Witness Reference Number SWFL8. 3

Electricity Act 1989 (Sections 36 and Schedule 8)
Town and Country Planning Act 1990 (Section 90)
The Electricity Generating Stations and Overhead Lines (Inquiries Procedure) Rules 2007

Public Inquiry to consider Section 36 Electricity Act 1989 Application by Steadings Wind Farm Ltd for consent and deemed planning permission to construct and operate a wind farm at Kirkwhelpington, Northumberland (Known as Steadings)

REBUTTALS PROOF OF EVIDENCE OF

KENNETH GWYNNE JAMES BSc

BRASEC, on behalf of Steadings Wind Farm Ltd

1 Introduction

I have read the proofs of evidence submitted by the Ministry of Defence, NATS En-Route Ltd and Newcastle International Airport. My comments on their evidence are set out below, cross-referenced to the paragraph numbers used by each witness. My silence on any point made in any proof or the fact that I have not addressed it should not be taken as an indication that I agree with or accept that point. In particular, I have left it to my colleagues to address operational issues.

In support of my rebuttals, I have referenced a number of publications, and have included the relevant extracts from those documents in this proof.

2 MoD

2.1 Sqn Ldr Colin Deane

In **paragraph 44**, Sq Ldr Deane asserts that road vehicles have “miniscule” radar cross section (RCS) in comparison to wind turbines. RCS is a function not just of size, but shape, reflectivity and angle of view from the radar. Published literature makes it clear that road vehicles can exhibit RCS values which exceed those of aircraft and approach those of wind turbines.

Skolnik[1], for example, reports that *“Automobiles generally can have a surprisingly large radar cross section”* which *“might vary from 10 to 200 m^2 at X-band, with 100 m^2 being a typical value”*. He attributes an even larger typical value (200 m^2) to pickup trucks, as shown in this table from the same source. In contrast, the assumed head-on RCS of a BAE Hawk aircraft is usually quoted as being just 1 m^2.

