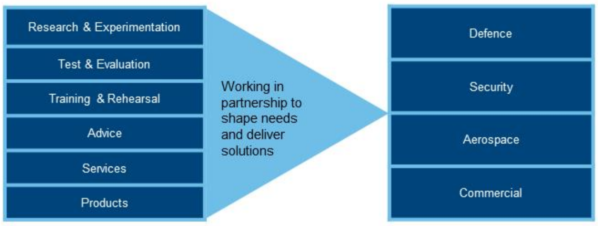
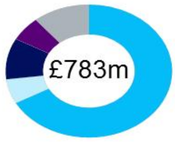
QinetiQ Overview



Delivering Customers' Advantage

Over 6250 employees, across 85 sites

UK and International Footprint



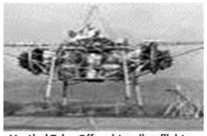
Revenue year ending March 2017

QINETIQ

Our Heritage – A History of innovation

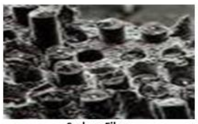
Former Research & Development Agency of the UK Ministry of Defence

Thermal Imaging

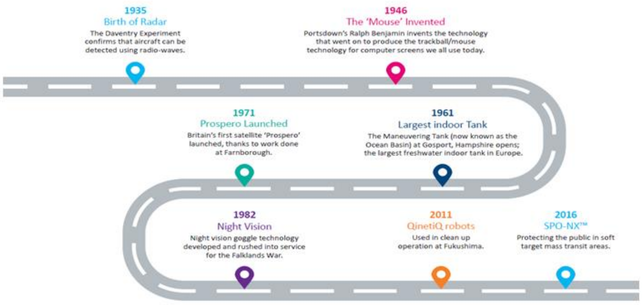


Vertical Take Off and Landing flight

Liquid Crystal Display



Carbon Fibre



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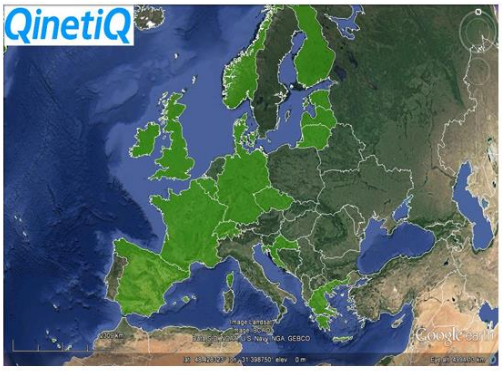
QinetiQ Radar Impact Assessment (RIA)

- Since 2002…
  - 600+ studies
  - 200+ customers
  - Research, consultancy, solutions
- 26 countries
  - Mainly Europe
  - Also United States, Canada, New Zealand, and South Africa



- Customer include wind farm developers, turbine manufacturers and radar stakeholders
- Systems studies include weather radars, Air Traffic Control radars, navigation aids, telecommunication links

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QinetiQ SWT technology

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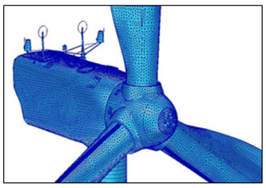
QinetiQ Stealth Wind Turbine (SWT) technology

- Technology allows wind turbines to be built within areas currently restricted due to objections by weather, airport or military radar operators
- Lightweight , minimal impact on mechanical performance and easily integrated in composite structures
- Patented technology and well established material supply chain
- Proven technology - World first stealth wind farm in operation since June 2016 (EDF EN project– 35 stealth turbines, 96MW)

Modelling software



Design tool and Simulation (CLOUDSiS and StealthSiS)

