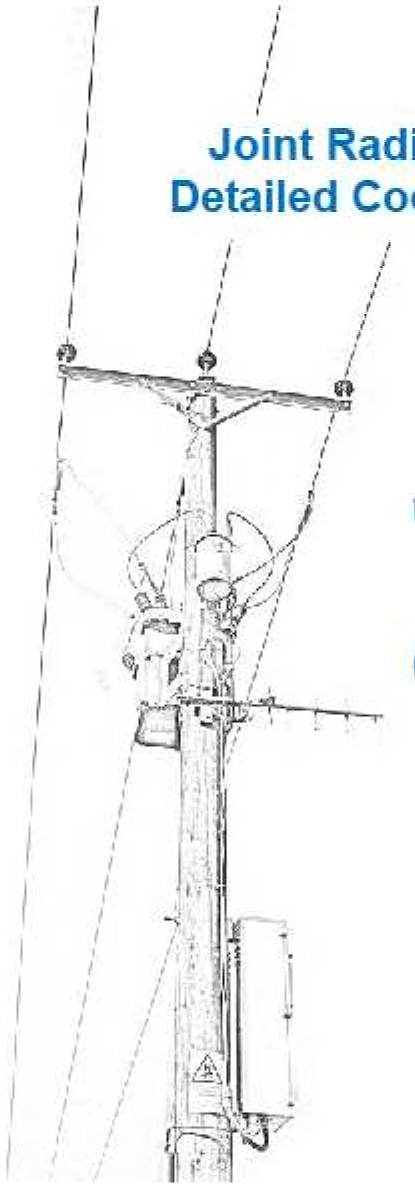
APPENDIX 13.1: JRC DETAILED COORDINATION REPORT

joint radio company

jrc

2010W0056EON



Joint Radio Company Ltd
Detailed Coordination Report

for Ecotricity
regarding a proposed
wind farm at
Heckington Fen
Lincolnshire
with respect to the radio
infrastructure of
EON
(Central Networks East)

October 2010

ACM UKAS QUALITY MANAGEMENT

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JRC is a wholly owned joint venture between the UK electricity and gas industries specifically created to manage the radio spectrum allocations for these industries used to support emergency and safety critical operations. JRC also represents gas and electricity interests to government on radio issues.
<www.jrc.co.uk/about.shtml>

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1 Executive Summary

(1) This report presents the results of an investigation into the effect of building a wind farm at Heckington Fen, Lincolnshire, on regulated radio links operated by EON (Central Networks East)

(2) The report concludes:

- That the proposed wind farm layout is predicted to reduce the availability of the EON link below that required when using either the JRC, or ITU-R BT805 methods of calculation and that mitigation options should be sought.

(3) It is considered that the influence of wind turbines on UHF telemetry and microwave links is sufficiently well understood to have confidence in the predicted effects.

(4) The report recommends:

- That Ecotricity should continue to liaise with EON and JRC whilst the wind energy development at Heckington Fen is being planned. This will enable them to understand any plans regarding their radio networks and if they have any future radio systems planned that would be affected by the wind farm. That the best options to mitigate the affected links are:
- To scan the affected sites at Holme Farm PMR from the alternative base station at Londonthorpe at an estimated cost of £10,000.

  Note: This option would be subject to a site and radio survey to establish the validity of the paths.

  OR:

  - To use GSM/UMTS as the data bearer at an estimated maximum cost of £7,500.
- That this report should be shared with EON to establish their opinion regarding this report as the final decision regarding removal or continuation of their objection resides with them.

(5) It must be stressed that all predictions have been made on the basis of best available data but, since there has been little practical work to investigate the precise nature of the effect of wind turbines on radio systems of interest to this report, the results are subjective.

(6) Due to the number of unknown variables involved it is not practical to consider the interference scenarios that will be created during the construction phase of the wind farm project, in particular the influence of any scaffolding or tower cranes used for construction.

2 Background

(7) The potential adverse effect of large inanimate structures on radio propagation is relatively well understood, and a number of sophisticated modelling tools exist to predict the effects. Wind farms will create a similar effect due to their physical bulk but raise new issues because of the large rotating elements, the effect of which is currently poorly understood.

(8) The majority of work reported in the public domain relates to interference to UHF television reception. There has also been a substantial amount of concern regarding potential interference to radar navigation systems, but much of this work is not in the public domain. Studies of the effect of wind farms on domestic TV reception have been conducted in mainland Europe. It is likely that these effects are observed in TV Band III (200 MHz) as well as the UHF bands (470-862 MHz) used in the UK.

(9) JRC, as the radio spectrum manager for the UK gas and electricity industry, is uniquely placed to investigate the potential impact of proposed wind farm developments, being experienced in radio engineering associated with operational radio systems used by the utilities, and also a part of the energy sector and therefore committed to finding solutions to the problems posed by this new energy source.

(10) JRC has undertaken similar studies for other wind farm developers, which have resulted in detailed mitigation proposals that have been agreed by all interested parties.

(11) The utility radio services that are potentially affected by the construction of wind farms are:

- Private Mobile Radio Systems operating in VHF and UHF frequency bands;
- Telemetry and telecontrol systems operating in the VHF and UHF bands; and
- Fixed microwave radio links
- In the context of the proposed wind farm development at Heckington Fen, JRC in this report has assessed the impact on the licensed telemetry radio systems used by EON.

3 The Heckington Fen Wind Farm

(12) The proposed development at Heckington Fen has been revised; it will have twenty eight turbines with a maximum 82m rotor diameter and maximum 85m hub height, giving a maximum blade tip height of 126m.

(13) The turbine layout as currently proposed is within coordination distance of radio systems operated by EON. The turbine locations used for compiling this report can be seen below.

Table 3.1: Turbine locations (British National Grid)

Turbine	Easting	Northing
1	520598	346257
3	519616	346033
4	519443	345675
5	519604	345471
6	519892	346338
7	519914	346012
8	519939	345704
9	519939	345402
10	520046	345164
11	520204	346354
12	520232	346033
13	520352	345770
14	520258	345025
15	520372	345438
16	520550	346549
17	520868	346581
18	521372	345578
19	521009	346372
20	520721	345968
21	521149	346154
22	520710	345618
23	521061	345817
24	521392	345896
26	521039	345505
27	520696	345310
28	520526	344960
29	520869	345049
30	521211	345231

(14) The wind farm development had been highlighted by Ofcom for coordination. EON had requested JRC coordinate the proposed wind energy development with their radio network. The coordination process indicated that there may be a problem and consequently an objection was raised.

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4 Radio systems affected

(15) For utility operations, there are three main classes of operational services that might be affected.

Microwave fixed links:
used for point-to-point communications over low-density traffic routes, for hard to reach locations, and for resilience as alternative routing to a wired connection. These typically operate in frequency bands of 1.4/1.5 GHz, 5 GHz, 7.5 GHz, 13/14 GHz, 24 GHz, 38 GHz and 58 GHz. They employ a variety of digital modulation techniques.

Scanning Telemetry and Telecontrol links:
used for point to multi-point communications, almost exclusively using equipment complying with OfW49/VNS2111 in the UHF 450-470 MHz band (although increasingly using the 140 MHz band as well).

Private Mobile Radio (PMR):
for communications with mobile (vehicle mounted) units and to a lesser extent hand-held radios. For the electricity industry, these systems usually operate around 140 MHz and employ MPT1327 trunking protocols.

(16) This report pertains to potential interference caused by the wind farm to licensed utility radio link systems within the coordination zone operated by EON.

4.1 Exclusions

(17) This report does not address the implications of this wind energy development on other types of communications systems used by utilities.

5 The study

(18) It was agreed that JRC would produce a study comprising of the following elements:

Undertake: a detailed study and survey into the existing radio communication infrastructure and locations within the area of the wind farm to confirm the data for the services operated by EON.

Review : the theoretical analysis of the proposed wind turbine layout on the licensed radio systems and in doing so identify the exclusion zone for the affected radio infrastructure.

Liaise: with Ecotricity Ltd to present the above.

6 Mechanisms by which wind farms may affect radio transmissions

(19) It may be helpful to consider the effects of wind turbines on radio transmissions under three main headings:

Obstruction:
Physically obstructing the direct radio path, attenuating the received signal.

Diffraction:
Because of the wave-like nature of a radio signal, large structures close to the radio path but not physically obstructing it can cause interference patterns to be generated, generally referred to as Fresnel Zone interference.

Reflection/Scattering:
where the radio waves are reflected or scattered off a large structure and interfere with the wanted signal.

(20) The sensitivity of a particular radio service to interference will depend on a number of radio parameters, including the frequency, modulation (some modulation types and coding schemes are designed to be more resilient than others) and the polarisation of the radio signal.

(21) The intensity of the effect on radio signals will depend on a number of the details of the construction of the turbine. This will include the materials used in the construction of the tower, nacelle and blades, particularly whether metallic, or incorporating metallic components. At certain radio frequencies, the propensity of the material to absorb surface water may also be significant. Although the overall size of the wind turbine will have an impact on its ability to cause interference, previous studies highlight the possibility of some elements of the wind turbine resonating at frequencies used in practical communications systems, giving rise to non-linear scaling factors.

(22) Wind turbines create a number of unique factors, not associated with other large structures. The turbine will offer a multiplicity of profiles, depending on:

- The speed of rotation of the blades
- The angle the blade subtends to the shaft (pitch)
- The angle the nacelle subtends (yaw)
- Moisture retention or icing of the turbine blades.

