COLEMAN AVIATION LTD

Aviation Technical Appendix

for

HARRYBURN WIND FARM

on behalf of

Innogy Renewables UK Ltd

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INTRODUCTION

The Harryburn Wind Farm site was originally assessed as 2 separate areas which were initially known as Elvanfoot and Leadhills. In 2014, Innogy Renewables UK Ltd (known at that time as RWE Npower Renewables Ltd (RNRL)) commissioned Osprey Consulting Services Ltd (Osprey CSL) to provide Aviation Impact Assessments (AIA) on both areas.

In February 2015, Innogy Renewables UK Ltd commissioned Coleman Aviation Ltd to provide advice on the aviation issues associated with the Elvanfoot and Leadhills sites which have since been amalgamated into one development and renamed as Harryburn Wind Farm.

The AIA produced by Osprey CSL accurately identified the potential aviation issues associated with the Harryburn development area. As a result, Coleman Aviation Ltd undertook to consult with the relevant aviation stakeholders in order to resolve any potential aviation issues prior to submission of a formal planning application.

During this consultation period, the layout and turbine numbers were revised on numerous occasions but for consistency, initial consultation took place on the basis of a 41 turbine layout with a maximum tip height of 130m. This was subsequently reduced to a 27 turbine layout but with a maximum tip height of 149.9m prior to submission of a Scoping Opinion request in May 2016. The site has since been further reduced to 17 turbines with a maximum tip height of 149.9m.

SCOPE

This report will provide an overview of the original AIA conclusions completed by Osprey CSL and explain how the aviation issues have been resolved by means of consultation with the relevant aviation stakeholders. It will also address other potential aviation issues raised in the Scoping Opinion responses.

OSPREY CSL AIAs

The AIAs completed by Osprey CSL provided an overview of the parameters and footprint for the Elvanfoot and Leadhills sites which encompassed the entire area now known as Harryburn Wind Farm. These AIAs provided an accurate baseline of the aviation environment within which the Harryburn site is situated; public release versions of these reports can be found at Enclosures A and B. In terms of potential aviation issues, the AIA

identified the following aviation stakeholders and receptors that may be affected by wind turbines in the development area:

Glasgow Prestwick Airport - due to potential adverse impact on the Primary Surveillance Radar (PSR).

National Air Traffic Services En-Route Plc (NERL) - due to potential adverse impact on the:

- Lowther Hill PSR; and the
- Cumbernauld PSR.

Ministry of Defence (MoD) – due to potential adverse impact on:

- Low Flying operations; and the
- Eskdalemuir Seismological Recording Station.

AVIATION STAKEHOLDER CONSULTATION

For the past 2 years, Coleman Aviation Ltd has been in negotiation with the aviation stakeholders relevant to the Harryburn Wind Farm development. Furthermore, all of the aviation stakeholders responded to the Harryburn Scoping Report which was submitted in May 2016. Taking each of the aviation stakeholders in turn:

GLASGOW PRESTWICK AIRPORT

The original AIA carried out by Osprey CSL indicated that only 2 turbines would be in radar-line-of-sight (RLOS) to the Glasgow Prestwick Airport PSR; and that ATC operations would not be affected. However, as revised turbine layouts were put forward, Coleman Aviation continued to liaise directly with Glasgow Prestwick to ensure that the new layouts did not adversely affect ATC operations at the airport. Although the final layout for Harryburn involved considerably larger turbines than were originally assessed in the AIA (149.9m as opposed to 130m), Prestwick Airport confirmed in their Scoping Opinion response (dated 11 June 2016) that the Harryburn development would not cause any safeguarding issues for the airport; their response can be reviewed at Enclosure C. As a result, an objection from Glasgow Prestwick Airport is not expected.

NATS EN-ROUTE LTD (NERL)

Following completion of the Osprey CSL AIA, NERL was commissioned to complete their own Technical and Operational Assessments (TOPA) on the Elvanfoot site (TOPA 18687) and a separate assessment of the Elvanfoot and Leadhills sites combined (TOPA 18688); these TOPA are included respectively at Enclosures D and E. In these assessments, NERL confirmed that there would be unacceptable impact on both the Lowther Hill and Cumbernauld PSRs and that mitigation would be required. As a result, Coleman Aviation entered into detailed consultation with NERL and, as turbine layouts and tips heights were refined, NERL agreed to carry out a further TOPA based on the 41 turbine layout. This confirmed that both Lowther Hill and Cumbernauld PSRs would be in RLOS of the turbines resulting in unacceptable interference to both radars. Further consultation with NERL followed to identify potential mitigation options and on 30 July 2015, NERL produced a mitigation offer which they were prepared to hold open subject to Innogy Renewables UK entering into contract. The mitigation proposal itself involves:

Radar blanking of the Harryburn turbines;

Infill data provided from 2 radar sources:

- Glasgow Airport PSR (owned and operated by National Air Traffic Services Ltd (NATS)); and

- Kincardine PSR (owned and operated by Sottish Power Renewables Ltd (SPR)).

Following design freeze in which the turbine numbers were reduced to 17 with the maximum tip height increased to 149.9m, NERL were re-consulted to ascertain whether mitigation was still required and at what level. On 8 February 2017, NERL confirmed by e-mail (Enclosure F) that mitigation was still required and that the mitigation offer dated 30 July 2015 was still valid. Innogy Renewables UK are yet to enter contract negotiations with NERL and SPR however, the path to mitigation has been clearly identified and any objection by NERL will be easily resolvable.

MINISTRY OF DEFENCE (MoD)

Consultation with the MoD commenced in February 2015 and, at that time, the MoD were not conducting pre-planning consultation due to lack of resources. However, on the basis that Harryburn would be submitted as a Section 36 application, the MoD agreed to carry out a full aviation assessment. Following this assessment, the

MoD wrote on 1 April 2015 (Enclosure G) confirming that they had no objection to the development; however, this response was caveated in that, if the cumulative situation changed in future, an objection may be necessary when the formal planning application is submitted. In particular, 2 potential areas of concern were highlighted:

Eskdalemuir Seismological Recording Station. The MoD outlined the following regarding the Eskdalemuir Seismological Recording Station:

"….this site is within the consultation zone for the seismological recording station at Eskdalemuir. Following research jointly commissioned by DTI, BWEA and MOD, it has been confirmed that wind turbines of current design generate seismic noise which can interfere with the operational functionality of the array. In order to ensure the UK complies with the Comprehensive Nuclear-Test-Ban Treaty, a noise budget based on the findings of the research has been allocated by the MOD for a 50 km radius surrounding the array. The budget has been set at 0.336 nm rms. The noise budget is allocated to planning applications that fall within the zone on a first come first serve basis. We cannot allocate any of the noise budget to this application until such time as we receive formal consultation on the Section 36 Application from The Scottish Government, and we cannot predict how much of the noise budget will have been allocated at the time that the planning application is submitted. If the budget has been fully allocated at the time that the planning application is submitted, MOD will object to the application."

Coleman Aviation continued to consult regularly with the MoD who confirmed that the noise tolerance budget was extremely unlikely to be exceeded prior to submission of a formal planning application. Following submission of the Scoping Opinion request, the MoD confirmed by e-mail on 7 September 2016 (Enclosure H) that Harryburn had now been added to the noise allocation budget for Eskdalemuir. As a result, there will be no objection from the MoD regarding the Eskdalemuir Seismological Recording Station.