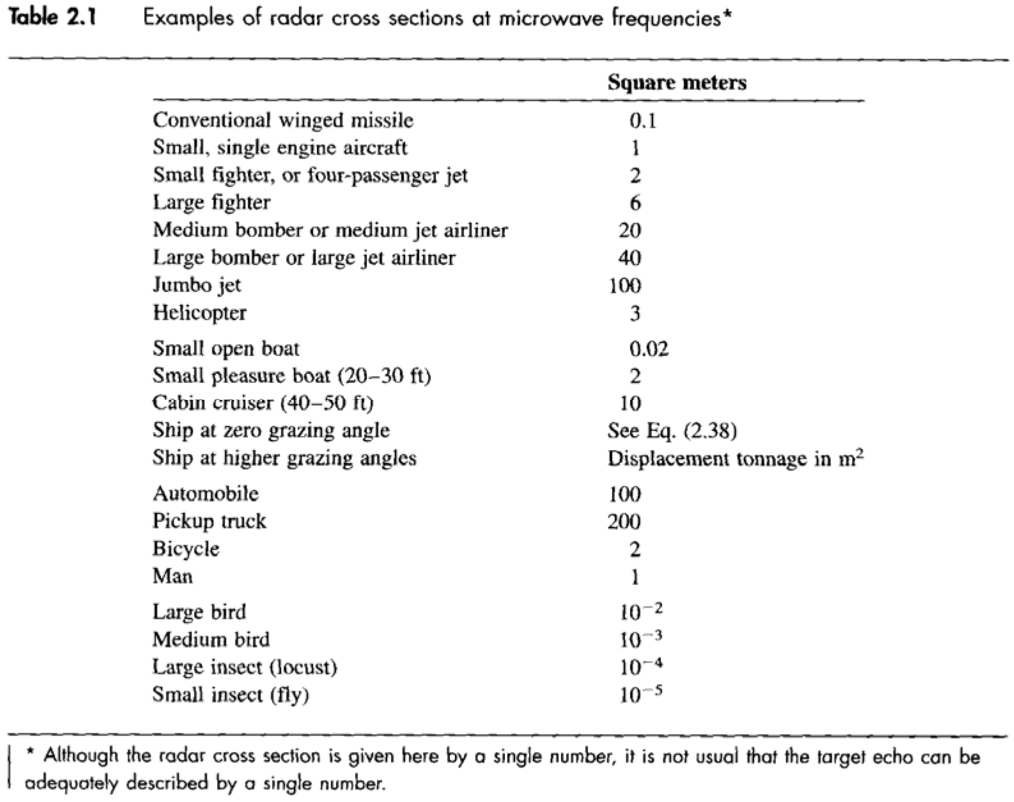

Table 2.1 Examples of radar cross sections at microwave frequencies*

	Square meters
Conventional winged missile	0.1
Small, single engine aircraft	1
Small fighter, or four-passenger jet	2
Large fighter	6
Medium bomber or medium jet airliner	20
Large bomber or large jet airliner	40
Jumbo jet	100
Helicopter	3
Small open boat	0.02
Small pleasure boat (20–30 ft)	2
Cabin cruiser (40–50 ft)	10
Ship at zero grazing angle	See Eq. (2.38)
Ship at higher grazing angles	Displacement tonnage in m^2
Automobile	100
Pickup truck	200
Bicycle	2
Man	1
Large bird	10^{-2}
Medium bird	10^{-3}
Large insect (locust)	10^{-4}
Small insect (fly)	10^{-5}

* Although the radar cross section is given here by a single number, it is not usual that the target echo can be adequately described by a single number.

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[1] Skolnik; Introduction to Radar Systems, 3rd edition, 2001

As the footnote to this table indicates, the RCS of an object cannot be defined by a single value. The following diagram, from Barton & Leonov[2], gives an indication of the ranges of RCS values that are typical of different target types. Here the RCS scale is expressed in dBm^2 (decibels related to 1 m^2) where 0 dBm^2 means 1 m^2, 10 dBm^2 means 10 m^2, 20 dBm^2 means 100 m^2, and so on. As can been, typical aircraft RCS ranges from 1 to 300 m^2 while ground vehicle RCS ranges from 10 to 1000 m^2.

Figure R67 RCS linear square meter and logarithmic decibel scales compared (from Knott, 1993, Fig. 3.3, p. 69).

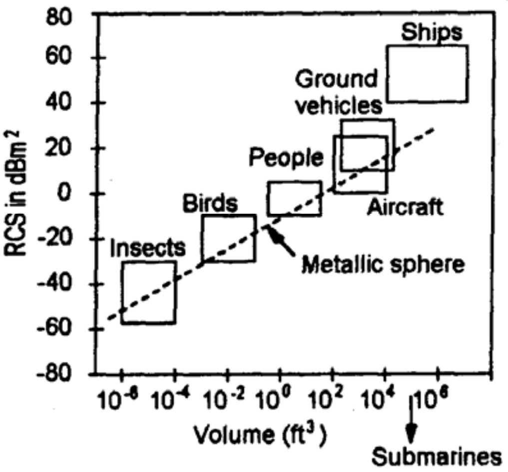

Figure R68 Typical RCS (after Brookner, 1988, Fig. 8.23, p. 436).

Far from having "miniscule" RCS in comparison with wind turbines, road vehicles can have comparable cross sections to the turbines, exceeding those of small aircraft. Like turbine blade tips, the vehicles may be moving at speeds high enough to be detected in the Doppler processing channels of a radar signal processor. Unlike wind turbines at fixed locations, road vehicles do change their positions..