(23) Wind turbines pose particular problems for radio transmissions as the turbines tend to occupy the high ground also used by the radio infrastructure, and their size implies that they offer radio interference paths that may be superior to the designed radio path profile.

(24) A full explanation of the method JRC uses to undertake an assessment of the impact a proposed wind turbine/farm may have on the radio infrastructure can be found on the JRC web site, www.jrc.co.uk/windfarms/.

7 Theoretical analysis

(25) The objection to this proposal was raised by JRC and EON as it was thought that one UHF Telemetry links may be affected. The verified location of the link to be coordinated can be seen below.

Table 7.1: The EON telemetry link within the coordination zone

JEEMQS1	BOSTON	532091 343929	JEEMQO26	HOLME FARM SK PMR	517073 345624

(26) JRC, as the licence holder for all Gas and Electricity telemetry links, coordinates links that pass within 1 km of a proposed industrial sized (>30m rotor diameter) wind energy development if below 1 GHz and 500m if above. The criterion is that the assigned availability of a link should not be degraded by any wind farm development.

(27) The wind farm coordination carried out within this document follows the methods set out in the JRC paper "Calculation of The Clearance Zone" [1]. JRC uses this for calculating the clearance zone for 460 MHz telemetry links, when turbine sizes and locations are accurately known. This is a modified version of the Ofcom David Bacon paper "Fixed-link wind-turbine exclusion zone method" [2], which doesn't specifically address UHF and obstructed paths (see below). Both methods specify the method of calculating diffraction clearance and the generally overlooked reflection clearance zones. This report also takes into consideration the latest Ofcom paper "RF Measurement Assessment of Potential Wind Farm Interference to Fixed Links and Scanning Telemetry Devices" [3].

(28) The primary difference between the first two methods is in the calculation of the reflection clearance. The Ofcom method was primarily intended for microwave fixed links above 3 GHz and assumes free-space-loss on all paths. Lower frequency links are not always in free-space, so JRC uses predicted losses for all paths within the same equation. The diffraction loss used is fundamentally the same in both methods.

(29) JRC employs several aids to wind farm coordination. These are:

- A MapInfo-based wind farm coordination GIS, specially developed by JRC;
- ICS Telecom, a professional radiocommunications planning tool developed by ATDI;
- Terrain height databases: Primarily an Ordnance Survey 50 metre dataset, which is cross-checked using NASA shuttle-derived data.
- The propagation algorithms used are from ITU-R P.525 and P.526.

Note:

Computer radio predictions have a finite accuracy limited by the algorithm employed, the accuracy of the terrain-height database and the clutter layers used. The inaccuracies are normally larger where antennas are employed within a clutter layer in an urbanised area. If the calculated Wanted-to-Unwanted (W/U) ratio is marginal then reference is made to ITU-R BT805, which is used for analysing television interference.

(30) The wind turbine layout showing the UHF telemetry link can be seen below.

Figure 7.1: The affected links in relation to the proposed turbine

7.1 UHF telemetry link diffraction clearance (Fresnel interference)

(31) The criterion used by the JRC and agreed by the industry is that no part of a turbine should enter area defined by the 0.6 Fresnel zone of the link. To this is added a buffer zone to allow for location inaccuracy of the link ends and turbine construction and ellipsoid conversion anomalies. In this case 25m has been used. An allowance for micrositing must be included. In this instance JRC was advised that the maximum would be 50m.

(32) The diffraction clearances for the turbines within coordination distance can be seen below.

Table 7.2: Two-dimensional diffraction clearance data

461 MHz								Clearances	
Link ID	Site	Turb	Blade rad	Microsite	from path	0.6 FZ	Buffer	Basic	+ B+M
JEEMQO26	Heckington Fen	1	41	50	1024	32	25	951.0	876.0
JEEMQO26	Heckington Fen	3	41	50	691	28	25	622.0	547.0
JEEMQO26	Heckington Fen	4	41	50	316	28	25	247.0	172.0
JEEMQO26	Heckington Fen	5	41	50	132	29	25	62.0	-13.0
JEEMQO26	Heckington Fen	6	41	50	1026	29	25	956.0	881.0
JEEMQO26	Heckington Fen	7	41	50	704	30	25	633.0	558.0
JEEMQO26	Heckington Fen	8	41	50	401	30	25	330.0	255.0
JEEMQO26	Heckington Fen	9	41	50	101	30	25	30.0	-45.0
JEEMQO26	Heckington Fen	10	41	50	124	31	25	52.0	-23.0
JEEMQO26	Heckington Fen	12	41	50	761	31	25	689.0	614.0
JEEMQO26	Heckington Fen	13	41	50	513	31	25	441.0	366.0
JEEMQO26	Heckington Fen	14	41	50	239	31	25	167.0	92.0
JEEMQO26	Heckington Fen	15	41	50	185	32	25	112.0	37.0
JEEMQO26	Heckington Fen	18	41	25	437	34	25	362.0	312.0
JEEMQO26	Heckington Fen	20	41	50	751	33	25	677.0	602.0
JEEMQO26	Heckington Fen	21	41	50	984	34	25	909.0	834.0
JEEMQO26	Heckington Fen	22	41	50	402	33	25	328.0	253.0
JEEMQO26	Heckington Fen	23	41	50	639	34	25	564.0	489.0
JEEMQO26	Heckington Fen	24	41	25	755	34	25	680.0	630.0
JEEMQO26	Heckington Fen	26	41	50	326	34	25	251.0	176.0
JEEMQO26	Heckington Fen	27	41	50	95	33	25	21.0	-54.0
JEEMQO26	Heckington Fen	28	41	50	273	32	25	200.0	125.0
JEEMQO26	Heckington Fen	29	41	50	146	33	25	72.0	-3.0
JEEMQO26	Heckington Fen	30	41	25	73	34	25	-2.0	-52.0

(33) As can be seen from the table, there is a predicted diffraction problem with this proposal with turbines 5, 9, 10, 27, 29 and 30 using 50m micrositing. If directional restrictions were applied then turbines 5, 27 and 29 would be clear.

7.2 Reflection interference

(34) The existing links operate in the 460 MHz band. The worst case monostatic Radar Cross Section (RCS) at 460 MHz of a turbine with an 85m hub and 82m rotor is estimated to be 26.9 dBsm, using the JRC method.

(35) The JRC coordination requirement is that the all the turbines when added should have a W/U equal or better than 38 dB.

(36) All paths were plotted using ICS Telecom. Reference is now made to ITU-R BT805 method used for assessing TV interference both as a cross-check of our calculations and to estimate the additional degradation when the link is operating within the forward scatter area of the turbine. A W/U of 22 dB is used when using this specification.

(37) As it is impractical to measure the signal at the hub height of the proposed turbine, we have to rely on predictions for this path. As a result of this the predicted signal level is used for the wanted signal as well, the theory being that if the paths are similar in horizontal angle then any inaccuracies will appear on both paths and cancel. If the angles are vastly different then a more in-depth investigation into local clutter is required.

(38) If a link is within the forward scatter zone of a turbine, which occurs at angles below 12 degrees on this size of turbine, as defined in ITU-R BT805, the Relative Amplitude (RA) figure as defined is used within the JRC formula. The RCS is also reduced from the monostatic figure between the forward scatter zone and 180 degrees, depending on the reflection angle.

(39) The reflection angle is calculated assuming worst case micrositing.

(40) Yagi type antennas have a polar response off of the main beam that has peaks and nulls, which can vary in response by up to 10 dB over small angle changes, in addition, these nulls can be influenced by the antenna's proximity to a tower and other antennas mounted on the tower. In order to reduce this uncertainty, when JRC coordinate they use a mask for the polar response rather than the manufacturer's polar patterns.

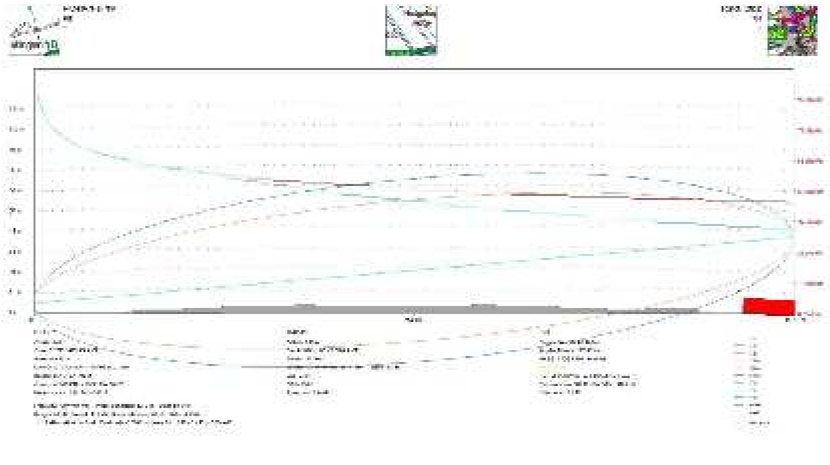
(41) If an outstation has a non-standard antenna, as defined in VNS2111, then the polar pattern of a standard antenna or the installed antenna is used whichever is better.

7.2.1 *JEEMQS1 (Boston) to JEEMQ026 (Holme Farm PMR)*

(42) There are two scanning base station which are connected to two Jaybeam 7536 antennas licensed for use at Boston. 24 of the turbines are within coordination distance of this link and are predicted free space loss to both ends of the link. There is a single Radio Jaybeam 7042 antenna licensed for use at the Holme Farm PMR.