Low Flying. In their letter of 1 April 2015 (Enclosure G), the MoD confirmed that the layout of the 42 turbine proposal was acceptable but reserved the right to object at a later date should the cumulative situation in the vicinity of Harryburn change significantly. Their only stipulation was for aviation lighting to be installed; the relevant section of their letter stated:

"*In the interests of air safety the MOD will request that the cardinal turbines are fitted with 25cd and IR combination aviation lighting and the perimeter turbines are fitted with 25cd or IR lighting with an optimised flash pattern of 60 flashes per minute of 200ms to 500ms duration at the highest practicable point."*

As revised turbine layouts were put forward, Coleman Aviation continued to liaise with the MoD to ensure that the new layouts did not adversely affect low flying operations. Following submission of the Scoping Opinion request, the MoD responded to this on 4 July 2016 (Enclosure I) stating that:

"In the interests of air safety the MOD will request that the development should be fitted with aviation lighting in accordance with Civil Aviation Authority (CAA) direction and CAP 393 Air Navigation Order Section 1 Part 28."

This change in response was apparently triggered by the increase in turbine tip height to 149.9m which the MoD interpreted as 150m. At 150m, CAA policy for aviation lighting supersedes MoD policy on aviation lighting. Coleman Aviation re-consulted with the MoD pointing out that the Harryburn turbines were in fact 149.9m. The MoD subsequently confirmed by e-mail on 16 September 2016 (Enclosure J) that the original the lighting requirements stated in their letter of 1 April 2015 remained the same for the 27 turbine layout submitted in the Scoping Opinion. Consequently, and subject to their aviation lighting requirement, the MoD are not expected to object due to adverse impact on low flying operations.

OTHER ISSUES RAISED IN SCOPING OPINION RESPONSES

Two other potential aviation issues were raised in the Scoping Opinion responses. The MoD requested in their response (Enclosure I) that the Meteorological (Met) Office be consulted; and the CAA response dated 16 June 2016 (Enclosure K) requested that the Emergency Service Helicopter Support Units (ESHSUs) be consulted:

Met Office. The MoD scoping response stated that if a wind turbine application falls within any of the Met Office safeguarded zones, the

developer would need to contact the Met Office directly. Liaison with the Met Office has confirmed that the Harryburn development area is not within any of the Met Office safeguarded zones therefore an objection is not expected.

ESHSUs. The CAA recommended that ESHSUs be consulted; these include Air Ambulance and Police services as well as the Maritime Coastguard Agency responsible for Search and Rescue. Coleman Aviation has commenced dialogue with each of these agencies. Their involvement with wind farm planning is still developing and neither agency yet has a clearly defined policy for dealing with the impacts of wind turbines. That said, the manner in which helicopter agencies are expected to mitigate the impact of wind turbines is by means of effective aviation lighting. This is already covered by the MoD's stance on aviation lighting and therefore an objection from any of the ESHSUs is considered highly unlikely but, if necessary, easily resolved.

SUMMARY

The Harryburn Wind Farm site has been the subject of extensive research and investigation into potential aviation issues. The site was originally assessed as 2 separate areas (Elvanfoot and Leadhills) but has since been amalgamated into one site and renamed Harryburn Wind Farm. Through commissioning of detailed AIAs, the potential aviation issues were clearly identified allowing meaningful and productive consultation with the relevant aviation stakeholders. Despite numerous turbine layout changes, Coleman Aviation has maintained dialogue with the various aviation stakeholders (namely, Glasgow Prestwick Airport, NERL and the MoD) and all aviation issues have either been resolved or a path to mitigation identified. The only objection expected from the planning application is from NERL due to adverse impact on the Lowther Hill and Cumbernauld PSRs; however, detailed discussion with NERL has resulted in an offer of mitigation which would allow Innogy Renewables UK to resolve this objection easily. All relevant aviation stakeholders responded to the Scoping Opinion request which was submitted in May 2016 as a 27 turbine development with a maximum tip height of 149.9m. The Scoping Opinion responses from the main aviation stakeholders were consistent with the negotiations and discussions held with Coleman Aviation. Although the MoD and CAA respectively requested that the developer consult with the Met Office and Emergency Service Helicopters units. Liaison with the Met Office revealed that Harryburn is not within any Met Office safeguarded areas and that any concerns by Emergency Service Helicopter units are resolvable by means of aviation lighting.

Since the Scoping Opinion, the site has been further reduced to 17 turbines but still with a maximum tip height of 149.9m. This is not expected to influence any of the aviation stakeholders' previous assessments.

ENCLOSURES:

A. Elvanfoot Wind Farm Aviation Impact Assessment (AIA) - 23 March 2017.
B. Leadhills Wind Farm Aviation Impact Assessment (AIA) - 23 March 2017.
C. Glasgow Prestwick Airport Response to Harryburn Scoping Opinion - 11 June 2016.
D. NERL Technical and Operational Assessment for Harryburn North Wind Farm - February 2014.
E. NERL Technical and Operational Assessment for Harryburn North and South Wind Farms - April 2014.
F. NERL e-mail confirming Lowther Hill and Cumbernauld PSR mitigation requirement - 8 February 2017.
G. MoD response to Pre-Application request for Harryburn Wind farm - 1 April 2015.
H. MoD e-mail including Harryburn to Eskdalemuir noise allocation budget - 7 September 2016.
I. MoD response to Harryburn Scoping Opinion request – 4 July 2016.
J. MoD e-mail confirming Low Flying lighting requirement - 16 September 2016.
K. CAA response to Harryburn Scoping Opinion request – 13 June 2016.

Osprey
Consulting Services Ltd

Elvanfoot Wind Farm Aviation Impact Assessment

Ref: 7677/001 Issue 2

Date: 23rd March 2017

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EXECUTIVE SUMMARY

RWE Npower Renewables (RWE NRL) are planning a wind energy development known as Elvanfoot Wind Farm, on land approximately 10 kilometres (km) northwest of Daer Reservoir, South Lanarkshire, Scotland. Ten turbines are planned for the site with a blade tip height of 130 metres (m). Another wind farm is proposed by RWE NRL, Leadhills Wind Farm, is adjacent to the Elvanfoot Wind Farm; a separate assessment has been completed on the Leadhills Wind Farm. A summary comparison of the two wind farms can be found in Annex A to this document.

RWE NRL has commissioned Osprey Consulting Services Ltd (Osprey) to complete this analysis.

Operational Impact

Prestwick Airport

Radar Line of Sight (LoS) analysis indicates that theoretically all ten turbines are not detectable to the Prestwick Airport Primary Surveillance Radar (PSR); therefore it is highly unlikely that operations at the Airport will be affected by the development.

National Air Traffic Services (NATS)

As a consequence of theoretical radar detectability to the Lowther Hill and Cumbernauld PSRs, NATS may consider the Wind Farm to present an unacceptable impact on NATS en-route operations.

The Wind Farm is below the Scottish Terminal Control Area (TMA), a complex airways structure heavily utilised by aircraft under the control of NATS; and is an area where normal and regular handover of aircraft between NATS and the Scottish Airports air traffic control will take place. It is considered that the anticipated turbine effects are highly likely to be considered to pose a detrimental effect on routine NATS operations.