Stealthy blade / nacelle / nose cone and hub

Lay-up of Structured Radar Absorbing Materials (SRAM) inside structure

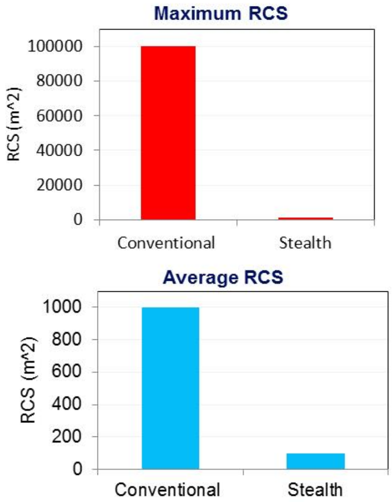
Stealthy Tower

Covering outside of tower with tiles with RAM

Proven track record of QinetiQ SWT technology

- World's first stealthy wind farm successfully opened in June 2016 by EDF, using QinetiQ's stealth technology
- 96 MW
- 35 turbines (Vestas V90 and V80)
- Near weather radar (S-band 2.8 GHz)
- Confirmed modelling results by over 450 measurements using QinetiQ's portable Multiband Pulse Radar

More than 90 % reduction of radar impact



99 % reduction of maximum Radar Cross Section
90 % reduction of average Radar Cross Section

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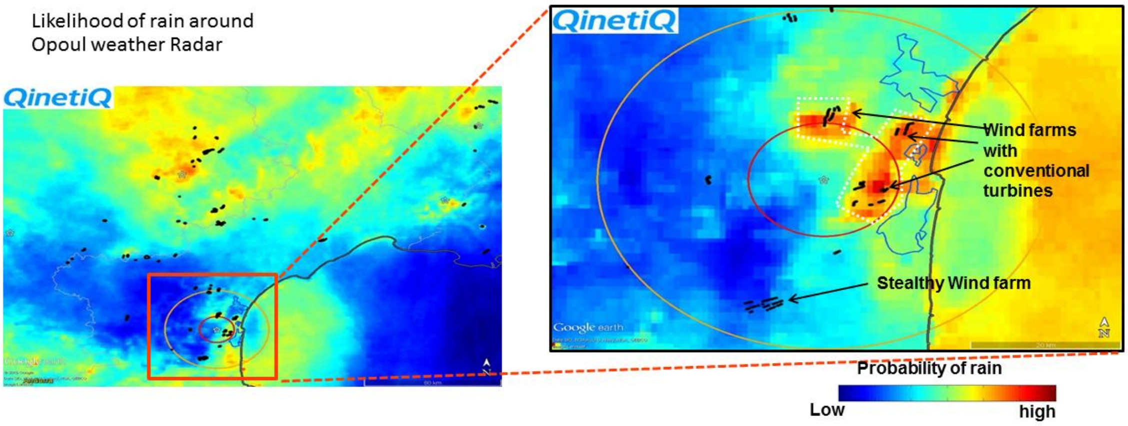
Impact on radar : conventional vs. stealthy turbine

Likelihood of rain around
Opoul weather Radar



Stealthy wind farm : no obvious effect on radar data
Conventional wind farms: **likely impact** on radar data

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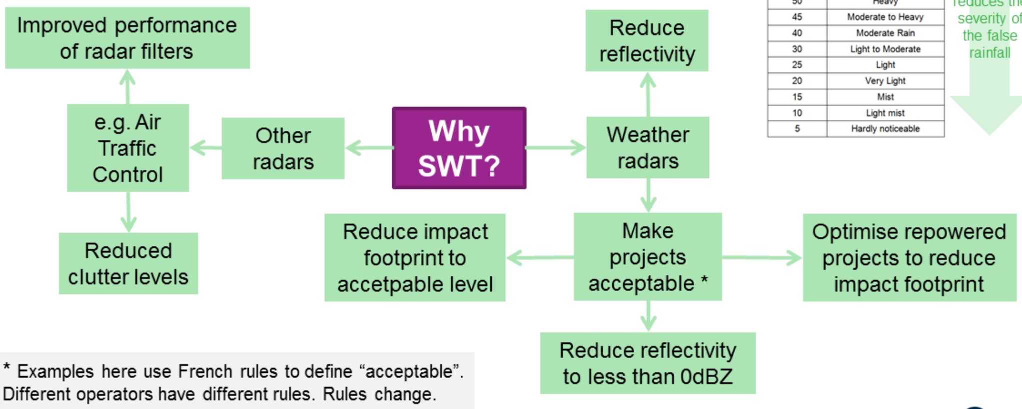
SWT Benfit Summary

Reflectivity (dBZ)	Rainfall description
65	Extreme / Large Hail
60	Extreme Moderate Hail
55	Very Heavy / Small Hail
50	Heavy
45	Moderate to Heavy
40	Moderate Rain
30	Light to Moderate
25	Light
20	Very Light
15	Mist
10	Light mist
5	Hardly noticeable

SWT reduces the severity of the false rainfall



* Examples here use French rules to define “acceptable”. Different operators have different rules. Rules change.