2.2 Mark Spencer

In the last sentence of **paragraph 7, page 16**, Mr Spencer states that *"The detection and identification of aircraft in and around windfarm regions is therefore likely to become difficult, as there may be nothing to differentiate them on the screen from a turbine."*

As illustrated in my radar evidence (SWFL8.2), in Newcastle Airport's NIAL8, and my animated ATC Display recordings (SWFL8.4) from which NIAL8 was extracted, aircraft history trails on screen are readily distinguishable from the much more random appearance of wind turbine detections within a wind farm. I have also shown that wind farm areas can easily be marked on the displays, as a further aid to differentiating between aircraft and turbine echoes.

In the **paragraphs immediately following Tables 8 to 13 inclusive**, Mr Spencer states that all turbines in all three wind farms would be detected by the radar, and that they would also be visible on the operators' displays. In practice, the combined actions of the radar clutter map and background averager processing will raise detection thresholds in the vicinity of the wind farms,

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[2] Barton & Leonov, Radar Technology Encyclopedia, 1997

thus ensuring that only a few of the turbines will be detected and displayed on any one rotation of the radar antenna.

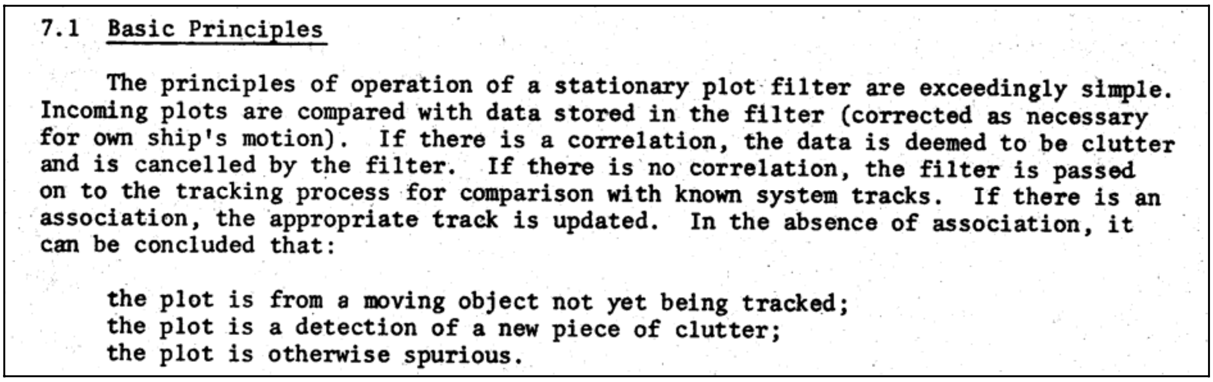
On **page 22, paragraph 35**, Mr Spencer suggests that removal of wind farm clutter from the radar picture would require a significant raising of the detection threshold level in the radar, with consequential loss of many wanted signals. The vast majority of these wanted signals will not be in close proximity to the wind farms. The Watchman radar's clutter map and background averager both automatically adjust their detection thresholds to geographically small, localised conditions, and so there is absolutely no need or justification for deliberately setting global threshold levels as a means to combat localised clutter.

Mr Spencer's **paragraphs 45 and 46** assert that little significant progress has been made towards the development of radar improvements that would help the "wind farm problem": The results of the last DTI/MoD trial aimed at investigating this with two rival solutions have not been released. However, Sensis (one of the competing companies) have published a summary of their half of the results in a paper[3]. These clearly show that significant progress has, in fact, been made. As the Sensis solution is an upgrade to the Plessey Watchman radar, as used at RAF Spadeadam and as the MoD's standard ATC radar, it would be extremely disappointing if the MoD were unaware of these activities.

3 NERL

3.1 Jason Strong

In **paragraph 3.7.3**, Mr Strong addresses the potential risk that false radar tracks may be initiated as a result of different turbines in close proximity (in the same wind farm) being detected on consecutive scans of the radar. Turbines are, of course, at fixed locations, so the radar plot positions they create are amenable to recognition and elimination immediately after the primary radar plot extraction process by a simple, long-established technique known as Stationary Plot Filtering (SPF). The date (1975) of the reference[4] at the bottom of this page show the technique's maturity. The basic concept of an SPF is outlined in this extract from the reference.