There is a collocated Secondary Surveillance Radar (SSR) located at Lowther Hill and at 8.6 km (estimated measurement from radar antenna) the Wind Farm is inside the 24 km consultation zone for SSR. SSR works by interrogating aircraft transponders to obtain information on aircraft heading, height, identification etc. Mode-S is a modern implementation of SSR which is less susceptible to 'reflections' from large structures/turbines than the traditional Mode-A/C SSR. All NATS radars have been upgraded to Mode-S but because all aircraft are not yet Mode-S compatible there are some residual effects linked to continued use of Mode-A/C.

Mitigation Option Capability:

1. At this early stage in the planning process for Elvanfoot, Osprey recommends that RWE NRL gives serious thought to the potential for designing out the impact on NATS Lowther Hill through removal or relocation of the four detectable turbines. Consultation with NATS could then concentrate on the tolerability of any potential impact on the Cumbernauld PSR;
2. The use of data from the Glasgow Airport PSR into the NATS MRT system is considered as a potential technical mitigation option. This will effectively

suppress/remove the radar returns in the vicinity of the Wind Farm and prevent the turbines producing clutter on NATS radar displays;

3. Raytheon Modification (Project RM) is however considered unsuitable for mitigation of Elvanfoot: The close location of the development to the Lowther Hill PSR is expected to rule out this form of mitigation solution for the Elvanfoot Wind Farm. It is a requirement of the mitigation that the Wind Farm be located outside 9 NM (16.6 km) from the PSR; and
4. There is no known technical mitigation available against the effects on the Lowther Hill SSR, however the effects of turbines on SSR systems are also relatively poorly understood and there is little, if any, recorded specific research. Consultation with NATS is required to investigate potential effects to the Lowther Hill SSR.

MoD Low Flying

The MoD may object to the Elvanfoot Wind Farm proposal based on the proliferation of obstacles and the impact to utilisation of the areas to complete essential low flying training. The proposed turbines would be located within Low Flying Area (LFA) 16 and Tactical Training Area (TTA) 20T which are considered by the MoD to be high priority low flying training areas. Therefore, turbine construction in this region could raise considerable and significant MoD concerns.

The issue of the proliferation of wind turbines in both LFA 16 and TTA 20T is of key concern to the MoD. MoD may request that all turbines are fitted with 25candela omni-directional red lighting or infrared lighting with an optimised flash pattern of 60 flashes per minute of 200ms to 500ms duration at the highest practicable point; it is considered important that wind developers initiate consultation with the MoD as soon as practicable within the site design process.

Eskdalemuir Seismic Array

The Elvanfoot Wind Farm would be located approximately 32.9 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area. It is highly likely that the MoD will object to the development based on its proximity to Eskdalemuir; however initial stage 0 research work, conducted by the Eskdalemuir Working Group (EWG) indicates that there is significant headroom budget available. The detailed research and generation of a revised safeguarding model (Stage 1) is expected to be concluded by the end of January 2014.

Any change in MOD Policy will most likely come after a Scottish Government led consultation and cross-Government department collaboration on working to develop an updated Eskdalemuir Safeguarding Policy.

Recommendations

Osprey first recommends that RWE NRL consider potential for redesigning the site to eliminate the potential impact on Lowther Hill PSR.

RWE NRL considers further investigation with NATS regarding the viability of implementing the suggested mitigation scheme for the Lowther Hill PSR and consultation is completed to understand any potential effect to the Cumbernauld PSR;

PSR – data from the Glasgow Airport PSR into the NATS MRT system ; and

Consultation with NATS to investigate any potential effects to the Lowther Hill SSR.

To limit the effect of the Wind Farm on Military Low Flying activities, RWE NRL considers early engagement with the MoD to ascertain the potential for MoD constraints. Additionally, consideration should be given to satisfying any request from the MoD to fit the Wind Farm with a form of aviation obstruction lighting.

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1. INTRODUCTION

1.1. General

RWE Npower Renewables (RWE NRL) are planning a wind energy development known as Elvanfoot Wind Farm, on land located in South Lanarkshire, Scotland, approximately 10 kilometres (km) northwest of the Daer Reservoir. Ten turbines are planned for the site with a blade tip height of 130 metres (m). Another wind farm is proposed by RWE NRL, Leadhills Wind Farm, is adjacent to the Elvanfoot Wind Farm; a separate assessment has been completed for Leadhills Wind Farm. A summary comparison of the two wind farms can be found in Annex A to this document.

All analysis has been carried out in accordance with Civil Aviation Authority (CAA) guidance in Civil Aviation Publication (CAP) 764 [Reference 1].

RWE NRL has commissioned Osprey Consulting Services Ltd (Osprey) to complete this analysis. Over the past five years, Osprey has developed a reputation for excellence in the field of wind energy and aviation impact. Osprey applies a combination of Air Traffic Control (ATC) operational and engineering expertise to projects in order to identify and deliver credible mitigation solutions that are proportional to the scale of the wind development. Osprey has extensive experience in integrating equipment into an Air Traffic Control environment and working with wind farm mitigation suppliers. Of particular note, Osprey has specialised in the specification, procurement and systems integration of communication, navigation and surveillance systems, having completed in excess of 30 projects in this area in the past five years. Osprey has a credible reputation for gaining regulatory approvals for new technologies and wrote the 'first' Safety Cases for all Thales ATM products (including the STAR 2000), the Safety Case Part 1 for Aveillant HR Infill™ and the C Speed LightWave radar.

1.2. Background

This report presents the results of Osprey's independent assessment of the likely operational impact on the Aviation Stakeholders listed in Table 1 below.

Stakeholder	Type	Approximate Distance	Approximate Bearing to wind farm
Prestwick Airport	Civil Airport with Radar	56.7 km/30.6 NM	095°
Edinburgh Airport	Civil Airport with Radar	57.7 km/31.1 NM	198°
Glasgow Airport	Civil Airport with Radar	66.6 km/35.9 NM	135°
NATS Lowther Hill	Civil En-Route Radar	8.6 km/4.6 NM	032°

Stakeholder	Type	Approximate Distance	Approximate Bearing to wind farm
NATS Great Dun Fell	Civil En-Route Radar	115.3 km/62.2 NM	317°
NATS Tiree	Civil En-Route Radar	231.0 km/124.7 NM	117°
NATS Perwinnes	Civil En-Route Radar	217 km/117.9 NM	206°
Cumbernauld	Civil En-Route Radar	58.9 km/31.8 NM	155°
Kincardine	Civil En-Route Radar	68.5 km/37.0 NM	176°
Eskdalemuir	Seismic Array	32.9 km/17.7 NM	299°

Table 1 Identified Aviation Stakeholders

No other Aviation Stakeholders in the region of the development were identified.

1.3. Wind Turbine Effects on Aviation

While the effects of wind turbines on aviation interests have been widely publicised the primary concern is one of safety. There are innumerable subtleties in the actual effects but there are two dominant scenarios that lead to objection from aviation stakeholders:

1. Physical: Turbines can present a physical obstruction at or close to an aerodrome; and
2. Radar/Air Traffic Services (ATS): Turbine clutter appearing on radar displays can affect the safe provision of ATS as it can mask unidentified aircraft from the air traffic controller and/or prevent the controller from accurately identifying aircraft under control. In some cases, radar reflections from the turbines can affect the performance of the radar system itself.