(43) The radio path analysis for the link can be seen below.

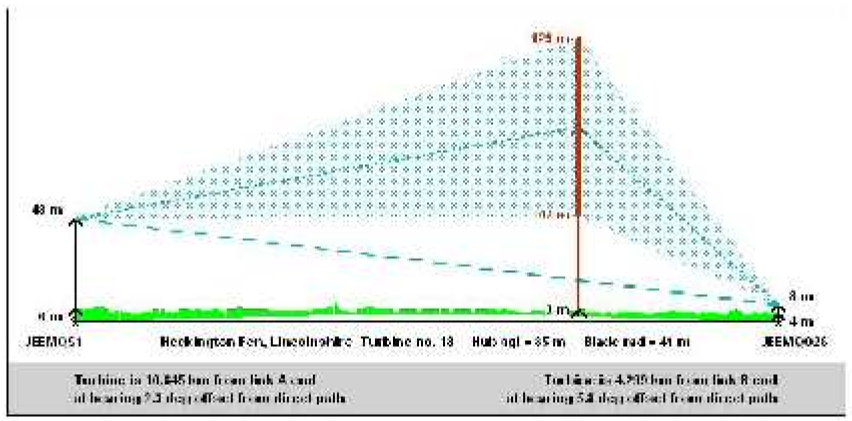
Figure 7.2: Radio path analysis: worst case main link path



(44) The predicted worst case (B – A) loss for this link is 121.0 dB. The predicted loss was used for the main path, with free space loss being used between the turbine and the both-ends of the link.

(45) The radio reflection diagram for Turbine 18 can be seen below.

Figure 7.3: Radio reflection diagram for Turbine 18

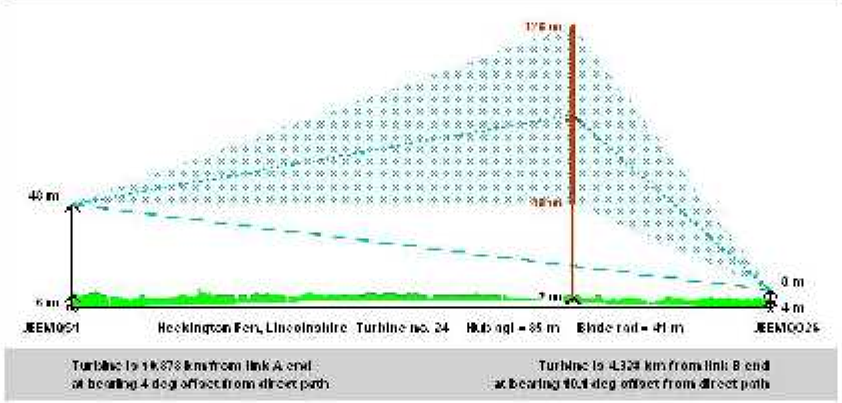


(46) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as

42.3 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 7.0 dB more than the monostatic RCS thus giving a predicted W/U of 35.4 dB.

(47) The radio reflection diagram for Turbine 24 can be seen below.

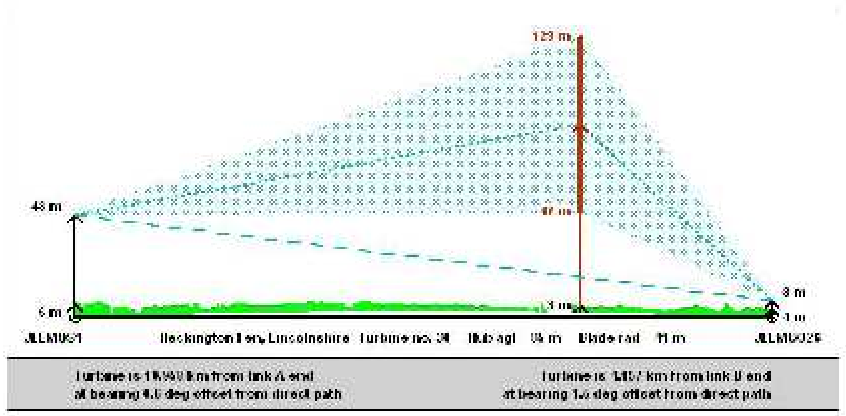
Figure 7.4: Radio reflection diagram for Turbine 24



(48) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 42.4 dB. The link not within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 3.0 dB less than the monostatic RCS thus giving a predicted W/U of 45.4 dB.

(49) The radio reflection diagram for Turbine 30 can be seen below.

Figure 7.5: Radio reflection diagram for Turbine 30



(50) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 42.1 dB. The link is within the normal forward scatter area of the turbine.

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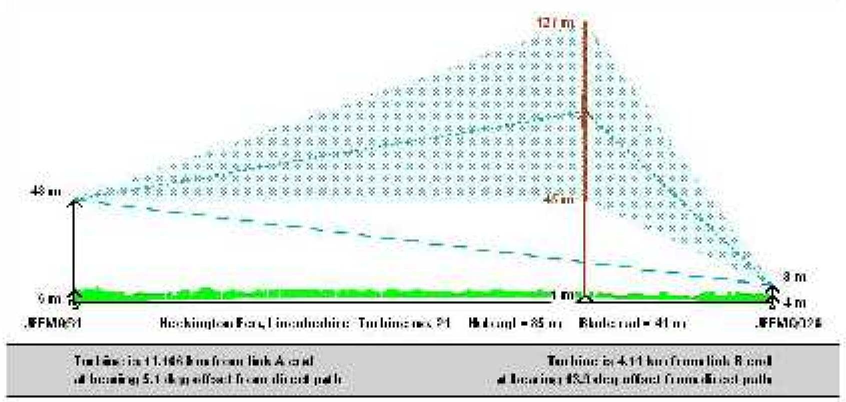
The bistatic RCS of the turbine is estimated to be 10.0 dB more than the monostatic RCS thus giving a predicted W/U of 32.1 dB.

(51) The radio reflection diagram for Turbine 21 can be seen below.

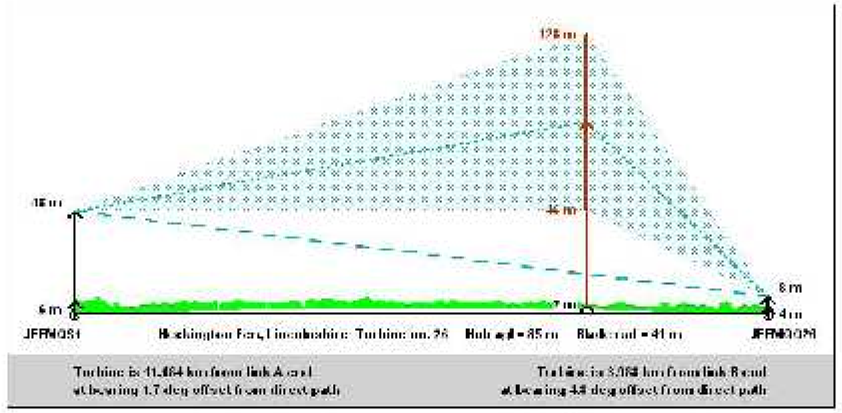
Figure 7.6: Radio reflection diagram for Turbine 21



(52) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 42.2 dB. The link is not within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 3.0 dB less than the monostatic RCS thus giving a predicted W/U of 45.2 dB.

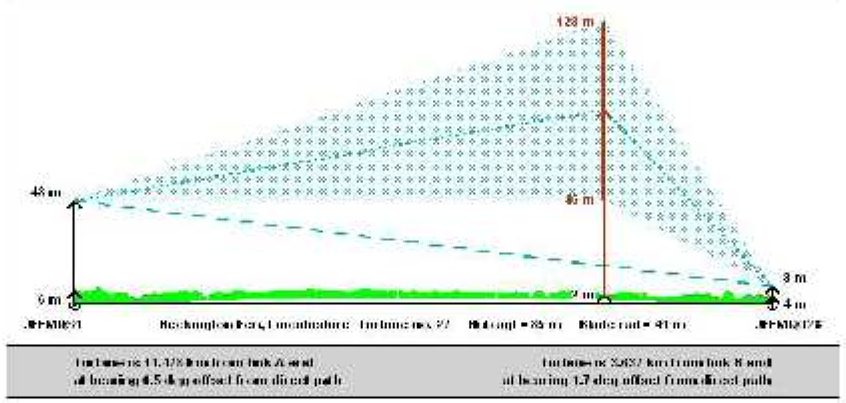
(53) The radio reflection diagram for Turbine 26 can be seen below.

Figure 7.7: Radio reflection diagram for Turbine 26



(54) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 41.9 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 8.7 dB more than the monostatic RCS thus giving a predicted W/U of 33.2 dB.