7.1 Basic Principles

The principles of operation of a stationary plot filter are exceedingly simple. Incoming plots are compared with data stored in the filter (corrected as necessary for own ship's motion). If there is a correlation, the data is deemed to be clutter and is cancelled by the filter. If there is no correlation, the filter is passed on to the tracking process for comparison with known system tracks. If there is an association, the appropriate track is updated. In the absence of association, it can be concluded that:

the plot is from a moving object not yet being tracked;
the plot is a detection of a new piece of clutter;
the plot is otherwise spurious.

In the case of an SPF implementation for a fixed, ground-based radar, compensation for own ship's motion is obviously not required! The filter would be primed with known point clutter locations (including those from wind turbines), and would prevent the generation of false tracks due to the radar detection of known turbines.

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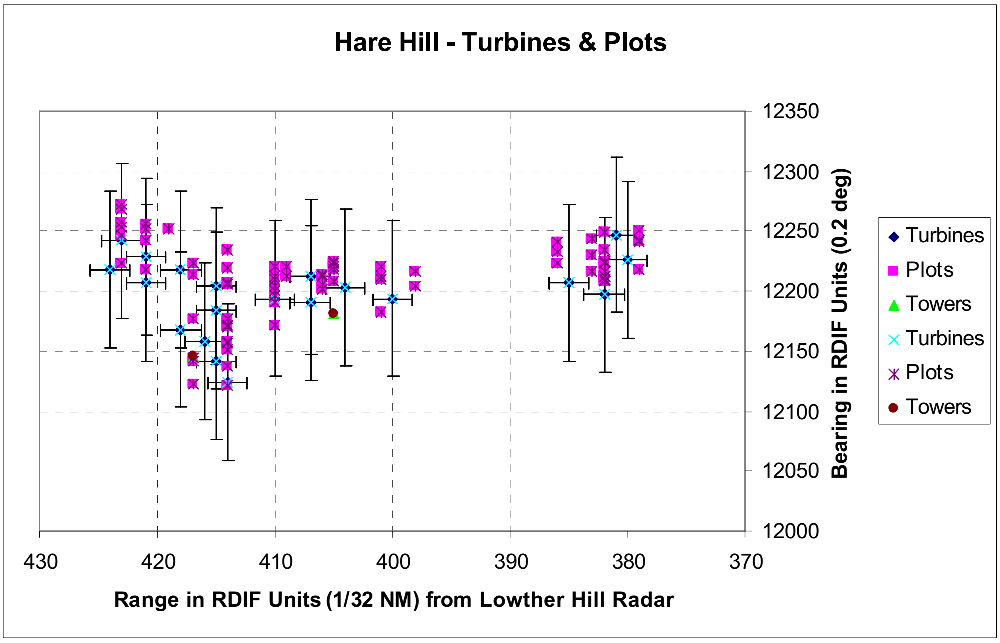
[3] IEEE A& E Systems Magazine, July 2007, pp35-40, "Wind Farm Clutter Mitigation In Air Surveillance Radar"

[4] Quigley & Holmes; The Development Of Algorithms For The Formation And Updating Of Tracks, 1975

Paragraph 3.10 refers to Appendix A. On examination, the two charts on this figure can be seen to have different vertical axis limits. When the axes are correctly aligned there's an apparent misalignment between turbine positions (RH chart) and measured plots (LH chart), due to non-correction for the difference between True North and Ordnance Survey Grid North. I have put these matters right in the following chart. On this chart, I have added "error bars" around the turbine locations, indicating my estimation of the likely errors in turbine positions that can be expected from the plot extraction process. With the possible exception of just 2 of the 77 plots, the areas defined by these error bars clearly encompass the measured turbine plot positions, indicating that turbine plots are amenable to recognition and therefore elimination. If this approach to the elimination of wind turbines echoes were to be adopted, the concerns expressed in paragraphs 6.1, 6.5 and 6.11 would be resolved.