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Wind Farm Impact on Radar Data: Example Ecotricity

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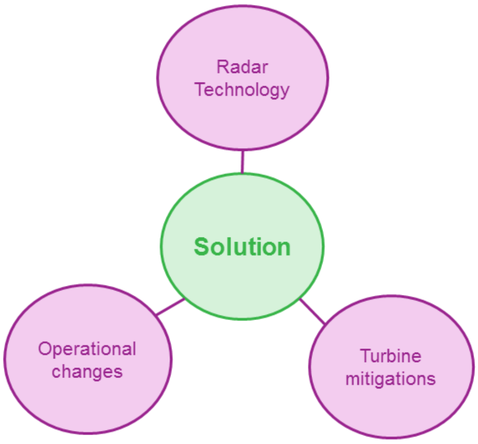
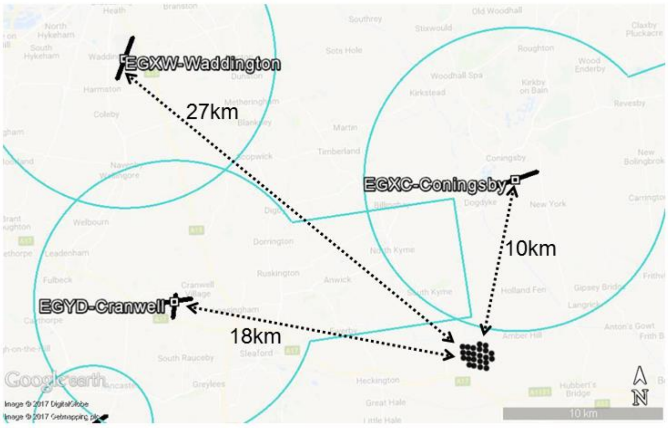
Discussion

- “You can please some of the people all of the time, all the people some of the time, but not all the peaople all of the time” *Abraham Lincoln*
- The same is true of radar mitigation
  - Can mitigate some radar impacts all of the time
  - Can mitigate all radar impacts some of the time,
  - But we cannot mitigate all radar impacts all of the time.
- There is no ‘silver bullet’. The radar and renewable industries have been looking for a long time.
- Sometimes a combination of technnologies is required…



East Heckington

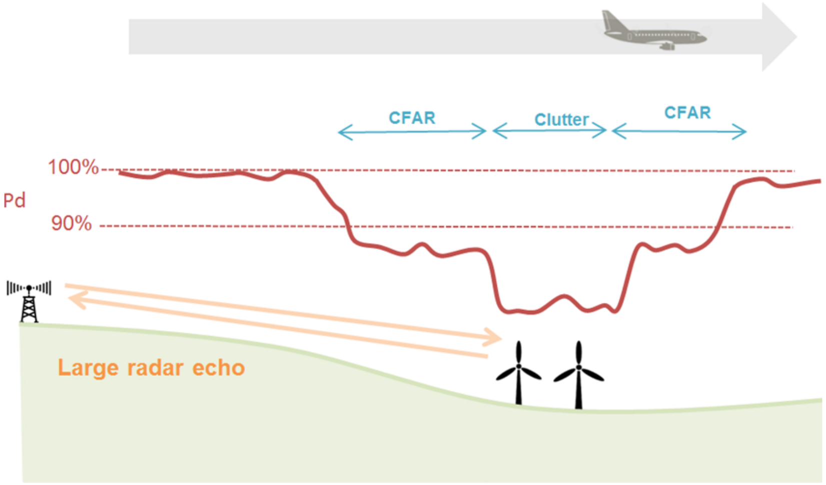
- Aquila report [1]
  - “*Aquila has examined the technical mitigations available and concluded that there are no solutions available that could be implemented in a timeframe prior to the replacement of the current BAE Systems Watchman PSRs at Coningsby, Cranwell and Waddington that can meet the requirements of ‘no derogation in performance’.*
  - *Furthermore, Aquila has examined the technical mitigations available and concluded that, at this moment in time, there are no Enduring Solutions available that will fully mitigate the effects of the onshore windfarms as well as meeting the Marshall requirements*