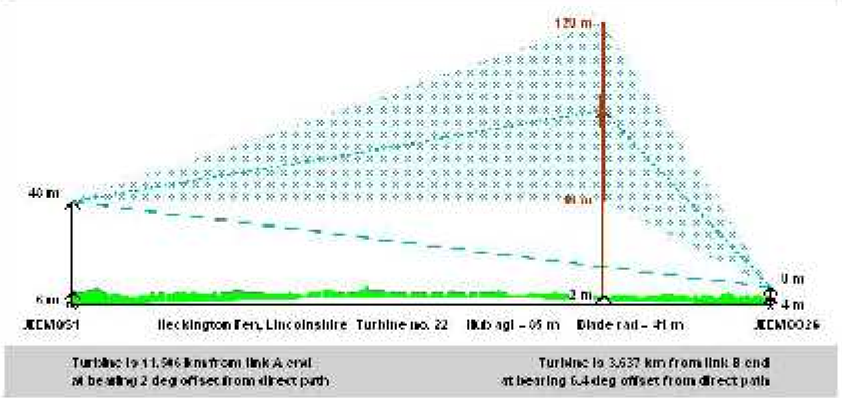
Figure 7.10: Radio reflection diagram for Turbine 27



(60) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 42.3 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 10.0 dB more than the monostatic RCS thus giving a predicted W/U of 31.4 dB.

(61) The radio reflection diagram for Turbine 22 can be seen below.

Figure 7.11: Radio reflection diagram for Turbine 22



(62) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 41.4 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 7.5 dB more than the monostatic RCS thus giving a predicted W/U of 33.9 dB.

(63) The radio reflection diagram for Turbine 20 can be seen below.

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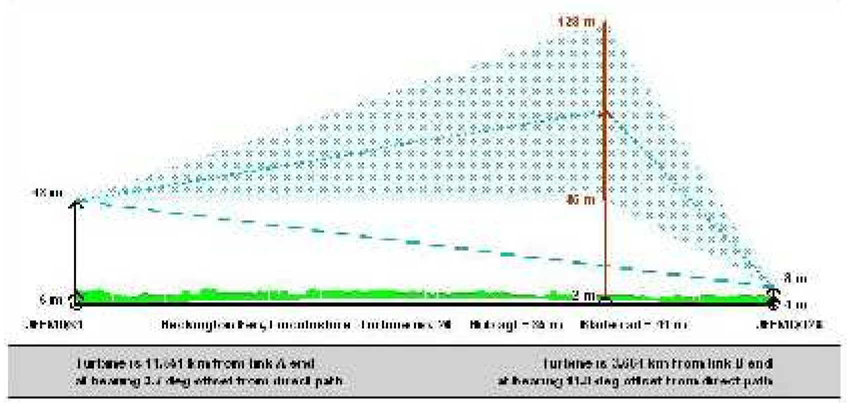
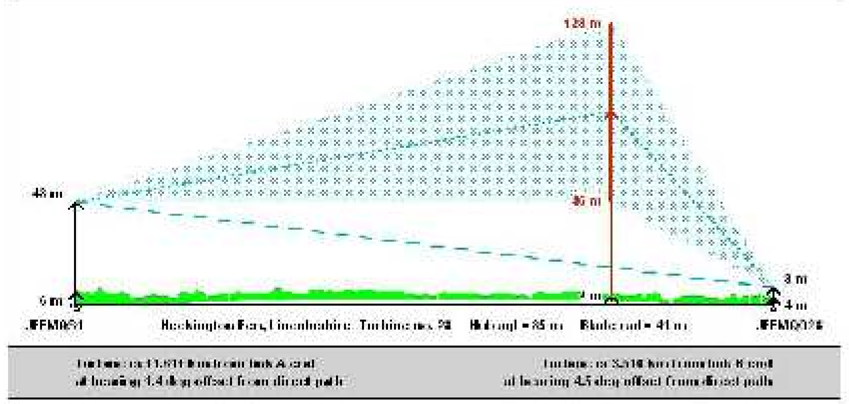
Figure 7.12: Radio reflection diagram for Turbine 20



(64) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 41.5 dB. The link is just outside the normal forward scatter area of the turbine. The monostatic RCS was used in the calculations thus giving a predicted W/U of 41.5 dB.

(65) The radio reflection diagram for Turbine 28 can be seen below.

Figure 7.13: Radio reflection diagram for Turbine 28



(66) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 41.2 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 9.0 dB more than the monostatic RCS thus giving a predicted W/U of 32.2 dB.

(67) The radio reflection diagram for Turbine 1 can be seen below.

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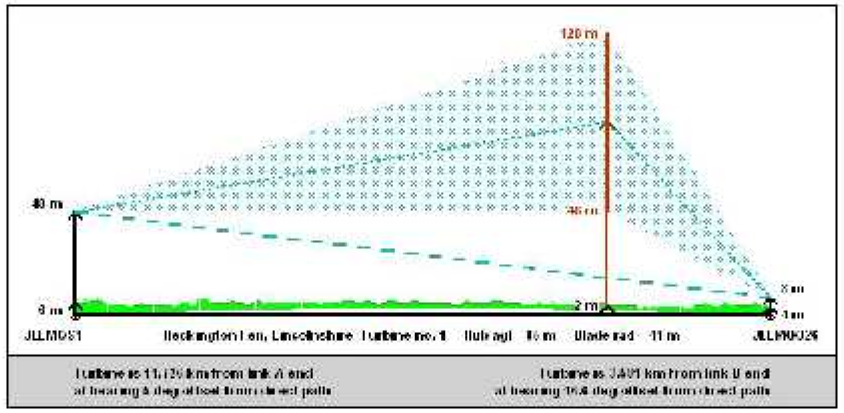
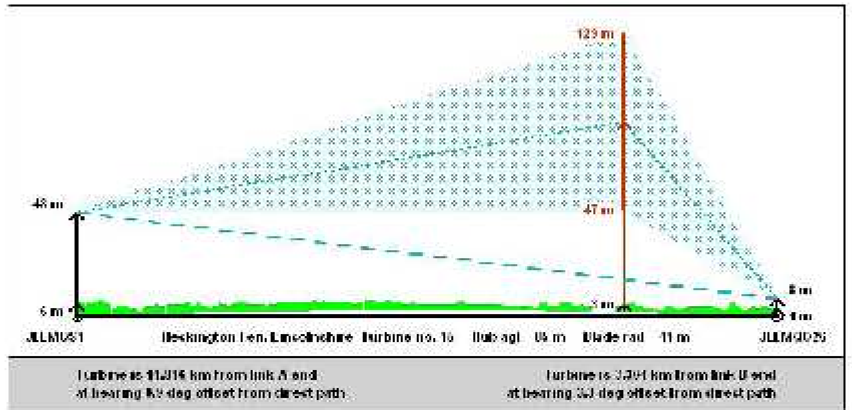
Figure 7.14: Radio reflection diagram for Turbine 1



(68) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 41.4 dB. The link is not within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 3.0 dB less than the monostatic RCS thus giving a predicted W/U of 44.4 dB.

(69) The radio reflection diagram for Turbine 15 can be seen below.

Figure 7.15: Radio reflection diagram for Turbine 15



(70) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 40.8 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 9.7 dB more than the monostatic RCS thus giving a predicted W/U of 31.1 dB.

(71) The radio reflection diagram for Turbine 13 can be seen below.

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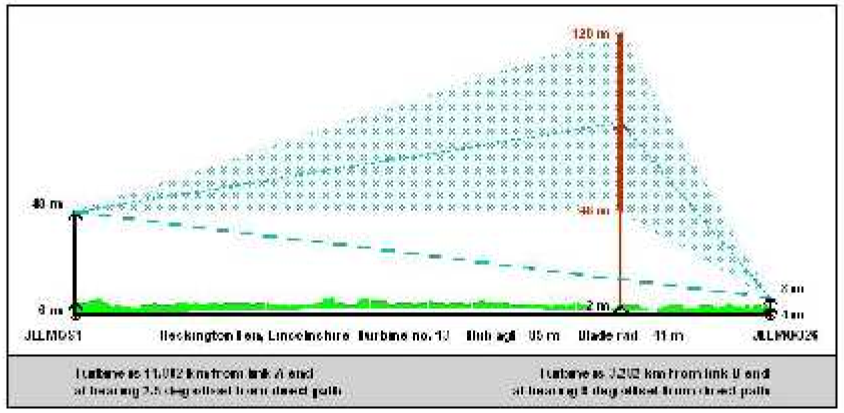
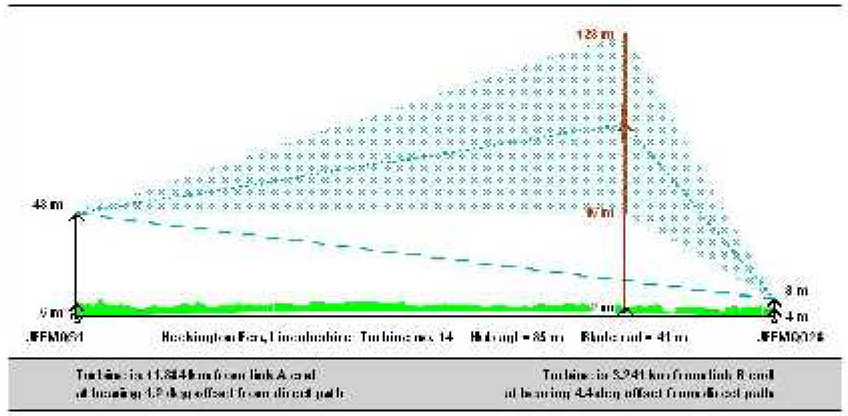
Figure 7.16: Radio reflection diagram for Turbine 13



(72) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 40.8 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 4.0 dB more than the monostatic RCS thus giving a predicted W/U of 36.8 dB.

(73) The radio reflection diagram for Turbine 14 can be seen below.