In **paragraph 6.7**, Mr Strong claims that NATS pioneered the development of Multi-Radar Tracking (MRT). To my knowledge, MRT was introduced into some regions of the NATO Air Defence Ground Environment during the 1980s, before NATS had even been thought of.

In paragraphs 6.7 to 6.17, Mr Strong extols the virtues of MRT and apparently seeks to promulgate the view that, without the permanent availability of overlapping radar coverage everywhere within NATS' volume of responsibility, its benefits will be lost. As I indicated in section 2.3 of my Proof (SWFL8-2), albeit without using the term "MRT*", I have also helped my clients to define and develop techniques for multi-sensor integration and data fusion – basically ways in which the deficiencies of single radars can be overcome by combining data from other radars.*

The major benefit of MRT is not improved accuracy (unless several radars are covering the same area), but helping to resolve the deficiencies of single radar coverage. These deficiencies are not limited to turbine-induced clutter, but all other sources of clutter and to loss of low-level coverage due to terrain screening. A well-implemented MRT design incorporates independent clutter maps for each contributing radar. It would automatically select data (if available) from both sources when both are clutter free, and would take due note of the relevant local clutter statistics if one or both were so affected.

Paragraph 6.14 tells us that NATS has a licence commitment which states that it "Must have regard, in providing, developing and maintaining the system, to the demands which are likely to be placed on it in the future." UK/EU policies towards renewable energy sources is surely one of those demands.

Paragraph 6.17 5th bullet states that, as only SCACC is due to be upgraded with MRT, other users of Great Dun Fell data would not benefit from the use of Lowther Hill as a fill-in above the Steadings Wind Farm. Which other users of GDF, other than those represented here, have an interest in this area?

3.2 Anne Isaac

In **paragraph 3.3.1**, Ms Isaac identifies the various types of human error that can occur in human information processing in air traffic control. In particular she refers to perception errors and memory errors, and the way in which these can lead to decision-making errors. In my proof of evidence, paragraph 9.2, I have explained how existing air traffic control display systems can have the areas around windfarms identified on their screens as a reminder to the air traffic controller that these are locations in which turbine clutter may be expected. The marking of windfarms in this way will substantially address any possibility that the controller will misperceive the situation or forget where the wind farms are located.

Paragraph 3.4 .4 goes on to state that the main source of traffic information is from the radar display, and that of the control builds a mental picture of what the situation really is like from this. In fact, the display of historic radar data, whether it is based on radar video or plot extracted symbology, provides a significant input to the provision of situation awareness. As I explained in my proof, controllers can select the length of the historic radar data, and that the appearance on the displays of a genuine aircraft track and the history of reports from turbine plant detections are significantly different. It is this difference that aids the controller to correctly understand the meaning of the radar returns (not a single return, as referred to in the first sentence of **paragraph 6.3**). A quick glance at the collection of individual returns comprising the history trail will quickly make it clear whether or not it represents an aircraft trajectory or a collection of clutter returns.

Paragraph 6.4 suggests that a controller may become complacent about the radar returns from a known clutter area and therefore may overlook a genuine aircraft presence in this region. As the controller can select the duration of the history trail, this can be set to an appropriate length such that it will extend beyond the boundaries of the clutter area. Even when the current aircraft position is inside the clutter area, a tail will be sticking outside as a reminder of the presence of a genuine aircraft.

The distraction caused by flashing information on the radar display is mentioned in **paragraphs 6.7 and 6.7.1**. Information flashing is commonly used to deliberately attract the display users attention to something of specific and immediate interest. It is unclear why turbine echoes, detected intermittently as they are, should be viewed as flashing on the displays.