1.4. Purpose, Methodology and Scope

1.4.1. Purpose

This assessment considers the impact of the turbines once they are fully installed and does not consider any safety issues relating to the construction, installation, through life support or visibility of the turbines on the site. However, Osprey recommends that the developer considers the information in this report when assessing the safety of any installation, construction or maintenance phases with respect to aviation interests.

1.4.2. Notification and Lighting Requirements

Tall slender constructions such as wind turbines or anemometer masts, despite their size, can be difficult to see from the air in certain weather conditions. Guidance has been issued by RenewableUK [Reference 2], which recommends that to facilitate safe visual flight, day or night, in the vicinity of anemometer masts and/or turbines:

> Information regarding construction should be passed to the Defence Geographic Centre and the General Aviation Awareness Council at least 6 weeks in advance of the erection or removal of an anemometer mast or first turbine and to follow up on the day with a confirmation that the activity has taken place;
>
> - Data should include location, height (of all structures over 150 feet (ft)), date of erection, date of removal and lighting type (none, infra-red or lighting brightness);
> - Local aerodromes identified during consultation should be notified, particularly any police helicopter or air ambulance unit; and
> - RenewableUK should be copied on the submission of all such information as an independent record and that they might share the information with other relevant official agencies.
>
> Appropriate information about the site construction and any associated lighting (where applicable), for example the height and temporary location of construction cranes, should be provided to the UK Aeronautical Information Service (NATS AIS) for promulgation in applicable aviation publications including the UK Integrated Aeronautical Information Package (UKIAIP) [Reference 3].

Other relevant existing legislation regarding land-based obstacles to air navigation includes the following:

> Obstacles close to licensed aerodromes: Section 47, Civil Aviation Act 1982;
>
> Obstacles close to government aerodromes: Town and Country Act, (Government permitted development) Order 2000; and
>
> Lighting of land-based tall structures (outside of aerodrome safeguarded areas): Article 219, Air Navigation Order 2012 (CAP 393).

1.4.3. Radar Line of Sight (LoS) Analysis and Caveat

Osprey used the ATDI ICS LT (Version 2) tool to model the terrain elevation profile between the identified radar systems and the Elvanfoot Wind Farm. Otherwise known as a point-to-point LoS analysis the result is a graphical representation of the intervening terrain and the direct signal LoS (taking into account earth curvature and radar signal properties).

Caveat: This is a limited and theoretical desk based study; in reality there are unpredictable levels of signal diffraction and attenuation within a given radar environment (ambient air pressure, density and humidity) that can influence the probability of a turbine being detected. Our analysis is designed to give an indication of the likelihood of the turbine being detected such that the operational significance of the turbine relative to nearby aviation assets can be assessed.

Although every care is taken during the line of sight modelling and analysis process, modelling limitations and assumptions obviously lead our conclusions to be based on theoretical results. The results are therefore indicative, and actual radar performance may differ from this analysis.

The qualitative definitions used in our assessment are defined in Table 2 below.

Result	Definition
Yes	the turbine is highly likely to be detected by the radar: direct LOS exists between the radar and the turbine
Likely	the turbine is likely to be detected by the radar at least intermittently
Unlikely	the turbine is unlikely to be detected by the radar but cannot rule out occasional detection
No	the turbine is unlikely to be detected by the radar as significant intervening terrain exists

Table 2 Qualitative Definitions of LoS results

The complete LoS results are contained in 7677/002 RWE NRL Elvanfoot Report LoS Diagrams Issue 1 attached with this assessment.

1.5. Document Structure

The document utilises the following structure:

Section 1 gives an introduction to the report;

Section 2 provides details of the Elvanfoot Wind Farm, its parameters and location;

Section 3 introduces the existing Aviation environment in the vicinity of the development;

Section 4 considers the potential of the development to affect operations at Glasgow Prestwick Airport;

Section 5 looks at the potential effect on NATS infrastructure and operations;

Section 6 studies potential mitigation options;

Section 7 assesses the potential for impact on MoD operations in the region;

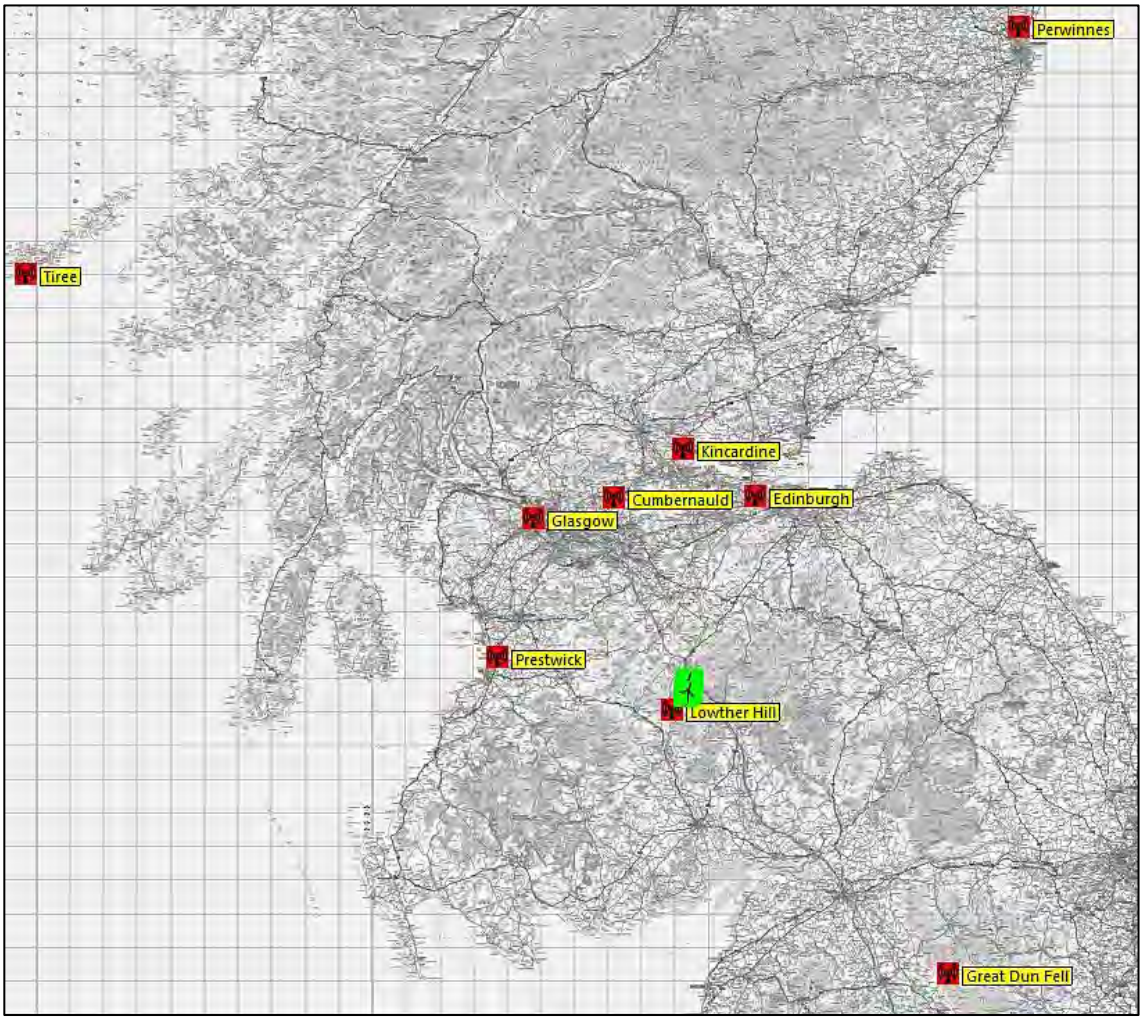
Section 8 gives the conclusions and recommendations and is followed by a list of references used throughout the analysis; and

There is one Annex which compares and contrasts the viability of the Elvanfoot and Leadhills Wind Farms.