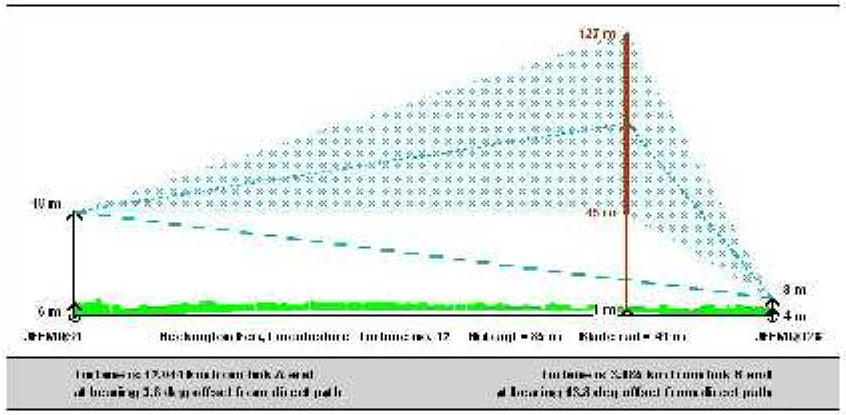
Figure 7.17: Radio reflection diagram for Turbine 14



(74) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 40.7 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 9.3 dB more than the monostatic RCS thus giving a predicted W/U of 31.4 dB.

(75) The radio reflection diagram for Turbine 12 can be seen below.

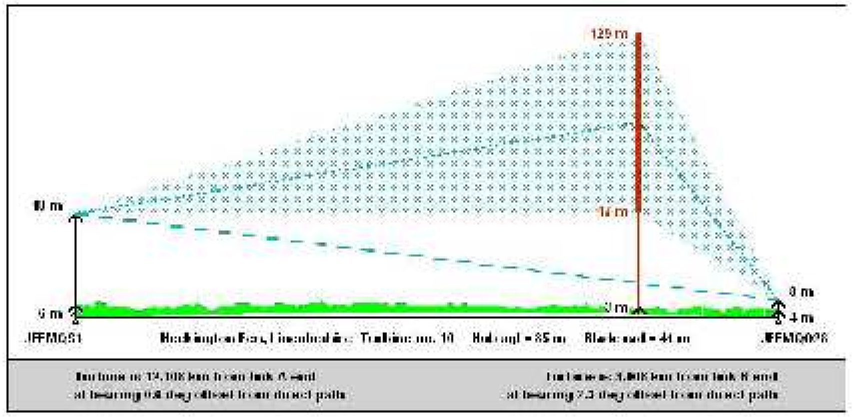
Figure 7.18: Radio reflection diagram for Turbine 12



(76) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 40.6 dB. The link is not within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 3.0 dB less than the monostatic RCS thus giving a predicted W/U of 43.6 dB.

(77) The radio reflection diagram for Turbine 10 can be seen below.

Figure 7.19: Radio reflection diagram for Turbine 10



(78) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 40.2 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 10.0 dB more than the monostatic RCS thus giving a predicted W/U of 30.2 dB.

(79) The radio reflection diagram for Turbine 9 can be seen below.

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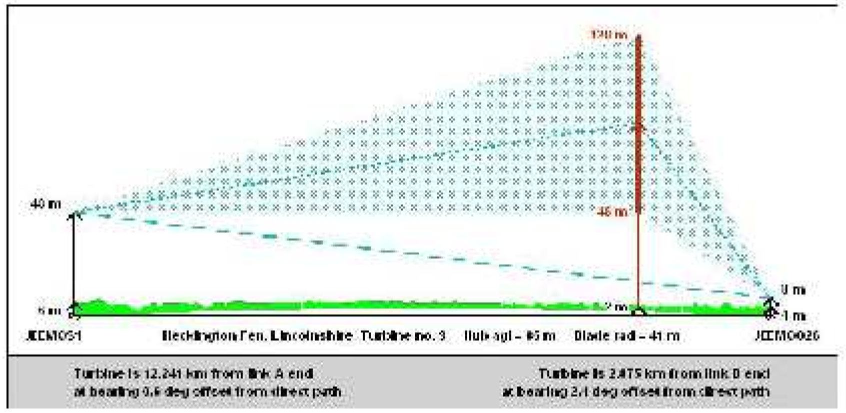
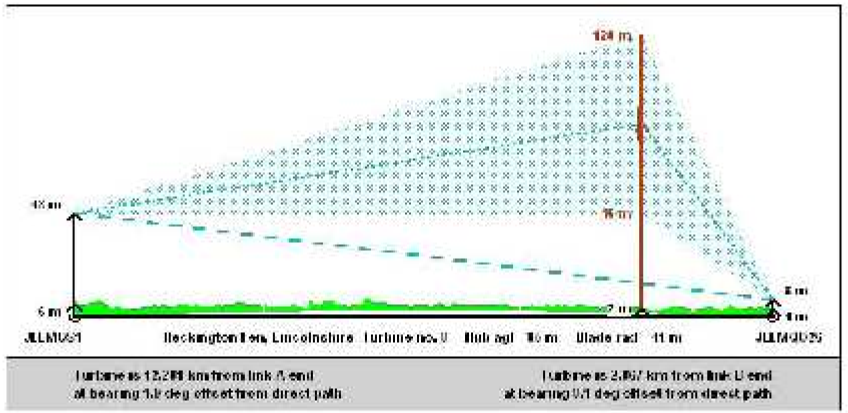
Figure 7.20: Radio reflection diagram for Turbine 9



(80) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 39.9 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 10.0 dB more than the monostatic RCS thus giving a predicted W/U of 29.9 dB.

(81) The radio reflection diagram for Turbine 8 can be seen below.

Figure 7.21: Radio reflection diagram for Turbine 8



(82) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 39.9 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 6.2 dB more than the monostatic RCS thus giving a predicted W/U of 33.7 dB.

(83) The radio reflection diagram for Turbine 7 can be seen below.

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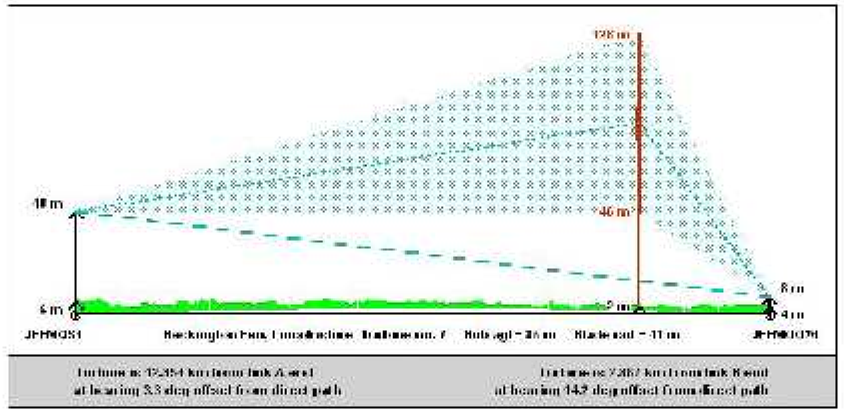
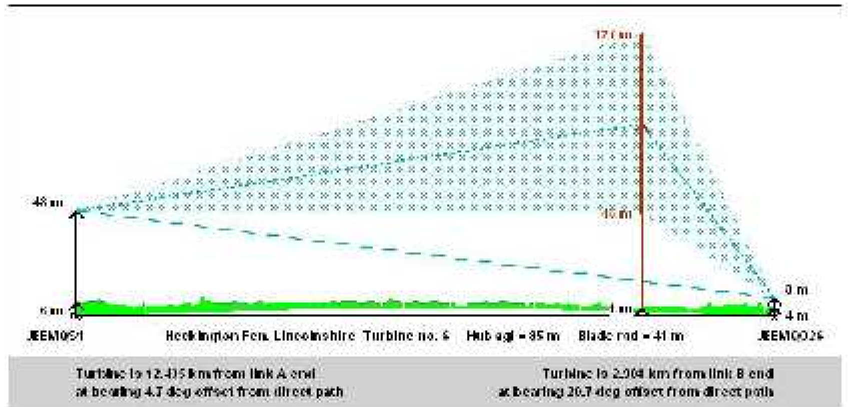
Figure 7.22: Radio reflection diagram for Turbine 7



(84) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 43.3 dB. The link is not within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 3.0 dB less than the monostatic RCS thus giving a predicted W/U of 42.9 dB.

(85) The radio reflection diagram for Turbine 6 can be seen below.

Figure 7.23: Radio reflection diagram for Turbine 6



(86) Assuming worst case micrositing, the polar mask of a standard antenna as defined in VNS2111 would offer 2.2 dB rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 42.3 dB. The link not within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 3.0 dB less than the monostatic RCS thus giving a predicted W/U of 45.3 dB.

(87) The radio reflection diagram for Turbine 5 can be seen below.