Firstly, let us consider how an aircraft is displayed to the operator in the case of a radar which, like that at great Dun fell, rotates at 7.5 rpm. On first detection, the aircraft's position is denoted by the appearance of a small cross. This remains static for eight seconds. It then changes to a dot, while a new cross appears at the latest aircraft position. If we assume that the operator has selected one minute's worth of history, this process will eventually lead to a series of seven dots headed by a single cross. From this point onwards, the cross will continue to advance across the screen, staying in one place while the last dot will be removed after it has been static on the display for one minute. This obviously does not constitute flashing, as otherwise the air traffic controller would be constantly distracted from the aircraft of interest by other aircraft appearing on the display.

What happens inside a wind farm? An individual turbine, on detection, will create a cross at its location. If, on the next rotation of the radar antenna, it is again detected, the cross will remain in place. If it is not detected this time the cross will become a dot. An individual turbine will never have a history trail. However, the collection of turbines inside the wind farm boundaries will asynchronously exhibit the same behaviour. This will lead to the crosses inside the wind farm boundary apparently moving from one place to another. The changes to the appearance of the display in this region will occur just once every eight seconds (in the case of the Great Dun Fell radar), and the new appearance will be fixed for the next eight seconds. This cannot seriously be argued to represent “flashing”.

4 NIA

4.1 Keith Rodgers

In **paragraph 5.3.4.**1, Mr Rodgers suggests that turbines between the radar and the aircraft will prevent a target being generated. In fact, the physics which govern the propagation of microwave energy ensure that the shadow behind a wind turbine fills in very rapidly, and so any aircraft masking is limited to a short distance behind the turbine is. At such short distances, a turbine will remain between radar and aircraft only for a very short area of time. The shadow itself is that cast by the turbine itself as viewed from the radar. In the case of a turbine at 25 Km from the radar (typical of Steadings), the angular extent of the shadow due to a turbine tower would be about 0.02 degrees, while even the blades broadside on sweep only about 0.25 degrees, or 1/10th of the angular width over which an aircraft generates detectable responses to the radar.

To overcome any residual perceived problems of **5.3.4.2**, in which an air traffic controller might be misled into believing that turbines cut returns might represent an aircraft, the simple and readily available process for marking wind farm areas on the existing air traffic control displays will serve as a strong reminder that radar returns within the confines of the wind farm are extremely unlikely to be from an aircraft. Mr Rodgers implies that a controller only need issue separation instructions if he believes that there is an aircraft present inside the windfarm area. Given the presence of history trails behind real aircraft tracks, it is difficult to imagine how an aircraft had entered the windfarm and then stayed hidden in it for long enough for its history to disappear.

Section 9 of Mr Rodgers’ evidence addresses some generic mitigation techniques, some of which are not even potentially applicable to NIA’s existing primary radar. The only one of these that I believe would possibly have any relevance to NIA is the Radar Mosaic (**9.2.8**) which, as I indicated in section 9.3 of my Proof of Evidence, is being implemented at Glasgow Airport. I have seen no documented evidence to support the assertion (9.2.9) that the CAA questions whether sufficient low level cover could be provided, nor have I seen a definition of what level is required. The NATS radar at Lowther Hill could potentially provide cover down to a few hundred metres above ground level in the vicinity of Steadings, while the now-withdrawn MoD objection on air defence radar grounds strongly indicated that the Brizlee Wood radar could just see down to turbine tip height.

In Section 10, Specific Mitigation Proposals, Mr Rodgers has not commented on my recommendation that the areas around the wind farms can be marked on the displays as a way to help the air traffic controller to avoid mistaking turbine returns for true aircraft returns. These can be implemented simply by adding the definitions of the areas, including boundaries and shading, in the set-up files for the existing radar displays. NIAL8 clearly shows the existing use of areas defined in this way for various purposes, and my recommendation is simply the addition of another category.