2. ELVANFOOT WIND FARM

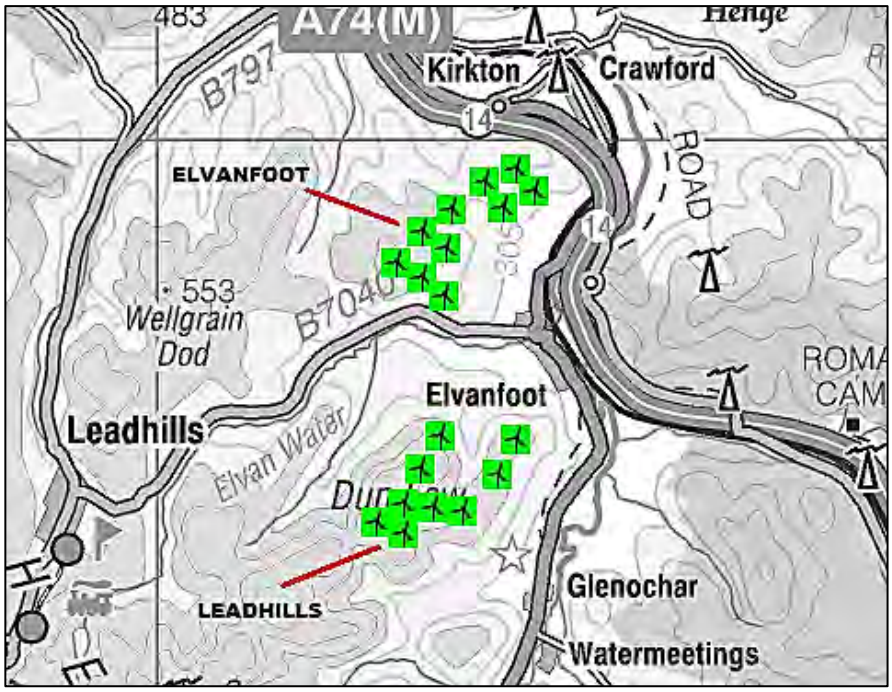
2.1. Overview

RWE NRL is proposing the Elvanfoot Wind Farm consisting of ten turbines on land located approximately 10 km northwest of the Daer Reservoir, South Lanarkshire, Scotland. Figure 1 below illustrates the regional radar assessed within this document in relation to the location of the proposed wind farm and Figure 2 gives an indicative layout of the Wind Farm, together with the layout of the adjacent proposed Leadhills development.



This map shows estimated location data which may be subject to error and is provided for reference only. This map has been produced by Osprey Consulting Services Ltd using the OS OpenData 1:250000 2009 Scale Raster. Contains Ordnance Survey Data © Crown Copyright and database right 2013.

Figure 1 Regional Radar Locations and position of Elvanfoot Wind Farm (not to scale)



This map shows estimated location data which may be subject to error and is provided for reference only. This map has been produced by Osprey Consulting Services Ltd using the OS OpenData 1:250000 2009 Scale Raster. Contains Ordnance Survey Data © Crown Copyright and database right 2013.

Figure 2 Elvanfoot Wind Farm Indicative Layout

2.2. Turbine Parameters

The candidate turbines have a maximum anticipated blade tip height of 130 m and the individual turbine coordinates are given in Table 3.

Ref	Easting	Northing	Lat/Long
T1	293229	618303	N55°26′48.88″ W003°41′22.25″
T2	293563	618111	N55°26′42.94″ W003°41′02.98″
T3	293858	617867	N55°26′35.28″ W003°40′45.87″
T4	293897	618506	N55°26′55.97″ W003°40′44.53″
T5	293967	619035	N55°27′13.13″ W003°40′41.27″
T6	294426	619394	N55°27′25.09″ W003°40′15.65″
T7	294679	619061	N55°27′14.52″ W003°40′00.80″
T8	295090	619285	N55°27′22.08″ W003°39′37.72″
T9	294833	619593	N55°27′31.84″ W003°39′52.76″
T10	293557	618727	N55°27′02.85″ W003°41′04.17″

Table 3 Elvanfoot Wind Farm Turbine Coordinates

2.3. Development Footprint

The physical size of the Elvanfoot Wind Farm on the ground is approximately 1.71 km (north to south) by 1.76 km (east to west)[1]. Assuming a nominally accepted 100m wide[2] margin for unwanted radar returns either side of a single turbine, the potential size of the Wind Farm footprint as represented on a typical Primary Surveillance Radar (PSR) display system is around 1.91 km by 1.96 km. Therefore, the radar footprint could equal an approximate total area of 3.74 km^2 (1.31 square nautical miles (NM^2)); however, dependent on the detectability of the wind farm will dictate the radar footprint presented.

[1] Note that in the aviation industry, an apparently curious mix of measurement units is used. Air Traffic Controllers and pilots use feet (ft) and nautical miles (NM) for measurement in the air (altitude, range) but lengths on the ground e.g. runway lengths, are given in metres (m). Equivalent alternative units will be given only when it is appropriate to do so.

[2] This is an estimate; the size of the clutter will depend on range and the specific operating parameters of the radar (e.g. range-azimuth cell size) i.e. the clutter could appear larger at a greater range from the radar.

3. AIRSPACE BASELINE ENVIRONMENT

3.1. Overview

The airspace in the vicinity of, and above the Elvanfoot Wind Farm is categorised as follows, and a cross section is shown in Figure 3.

Class G uncontrolled airspace from surface level to 5,500 feet (ft), anyone can fly here without permission of air traffic control;

Class D controlled airspace is established above from 5,500 ft above mean sea level (amsl) to Flight Level (FL) 195 (approximately 19,500 ft) which forms the Scottish Terminal Control Area (TMA); airspace which is used for the protection of flights into and out of Edinburgh, Glasgow and Glasgow Prestwick Airports. All aircraft operating in this airspace must be in receipt of an air traffic service from NATS, Military controllers located at a NATS control centre, or a controller from the three airports if required; and

Class C controlled airspace is established above the Scottish TMA; all aircraft operating in this airspace must be in receipt of an air traffic service from NATS or Military controllers located at a NATS control centre.

In addition, the proposed turbines would be located within Low Flying Area (LFA) 16 and when the area is active, within Tactical Training Area (TTA) 20T. These areas are located in southern Scotland, which includes the Borders Region, Dumfries and Galloway and other counties up to and including those within the central belt of Scotland.