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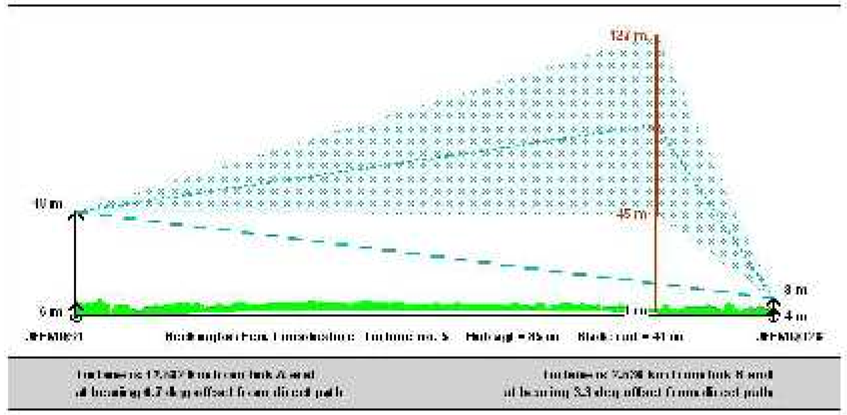
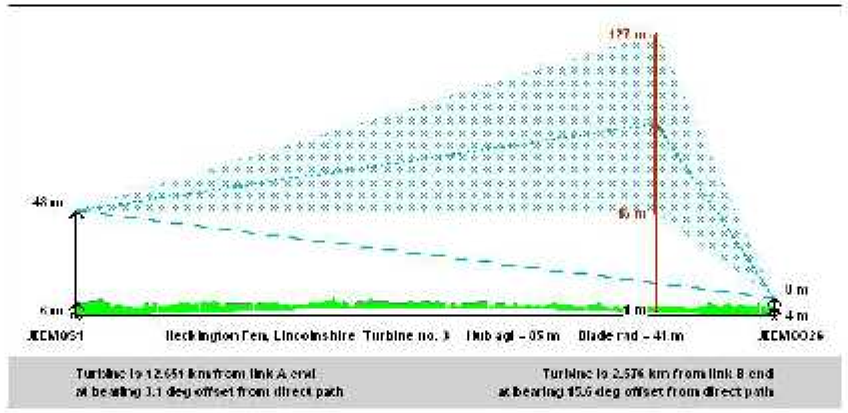
Figure 7.24: Radio reflection diagram for Turbine 5



(88) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 39.0 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 9.9 dB more than the monostatic RCS thus giving a predicted W/U of 29.1 dB.

(89) The radio reflection diagram for Turbine 3 can be seen below.

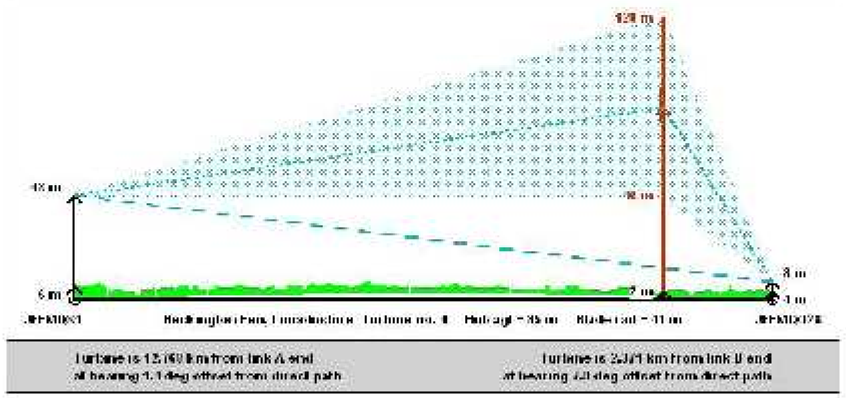
Figure 7.25: Radio reflection diagram for Turbine 3



(90) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 39.2 dB. The link is not within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 3.0 dB more than the monostatic RCS thus giving a predicted W/U of 42.2 dB.

(91) The radio reflection diagram for Turbine 4 can be seen below.

Figure 7.26: Radio reflection diagram for Turbine 4



(92) Assuming worst case micrositing, the polar mask of a Jaybeam 7042 or a standard antenna as defined in VNS2111 would offer negligible rejection to the unwanted signal. The basic W/U using the JRC method is calculated as 38.6 dB. The link is within the normal forward scatter area of the turbine. The bistatic RCS of the turbine is estimated to be 7.3 dB more than the monostatic RCS thus giving a predicted W/U of 31.3 dB.

(93) It can be seen that 15 of the turbines are individually below JRC recommended levels and when combined predict a W/U of 19.9 dB.

(94) The analysis also shows that 17 of the turbines are working to a greater or lesser extent in forward scatter mode; these are more likely to add under similar wind conditions than those operating in side scatter mode, if the worst five are added they predict a W/U of 23.3 dB.

(95) When using ITU-R BT805 the predicted figures are 1.1 dB better with respect to the specifications, however both methods predict a W/U well below JRC recommendations.

(96) The figures used in the calculation can be seen in the appendix.

8 Definition of an Exclusion Zone

(97) In this instance the reflection/scattering clearance requirement is greater than the diffraction clearance requirement.

(98) For the worst five turbines to add and produce a combined W/U better than the JRC recommended level then each individual turbine needs to be equal or exceed a W/U of 45 dB.

(99) As can be seen from the figures only three of the existing turbines (T6, T21 & T24) within the coordination zone actually exceed this figure. This in affect means that defining an exclusion zone is not practical as 21 turbines would need to be excluded.

9 Mitigation options

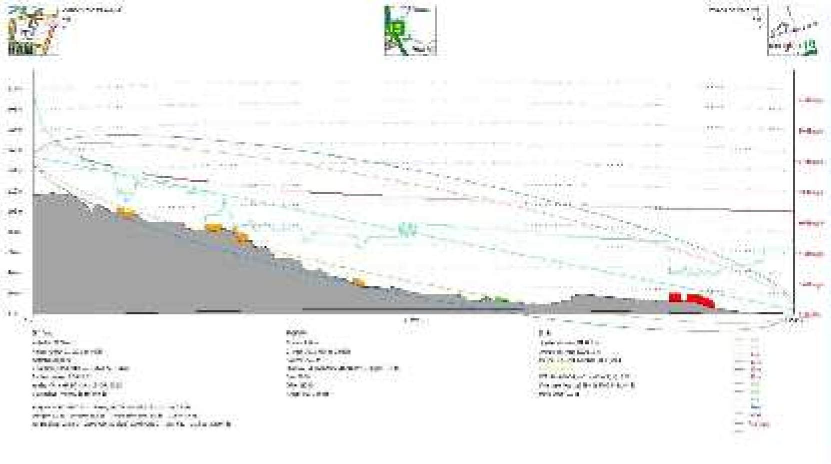
(100) Antenna upgrades, private circuits and satellite are not viable mitigation options for this link as it is a Pole Mounted Recloser installation (see cover page for an illustration of a PMR).

9.1 The use of other radio scanner sites

(101) The normal maximum link length defined in OfW49 is 30 km, although this is not a hard and fast rule. The logical site that the link could be diverted to is Londonthorpe. This would give a path length of approximately 24 km.

(102) The forward link path prediction for Holme Farm using existing licensed power at Londonthorpe can be seen below.

Figure 9.1: The proposed path from Londonthorpe to Holme Farm



(103) The link is predicted to only just have adequate signal with licensed power at Londonthorpe.

(104) It is recommended that if this option is to be considered that a survey is undertaken to check the path from Holme Farm. It may be possible to increase the power if required at Londonthorpe however this would be subject to co-channel coordination checks.

(105) EON would also need to confirm they could from an operational point of view add these sites to the scanner proposed. If acceptable the links would need to be re licensed and the RF power of the links would also need to be adjusted to meet the new licensed parameters.

(106) The estimated cost for changing the affected sites to the Londonthorpe base station would be in the order of £5,000.

(107) JRC is not aware of any wind farms on this proposed reroute. There are no wind farms, built, consented or in planning according to the Renewable UK database.

9.2 Other Technologies

(108) As this site is a Pole Mounted Recloser rather than a primary substation, EON have in the past have used GSM/UMTS bearers on these class of links.

(109) It is suggested that this technology could be employed to mitigate the affected radio links. The cost of installing the equipment would not be in excess of £7,500.

(110) This report presents the results of an investigation into the effects of potential interference caused to the EON licensed radio systems by the construction of a wind farm at Heckington Fen.

10 Conclusions

(111) The report concludes:

- That the proposed wind farm layout is predicted to reduce the availability of the EON link below that required when using either the JRC, or ITU-R BT805 methods of calculation and that mitigation solutions should be sought.

(112) It is considered that the influence of wind turbines on UHF telemetry and microwave links is sufficiently well understood to have confidence in the predicted effects.

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11 Recommendations

(113) The report recommends:

- That Ecotricity should continue to liaise with EON and JRC whilst the wind energy development at Heckington Fen is being planned. This will enable them to understand any plans regarding their radio networks and if they have any future radio systems planned that would be affected by the wind farm. That the best options to mitigate the affected links are:
- To scan the affected sites at Holme Farm PMR from the alternative base station at Londonthorpe at an estimated cost of £10,000.

  Note: This option would be subject to a site and radio survey to establish the validity of the paths.

  OR:
- To use GSM/UMTS as the data bearer at an estimated maximum cost of £7,500.

(114) This report should be shared with EON (Central Networks) to establish their opinion regarding this report as the final decision regarding mitigation resides with them.

12 Disclaimer

(115) Although JRC has used best endeavours to produce an accurate assessment, the nature of predictions of radio effects and approximations inherent in the planning tools mean that JRC cannot offer any guarantee that the effects will be as predicted. In particular, the report highlights the uncertainties surrounding the new phenomenon of wind turbines in respect of their impact on radio propagation, especially in the use of unproven radio formulae. JRC seeks to validate all input data received from third party sources, but within the constraints of the contract cannot independently verify the data and therefore cannot be held responsible for any inaccuracies in data provided by third parties.