[1] Aquila, *Windfarms Phase 1 Scoping Study, Heckington Fen Onshore Windfarm Final Report*, AQUILA 3259, February 2017

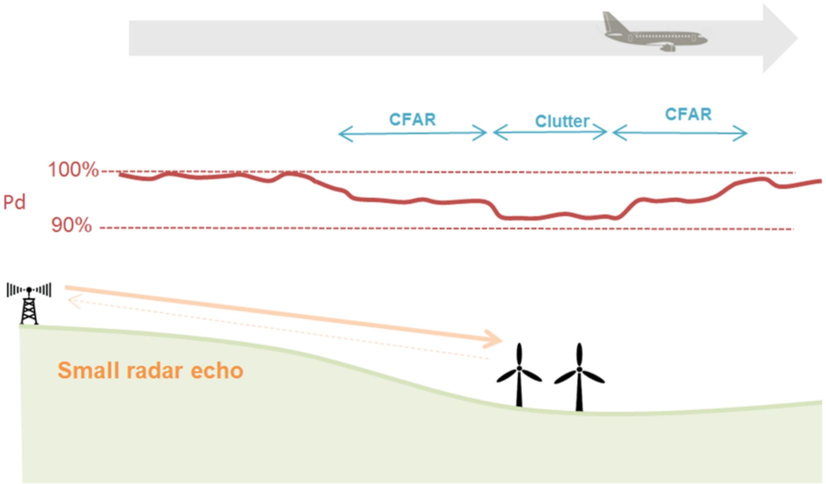
Current best solution

- Aquila assessed curent technical solutions (radar, filters, infill…)
- No solution considered is good enough
- Pd shown here as figure of merit. There are several others.



Current Best solution & stealth?

- Benefits of stealth not yet assessed
- Figure shows the **potential** benefit of stealth



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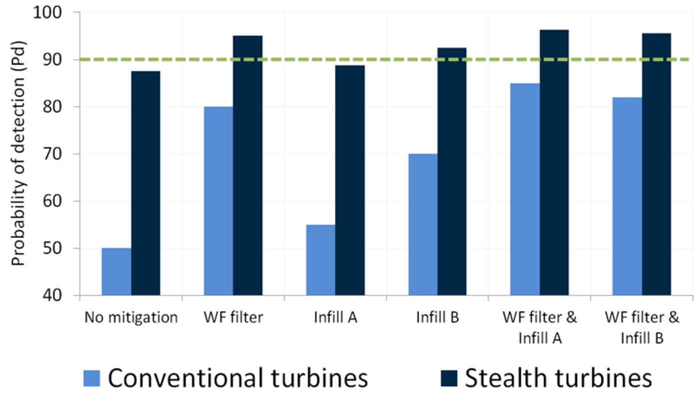
East Heckington next steps?

- Reassess the radar solutions using SWT values
- Radar solution + SWT has the potential to find one or more acceptable solutions
- How far away from acceptable are the existing radar solutions?



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3 Discussion points

3.1 Polarisation

The Catalan SWT solution was designed to have low azimuthal variation to ensure similar performance as the blades rotate. The solution is expected to have similar performance for linear and circular polarisations. The majority of Meteo France weather radars are now dual (linear)-polarisation.

3.2 Change in performance for ATC filter

Different parts of a wind turbine move at different speeds. This is a result of the orientation of the yaw axis (vertical axis) relative to the radar, and because the blade tips travel faster than the near-stationary hub (horizontal axis). Accordingly, radar reflections from a wind turbine will have a spread of Doppler frequencies.

Weather and ATC radars use moving target identification (MTI) and detection (MTD) techniques to discriminate between moving and stationary targets. Weather radars use MTI/MTD to eliminate echoes from the ground and to understand the motion of precipitation; ATC radars use MTI/MTD to separate aircraft echoes from the ground echoes.