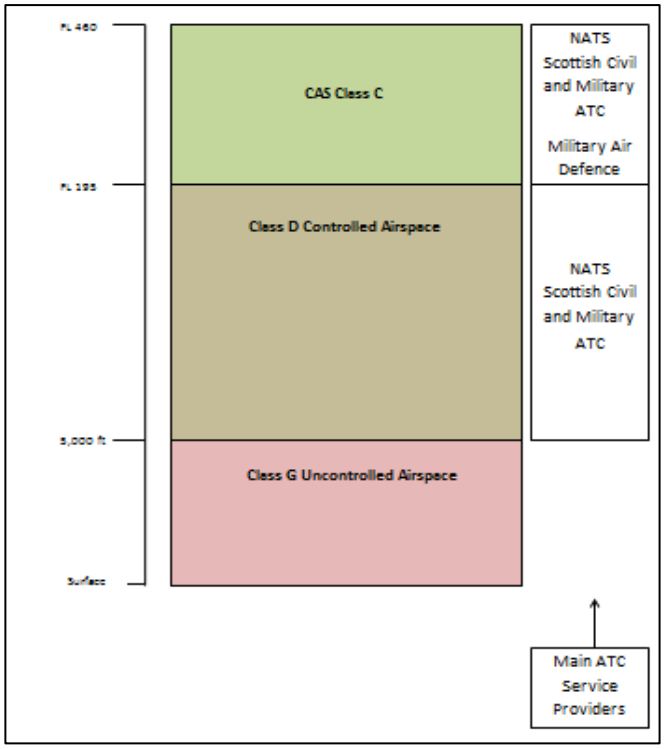


Figure 3 Categorisation of Airspace in the vicinity of Elvanfoot Wind Farm

Figure 4 below shows the approximate position of the Elvanfoot Wind Farm in relation to the established Scottish TMA Controlled Airspace.

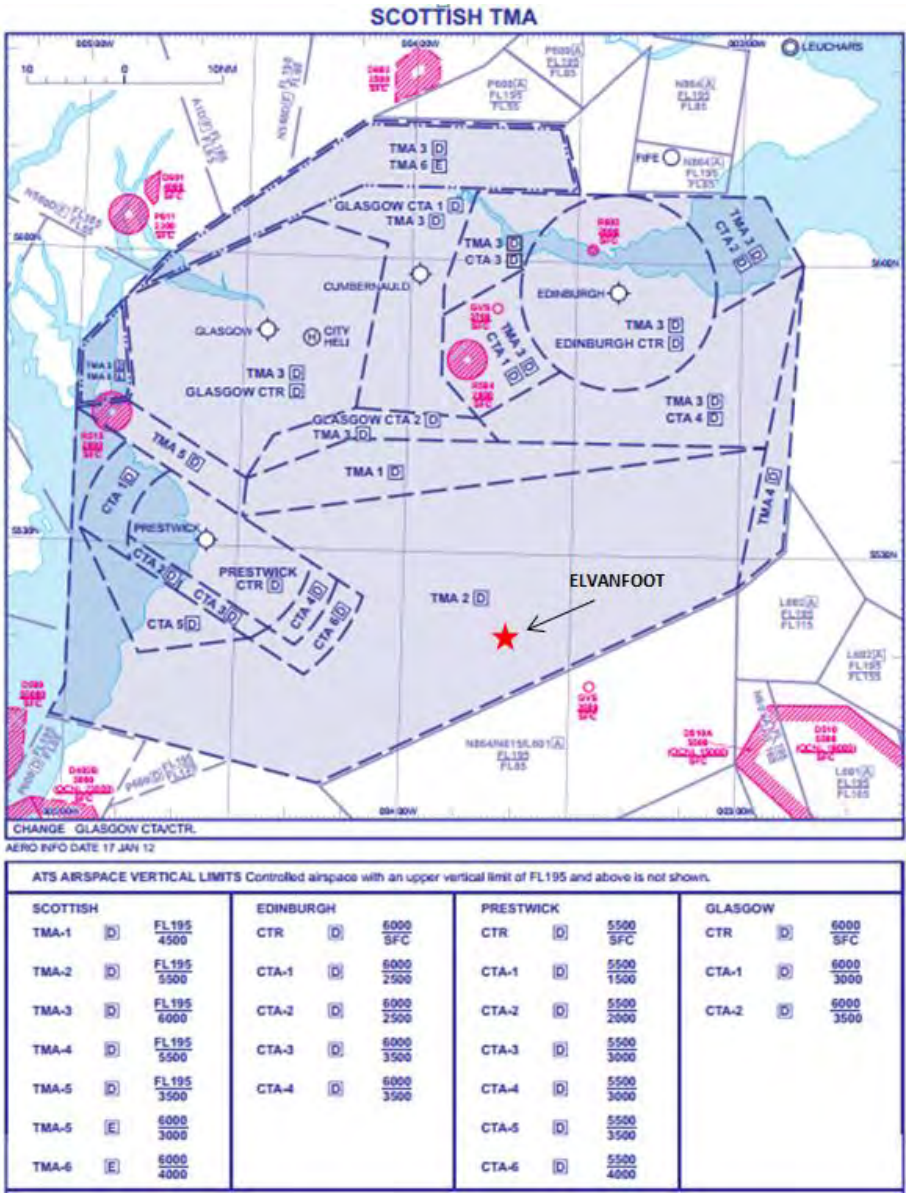


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Figure 4 Airspace in the vicinity of Elvanfoot Wind Farm (not to scale)

4. GLASGOW PRESTWICK AIRPORT

4.1. Overview

Glasgow Prestwick Airport (Prestwick Airport) is an international airport situated on the coast of Ayrshire, approximately 50 km from the city centre of Glasgow. Low cost airline Ryanair utilises its facilities as a hub for operations. Part of the Prestwick Airport site is occupied by the Royal Navy Fleet Air Arm, where a detachment of three Sea King helicopters provide a Search and Rescue capability.

4.2. Runways and Airspace

Prestwick Airport operates two runways. The primary runway is of length 2,986 m and designated 13/31; the secondary runway is designated 03/21 and is of length 1,905 m.

Prestwick also has airspace allocated as the Prestwick Control Area (CTA) and Zone (CTR), which provides protection to aircraft lining up with the runway for final approach and for providing connectivity with the Class D airways structure of the Scottish Terminal Control Area (TMA) which is established above the airport. The CTA and CTR are Class D controlled airspace.

The Elvanfoot Wind Farm would be located approximately 56.7 km (30.6 NM) from the Prestwick Airport PSR. Although the standard consultation distance for an aerodrome with surveillance radar facilities is 30 km, Osprey allows a significant margin as we recognise that valid objections can come from beyond these areas. In addition, Prestwick PSR is often considered as future source of mitigation for NATS issues in this area; hence it is prudent to include it in the assessment.

4.3. Radar Line of Sight (LoS)

The PSR in operation at Prestwick Airport is a hybrid consisting of a Marconi processor and Watchman antenna system. The PSR is sited on the airport at approximately 55′30″05°N 04′35″58°W and the antenna is estimated as being approximately 20 m above ground level (agl). The radar is due for replacement but for the purpose of this assessment the new radar is assumed to be located in the same place and with similar nominal operating parameters.