(116) It must be stressed that any changes subsequent to this report, especially changes in the location or profile of any of the turbines, could negate the analyses that have been conducted.

(117) It should be noted that this report appertains only to the date of its issue. As the use of the radio spectrum is dynamic and the use of the 460 MHz band is changing on an ongoing basis you are advised to seek re-coordination prior to submitting a formal planning application. This will avoid the possibility of an objection being raised at that time as a consequence of any links being assigned between your enquiry and the finalisation of your project.

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13 Bibliography

[1] "Calculation of the Clearance Zone". Peter Swan, et al. Version 3.1, September 2009, Joint Radio Company Ltd.
Download:
http://www.jrc.co.uk/windfarms/CalculationOfTheClearanceZone.pdf

[2] "Fixed-link wind-turbine exclusion zone method". Dr. David Bacon. Version 1.1, 28 October 2002, UK Radiocommunications Agency (now part of Ofcom).
Download:
http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/fixed/Windfarms/windfarmdavidbacon.pdf

[3] Ofcom Independent Report on RF Measurement Assessment of Potential Wind Farm Interference to Fixed Links and Scanning Telemetry Devices, published in March 2009.
Download:
http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/fixed/Windfarms/rf_measurement/

NOTE: More information on how JRC assesses Wind Energy Developments and links to other reference documents can be found on the JRC Web Site: http://www.jrc.co.uk/windfarms/

Appendix 1: Figures used in calculation of W/U (JRC Method)

481 MHz					A End to Turbine					B End to Turbine			Link	Basic W/U Ratio		Turbines to
Link ID	Site	Turbine	RCS	d (m)	angle	angle -U-MS	Disc dB	LAFS (dB)	d (m)	angle	angle -U-MS	Disc dB	LAFS (dB)	Bacon	JRC	add. No =100
JEEMQO26	Heckington	18	26.9	10845	2.3	2.05	0	0	4299	5.8	5.17	0.00	11.6	53.9	42.3	42.3
JEEMQO26	Heckington	24	26.9	10878	4	3.72	0	0	4328	10.1	9.39	0.00	11.6	54.0	42.4	42.4
JEEMQO26	Heckington	30	26.9	10958	0.6	0.12	0	0	4157	1.5	0.32	0.00	11.6	53.7	42.1	42.1
JEEMQO26	Heckington	21	26.9	11166	5.1	4.67	0	0	4110	13.9	12.83	0.00	11.6	53.8	42.2	42.2
JEEMQO26	Heckington	26	26.9	11164	1.7	1.29	0	0	3968	4.8	3.63	0.00	11.6	53.5	41.9	41.9
JEEMQO26	Heckington	23	26.9	11190	3.3	2.89	0	0	3993	9.2	8.14	0.00	11.6	53.6	42.0	42.0
JEEMQO26	Heckington	29	26.9	11278	0.8	0.36	0	0	3839	2.3	1.06	0.00	11.6	53.3	41.7	41.7
JEEMQO26	Heckington	27	26.9	11478	0.5	0.10	0	0	3637	1.7	0.32	0.00	11.6	53.0	41.4	41.4
JEEMQO26	Heckington	22	26.9	11506	2	1.63	0	0	3637	6.4	5.17	0.00	11.6	53.0	41.4	41.4
JEEMQO26	Heckington	20	26.9	11551	3.7	3.36	0	0	3664	11.8	10.67	0.00	11.6	53.1	41.5	41.5
JEEMQO26	Heckington	28	26.9	11611	1.4	0.98	0	0	3516	4.5	3.23	0.00	11.6	52.8	41.2	41.2
JEEMQO26	Heckington	1	26.9	11726	5	4.64	0	0	3581	16.6	15.46	0.00	11.6	53.0	41.4	41.4
JEEMQO26	Heckington	15	26.9	11816	0.9	0.53	0	0	3304	3.3	1.91	0.00	11.6	52.4	40.8	40.8
JEEMQO26	Heckington	13	26.9	11882	2.5	2.11	0	0	3282	9	7.69	0.00	11.6	52.4	40.8	40.8
JEEMQO26	Heckington	14	26.9	11884	1.2	0.79	0	0	3241	4.4	2.91	0.00	11.6	52.3	40.7	40.7
JEEMQO26	Heckington	12	26.9	12044	3.6	3.27	0	0	3185	13.8	12.51	0.00	11.6	52.2	40.6	40.6
JEEMQO26	Heckington	10	26.9	12108	0.6	0.23	0	0	3008	2.3	0.93	0.00	11.6	51.8	40.2	40.2
JEEMQO26	Heckington	9	26.9	12241	0.6	0.12	0	0	2875	2.4	0.52	0.00	11.6	51.5	39.9	39.9
JEEMQO26	Heckington	8	26.9	12281	1.9	1.52	0	0	2867	8.1	6.55	0.00	11.6	51.5	39.9	39.9
JEEMQO26	Heckington	7	26.9	12354	3.3	2.92	0	0	2867	14.2	12.75	0.00	11.6	51.5	39.9	39.9
JEEMQO26	Heckington	6	26.9	12435	4.7	4.39	0	0	2908	20.7	19.27	2.20	11.6	53.9	42.3	42.3
JEEMQO26	Heckington	5	26.9	12582	0.7	0.26	0	0	2536	3.3	1.29	0.00	11.6	50.6	39.0	39.0
JEEMQO26	Heckington	3	26.9	12651	3.1	2.79	0	0	2576	15.6	13.94	0.00	11.6	50.8	39.2	39.2
JEEMQO26	Heckington	4	26.9	12768	1.4	1.08	0	0	2371	7.8	5.86	0.00	11.6	50.2	38.6	38.6
														Resulting W/U		27.0
														Composite WRT Spec		-11.0

Appendix 2: Figures used for forward scatter and monostatic RCS Modifier

481 MHz				A End to Turbine		Basic W/U Ratio		Turbines to		Bistatic	W/U	Turbines to	Turbines to
Link ID	Site	Turbine	RCS	distance	angle	Bacon	JRC	add. No =100	Fwd Scatter	Reduction	Incl FS +BS	add. No =100	add. No =100
JEEMQO26	Heckington	18	26.9	10845	2.3	53.9	42.3	42.3	6.96	0.0	35.4	35.4	100.0
JEEMQO26	Heckington	24	26.9	10878	4	54.0	42.4	42.4	0.00	3.0	45.4	45.4	100.0
JEEMQO26	Heckington	30	26.9	10958	0.6	53.7	42.1	42.1	9.99	0.0	32.1	32.1	100.0
JEEMQO26	Heckington	21	26.9	11166	5.1	53.8	42.2	42.2	0.00	3.0	45.2	45.2	100.0
JEEMQO26	Heckington	26	26.9	11164	1.7	53.5	41.9	41.9	8.70	0.0	33.2	33.2	100.0
JEEMQO26	Heckington	23	26.9	11190	3.3	53.6	42.0	42.0	2.02	0.0	39.9	39.9	100.0
JEEMQO26	Heckington	29	26.9	11278	0.8	53.3	41.7	41.7	9.89	0.0	31.8	31.8	100.0
JEEMQO26	Heckington	27	26.9	11478	0.5	53.0	41.4	41.4	9.99	0.0	31.4	31.4	100.0
JEEMQO26	Heckington	22	26.9	11506	2	53.0	41.4	41.4	7.48	0.0	33.9	33.9	100.0
JEEMQO26	Heckington	20	26.9	11551	3.7	53.1	41.5	41.5	0.00	0.0	41.5	41.5	100.0
JEEMQO26	Heckington	28	26.9	11611	1.4	52.8	41.2	41.2	9.01	0.0	32.2	32.2	100.0
JEEMQO26	Heckington	1	26.9	11726	5	53.0	41.4	41.4	0.00	3.0	44.4	44.4	100.0
JEEMQO26	Heckington	15	26.9	11816	0.9	52.4	40.8	40.8	9.68	0.0	31.1	31.1	31.1
JEEMQO26	Heckington	13	26.9	11882	2.5	52.4	40.8	40.8	3.96	0.0	36.8	36.8	100.0
JEEMQO26	Heckington	14	26.9	11884	1.2	52.3	40.7	40.7	9.28	0.0	31.4	31.4	31.4
JEEMQO26	Heckington	12	26.9	12044	3.6	52.2	40.6	40.6	0.00	3.0	43.6	43.6	100.0
JEEMQO26	Heckington	10	26.9	12108	0.6	51.8	40.2	40.2	9.95	0.0	30.2	30.2	30.2
JEEMQO26	Heckington	9	26.9	12241	0.6	51.5	39.9	39.9	9.98	0.0	29.9	29.9	29.9
JEEMQO26	Heckington	8	26.9	12281	1.9	51.5	39.9	39.9	6.18	0.0	33.7	33.7	100.0
JEEMQO26	Heckington	7	26.9	12354	3.3	51.5	39.9	39.9	0.00	3.0	42.9	42.9	100.0
JEEMQO26	Heckington	6	26.9	12435	4.7	53.9	42.3	42.3	0.00	3.0	45.3	45.3	100.0
JEEMQO26	Heckington	5	26.9	12582	0.7	50.6	39.0	39.0	9.89	0.0	29.1	29.1	29.1
JEEMQO26	Heckington	3	26.9	12651	3.1	50.8	39.2	39.2	0.00	3.0	42.2	42.2	100.0
JEEMQO26	Heckington	4	26.9	12768	1.4	50.2	38.6	38.6	7.31	0.0	31.3	31.3	100.0
						Resulting W/U		27.0			W/U	19.9	23.3
						Composite WRT Spec		-11.0			WRT Spec	-18.1	-14.7

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Appendix 3: Figures used in the calculation for turbines UHF.