For purpose of discriminating between stationary and moving targets, weather radars commonly use a narrower filter than ATC radars. This is because aircraft typically move faster than precipitation. Representative processing [A] of measurements of the Catalan turbines showed improved performance for an ATC filter for the Doppler (moving) RCS. However, the increased filter width means an increased static RCS.

In summary, the change in performance is not trivial, depending on the Doppler processing applied (depth of cancellation, number and width of filters). However, the SWT performance is considered to be comparable or slightly better for ATC radars, in respect of the generally wider filter width.

3.3 Long-term performance

Long term testing has been carried out on circuit analogue (CA) radar absorbing materials (RAM) comparable to the Catalan solutions, and demonstrated no significant performance degradation. The QinetiQ SWT solutions do not modify the external blade surface materials or shape.

3.4 Rain and ice

Testing showed that in normal operational conditions, where rain water is shed quickly from the blade, there is a low impact on stealth performance of the S-band SWT solution.

Frost is judged unlikely to impact the performance of an S-band solution.

Significant build-up of ice will de-tune the performance of the SWT designs and affect the performance. It is understood that significant accumulation of ice will change the weight and aerodynamics of blades and turbines will be generally be stopped in these circumstances. A detailed analysis of the impact of operationally-

[A] The processing assumed a ±10Hz filter to reject stationary echoes for a weather radar, and ±140Hz for the representative ATC radar. A clutter improvement factor of 30 dB was assumed for both radars.

expected ice on blade RCS has not been carried out, but would be relatively straightforward.

3.5 Bandwidth of the solution

Bandwidth refers to the range of frequencies over which the specified stealth performance applies. Large reductions (e.g. 30dB) will apply over a relatively narrow bandwidth; smaller reductions (e.g. 10dB) apply over a larger bandwidth.

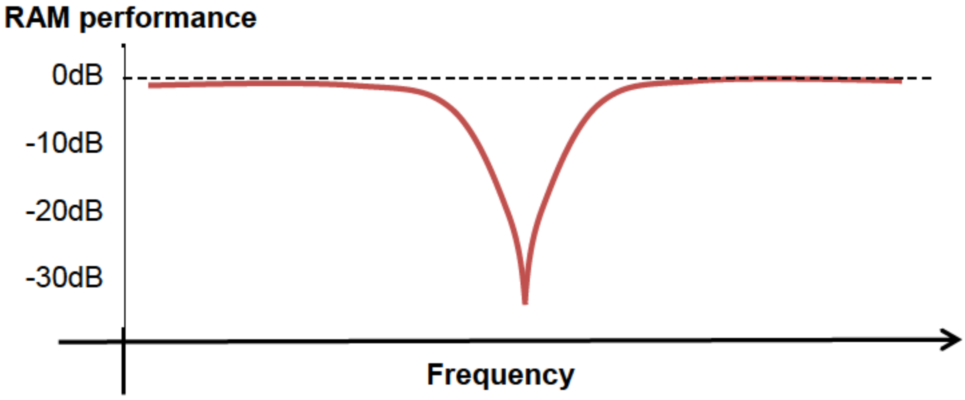

Figure 3-1: Illustrative performance for one SWT design

The QinetiQ SWT solution typically comprises several different design solutions across the blade. Each design is tuned to give the desired performance, trading off depth of the null against bandwidth.

The Catalan solution was optimised at the Opoul radar frequency of 2.805 GHz. Measurements of the installed turbines were made at 2.805 GHz, 2.828 GHz and 3.12 GHz. The RCS performance degradation was approximately 2dB at 3.12 GHz.

4 References

[1] EDF, Ensemble Eolien Catalan, URL: https://www.edf.fr/en/edf/edf-group-commissions-france-s-most-powerful-wind-farm-the-ensemble-eolien-catalan-facility

[2] The Telegraph, Blown over: QinetiQ baffles radar with 'stealth' wind turbines, URL: http://www.telegraph.co.uk/business/2017/01/01/blown-qinetiq-baffles-radar-stealth-wind-turbines/