The LoS terrain elevation profile between the Prestwick Airport PSR (to the left of the diagram) and the nearest Elvanfoot Wind Farm development wind turbine T1, to the right of the diagram, is given at Figure 5. The grey area represents any intervening terrain. The direct LoS, which takes into account the curvature of the earth, is represented by the red straight line and the orange ellipse around the signal is known as the 1st Fresnel zone. The Fresnel zone is an area around the direct LoS where the signal remains strong; Osprey looks at the degree to which the direct LoS and the Fresnel ellipse are blocked by the terrain in order to make a qualitative assessment of the likelihood that turbines will be detected. The magenta and cyan curves on the upper part of the graph are not relevant to this type of assessment.

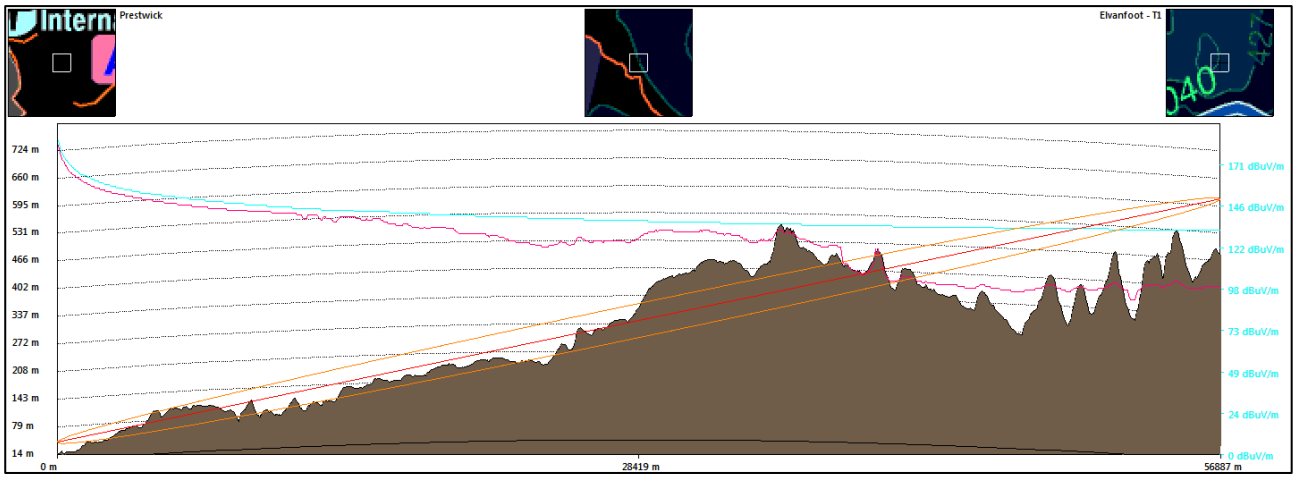

Figure 5 Theoretical LoS elevation profile between the Prestwick Airport PSR and Elvanfoot Wind Farm T1

LoS analysis indicates that turbine T1 of height 130 m would theoretically be undetectable by the Prestwick Airport PSR due to significant intervening terrain. This result is indicative of all ten of the proposed 130 m turbines for the Elvanfoot Wind Farm development; therefore, no radar screen clutter generation would be expected as a result of the development. Osprey does not anticipate any impact to Prestwick Airport operations in terms of turbine PSR detectability. Full line of sight diagrams are contained in Osprey document 7677/002 which is attached.

4.4. Prestwick Airport Conclusions

LoS analysis has determined that the Elvanfoot Wind Farm would theoretically be undetectable by the Prestwick Airport PSR due to significant intervening terrain features. Osprey predicts no impact on Prestwick Airport operations attributable to the development of Elvanfoot Wind Farm.

5. NATIONAL AIR TRAFFIC SERVICES

5.1. Overview

National Air Traffic Services Ltd (NATS) provides air traffic services at some airports in the UK and to traffic en-route within UK airspace. NATS operate a number of long range primary and secondary radars positioned to provide maximum coverage of UK airspace. Additionally, military controllers operate at NATS Air Traffic Control Centres; in conjunction with their civilian counterparts, they manage the coordination between civilian and military flights. Surveillance data is also used by other air traffic service providers such as the MoD and airports. NATS has a licence obligation to provide these services to a high quality and performance standard for the benefit of UK aviation as a whole. Any effect the proposed development might have on NATS radars must be considered both in terms of effect on the civilian and military en-route services and in the context of its remote users.

The Elvanfoot Wind Farm is on an approximate range and bearing of 8.6 km (4.6 NM) and 032° from the Lowther Hill PSR.

5.2. Radar Line of Sight Analysis

5.2.1. Lowther Hill PSR

Figure 6 presents the theoretical radar LoS terrain elevation profile between the NATS Lowther Hill PSR (left of the diagram) and the blade tip height of Elvanfoot T3 (right of the diagram).

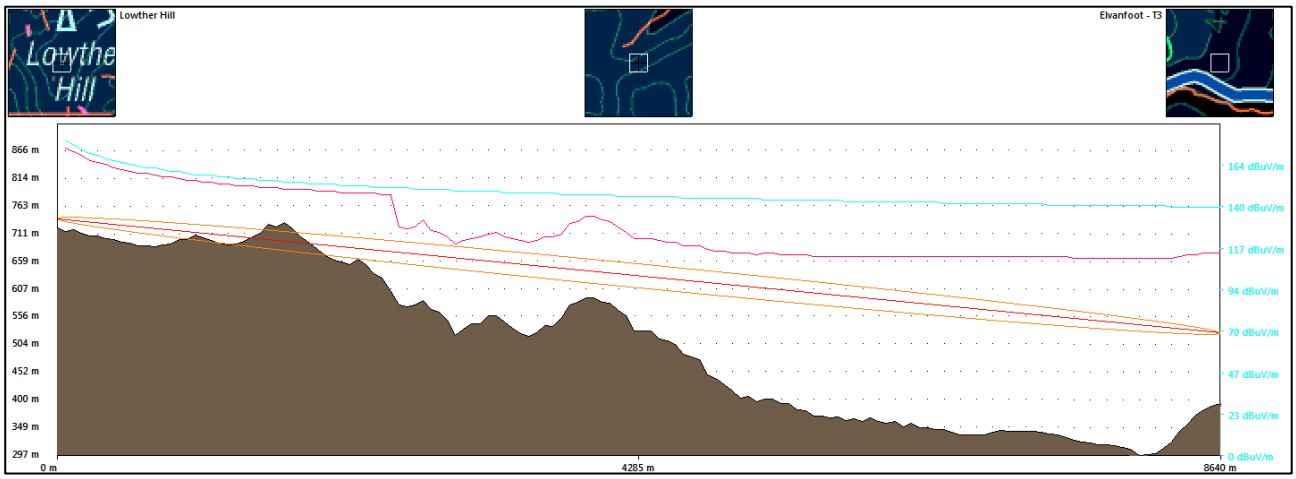

Figure 6 Terrain Elevation profile – NATS Lowther Hill PSR to Elvanfoot T3

Figure 6 indicates the turbine is highly unlikely to be detected by the radar: direct LoS is blocked by significant terrain features. The full set of line of sight profiles is contained in Osprey document 7677/002; these profiles indicate that the results vary by turbine as indicated in Table 4 below.