BT 805	460.00 MHz
Turbine Blade Diameter m	82.00
Turbine Blade width m	2.31
Turbine Blade Area m^2	71.03
RCS Monostatic dBsm JRC	26.87
RCS Factor Monostatic dB JRC	41.60
RF- 805 dB	19.24
RF WRT Ref Turb dB	2.50
RF -805 JRC equiv dB	34.12
JRC RCS using BT805	41.76
JRC RCS using BT805 Worst FS	51.76
Diff Mono RCS JRC BT805	14.90

Link ID		Turb	Loss to Turb	RF	Ref Angle	Ref Angle US	RA	RA +us	Bi stat	T-B	Sig Refl	Loss A-B	W/U	add. No =100	W/U Ino Bi Stat	add. No =100	add. No =100
JEEMQO26	Heckington	18	106.48	19.24	8.1	7.2	3.82	3.04	0.00	12.67	141.42	120.96	20.46	20.46	20.46	20.5	100.0
JEEMQO26	Heckington	24	106.50	19.24	14.0	13.1	10.00	10.00	-3.00	12.73	148.47	120.96	27.51	27.51	30.51	30.5	100.0
JEEMQO26	Heckington	30	106.57	19.24	1.4	0.4	0.08	0.01	0.00	12.38	138.19	120.96	17.23	17.23	17.23	17.2	100.0
JEEMQO26	Heckington	21	106.73	19.24	18.9	17.5	10.00	10.00	-3.00	12.28	148.25	120.96	27.29	27.29	30.29	30.3	100.0
JEEMQO26	Heckington	26	106.73	19.24	6.4	4.9	2.21	1.30	0.00	11.97	139.24	120.96	18.28	18.28	18.28	18.3	100.0
JEEMQO26	Heckington	23	106.75	19.24	12.5	11.0	10.00	7.98	0.00	12.03	146.00	120.96	25.04	25.04	25.04	25.0	100.0
JEEMQO26	Heckington	29	106.82	19.24	2.9	1.4	0.43	0.11	0.00	11.68	137.85	120.96	16.89	16.89	16.89	16.9	100.0
JEEMQO26	Heckington	27	106.97	19.24	2.0	0.4	0.18	0.01	0.00	11.21	137.43	120.96	16.47	16.47	16.47	16.5	100.0
JEEMQO26	Heckington	22	106.99	19.24	8.3	6.8	4.03	2.52	0.00	11.21	139.97	120.96	19.01	19.01	19.01	19.0	100.0
JEEMQO26	Heckington	20	107.03	19.24	15.6	14.0	10.00	10.00	0.00	11.28	147.55	120.96	26.58	26.58	26.58	26.6	100.0
JEEMQO26	Heckington	28	107.07	19.24	5.8	4.2	1.92	0.99	0.00	10.92	138.22	120.96	17.26	17.26	17.26	17.3	100.0
JEEMQO26	Heckington	1	107.16	19.24	21.6	20.1	10.00	10.00	-3.00	11.08	147.48	120.96	26.52	26.52	29.52	29.5	100.0
JEEMQO26	Heckington	15	107.22	19.24	4.1	2.4	0.89	0.32	0.00	10.38	137.16	120.96	16.20	16.20	16.20	16.2	16.2
JEEMQO26	Heckington	13	107.27	19.24	11.5	9.8	8.74	6.04	0.00	10.32	142.87	120.96	21.91	21.91	21.91	21.9	100.0
JEEMQO26	Heckington	14	107.27	19.24	5.4	3.7	1.53	0.72	0.00	10.21	137.45	120.96	16.49	16.49	16.49	16.5	16.5
JEEMQO26	Heckington	12	107.39	19.24	17.4	15.8	10.00	10.00	-3.00	10.06	146.69	120.96	25.73	25.73	28.73	28.7	100.0
JEEMQO26	Heckington	10	107.44	19.24	2.9	1.2	0.43	0.05	0.00	9.57	136.30	120.96	15.33	15.33	15.33	15.3	15.3
JEEMQO26	Heckington	9	107.53	19.24	2.5	0.6	0.32	0.02	0.00	9.17	135.96	120.96	15.00	15.00	15.00	15.0	15.0
JEEMQO26	Heckington	8	107.56	19.24	9.9	8.1	6.04	3.82	0.00	9.15	139.77	120.96	18.80	18.80	18.80	18.8	100.0
JEEMQO26	Heckington	7	107.61	19.24	17.5	15.7	10.00	10.00	-3.00	9.15	146.00	120.96	25.04	25.04	28.04	28.0	100.0
JEEMQO26	Heckington	6	107.67	19.24	25.4	23.7	10.00	10.00	-3.00	11.47	148.38	120.96	27.42	27.42	30.42	30.4	100.0
JEEMQO26	Heckington	5	107.77	19.24	3.6	1.5	0.64	0.11	0.00	8.08	135.20	120.96	14.24	14.24	14.24	14.2	14.2
JEEMQO26	Heckington	3	107.82	19.24	18.7	16.7	10.00	10.00	-3.00	8.22	145.28	120.96	24.31	24.31	27.31	27.3	100.0
JEEMQO26	Heckington	4	107.90	19.24	9.1	6.9	4.96	2.69	0.00	7.50	137.32	120.96	16.36	16.36	16.36	16.4	100.0
													W/U	4.8	W/U	5.0	8.4
													WRT Spec	-17.2	WRT Spec	-17.0	-13.6

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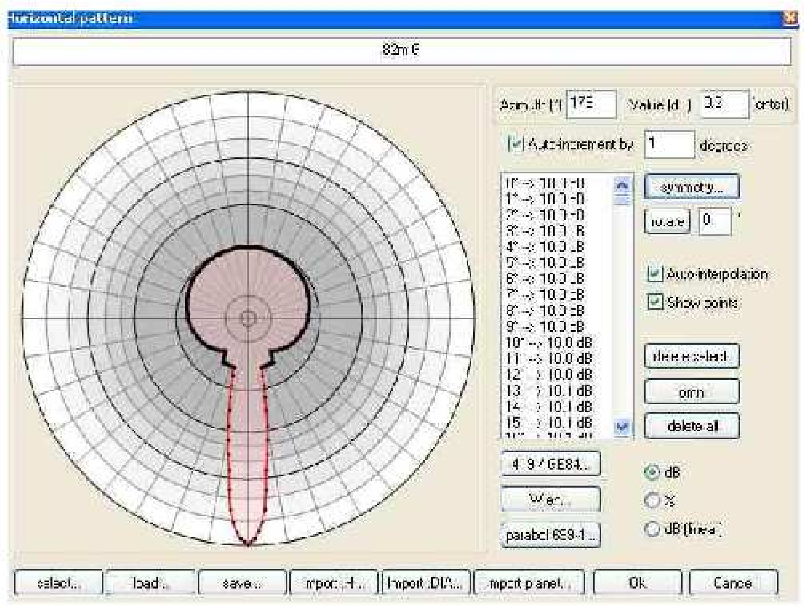
Appendix 5. Equivalent Polar Pattern: 82m rotor turbine

82m rotor turbine Monostatic RCS = 26.9 dBsm peak RCS = 36.9 dBsm.



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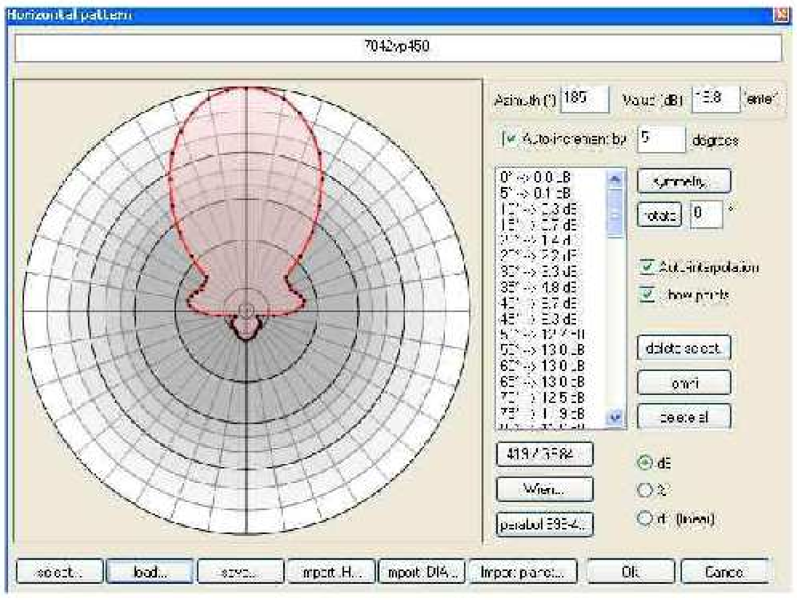
Appendix 6 Polar Pattern: Jaybeam 7042 H plane. Horizontal pattern, vertical polarisation.

H-plane polar pattern for a Jaybeam 7042 in vertical polarisation.



Appendix 7 Polar Pattern for a Standard Antenna (VNS2111).

H-plane polar pattern for a VNS2111 Standard Antenna, vertical polarisation.