Turbine	Detectability by Lowther Hill PSR
1	Yes
2	Likely
3	No
4	No
5	Likely
6	No
7	No
8	No
9	No
10	Yes

Table 4 Theoretical indicative visibility of the Elvanfoot turbines to the Lowther Hill PSR

Turbines 1 and 10 are highly likely to be detected by the radar; the analysis also cannot rule out occasional detection of turbines 2 and 5: around 60% of the 1st Fresnel zone upper limit is blocked for these two turbines. The remaining six turbines will theoretically not be detected by the radar as significant intervening terrain exists and the entire 1st Fresnel zone of signal is blocked. Qualitative definitions of the line of sight results are shown in Section 1.4.3.

5.2.2. Cumbernauld PSR

The Cumbernauld PSR is provided to mitigate against effects of the adjacent Clyde Wind Farm to NATS radars [Reference 4].

Figure 7 presents the LoS terrain elevation profile for the Cumbernauld PSR to T9 at the Elvanfoot Wind Farm, the closest turbine to the Cumbernauld PSR.

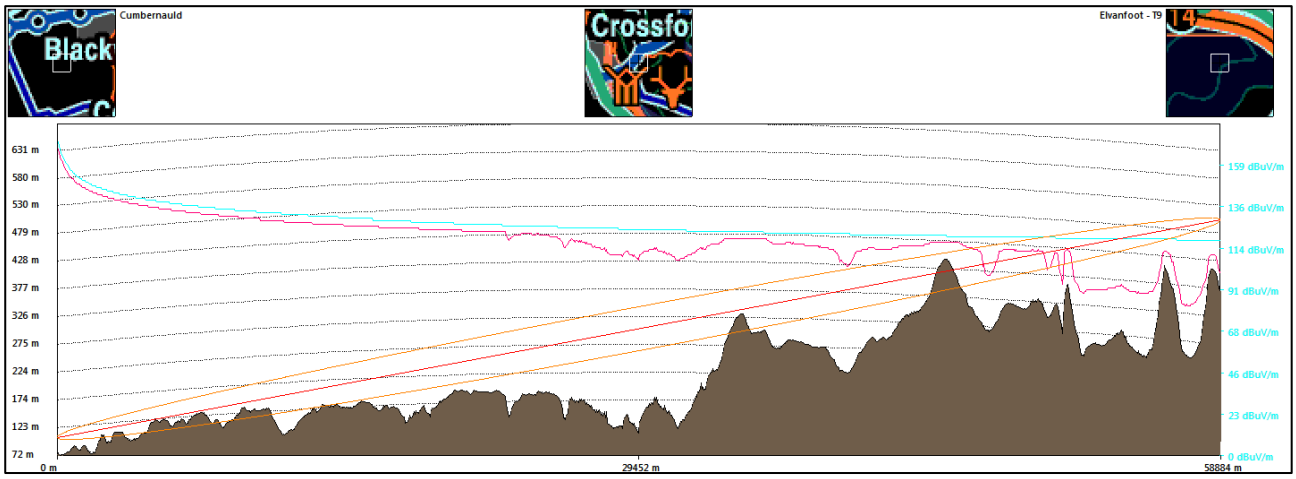

Figure 7 Terrain Elevation profile – Cumbernauld PSR to Elvanfoot T9

Figure 7 above, indicates the turbine is unlikely to be detected by the Cumbernauld PSR: terrain features exists between the turbine and the radar. The full set of line of sight profiles is contained in Osprey document 7677/002; these profiles indicate that the results vary by turbine as indicated in Table 5 below.

Turbine	Detectability by Cumbernauld PSR
1	Yes
2	Yes
3	Likely
4	Likely
5	Likely
6	Likely
7	No
8	No
9	Unlikely
10	Yes

Table 5 Theoretical indicative visibility of the Elvanfoot turbines to the Cumbernauld PSR

Turbines 1, 2 and 10 are highly likely to be detected by the radar; the analysis also cannot rule out occasional intermittent detection of turbines 3, 4, 5 and 6. The remaining three turbines will theoretically not be detected by the radar, however the analysis cannot rule out completely occasional detection of turbine 9.

However, as this PSR is utilised for the mitigation of the adjacent Clyde Wind Farm, it is considered that turbines within the remaining coverage of this radar may not constitute an issue for NATS. Consultation with NATS is advised to confirm.

5.2.3. Other Regional NATS Radars

LoS analysis indicates, theoretically, that the following NATS PSR will not detect the proposed turbines at the Elvanfoot Wind Farm:

Great Dun Fell;

Perwinnes; and

Tiree.

Full LoS profiles are contained in Osprey document 7677/002 attached with this document.

5.2.4. Secondary Surveillance Radar (SSR)

There is a Secondary Surveillance Radar (SSR) co-located at the Lowther Hill PSR. The closest turbine would be located approximately 8.6 km from the facility. The CAA advises that:

"24 km should be used as the trigger point for further discussion with the appropriate service provider who can make a more detailed, accurate assessment of the likely effect on their SSR. The majority of effects are likely to be within 10 km but, because the possibility exists for effects out to 24 km, the greater distance should be utilised for consultation. It must be noted that this is not intended as a range within which all turbines should be objected to".

SSR works by interrogating aircraft transponders to obtain information on aircraft heading, height, identification etc. Mode-S is a modern implementation of SSR which is less susceptible to 'reflections' from large structures/turbines than the traditional Mode-A/C SSR. All NATS SSR have been upgraded to Mode-S but because all aircraft are not yet Mode-S compatible there are some residual effects linked to continued use of Mode-A/C. Consultation with NATS will be required to investigate any potential effects further.

5.3. Operational Impact Analysis

In conjunction with NATS owned/operated PSR systems, a number of regional radars (Edinburgh, Glasgow, Kincardine and Cumbernauld) provide data to the Multi-Radar Tracker (MRT)[3] used for surveillance of aircraft within the NATS Prestwick ATCC[4].

As radar cannot distinguish between returns from wind turbines and those representing a real aircraft, the air traffic controller is required to assume that the turbine induced radar returns could harbour a real aircraft. In providing safe air traffic (radar) services, an air traffic controller must maintain a standard separation distance (5 NM laterally) between aircraft he is controlling and those that are unknown or not in receipt of a radar service, therefore the provision of navigational services by NATS has potential to be impacted in the area of the Wind Farm.

NATS will require that the radar coverage provided by an alternative source of radar data would be low enough to support the provision of navigation services to aircraft operating in proximity to the development.

NATS located at the Prestwick Air Traffic Control Centre (ATCC) are responsible for the provision of air traffic services to aircraft operating within the airways structure in the region. The Wind Farm would be situated beneath airspace which is heavily utilised for the protection of flights predominantly into and out of the main Scottish Airports, NATS utilise this airspace in the area in support of these tasks.

Additionally, the air routes above FL 195 are predominantly used by aircraft transiting UK airspace between Continental Europe, the UK and North America and are provided an Air Traffic Service (ATS) by NATS.

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[3] MRT: A means of integrating data from multiple radar sources into a single recognised air picture. NATS maintains a network of long range radars, as well as accepting feeds from a number of airfield radars. Data from these radars is fed into NATS MRT systems to produce integrated air pictures at the relevant ATCC.

[4] Prestwick ATCC provides radar services to aircraft in transit and should not be confused with operations completed at Prestwick Airport.

Figure 8 below illustrates the Elvanfoot development area and the position of the Scottish TMA and the lower airways structure adjacent to the development.

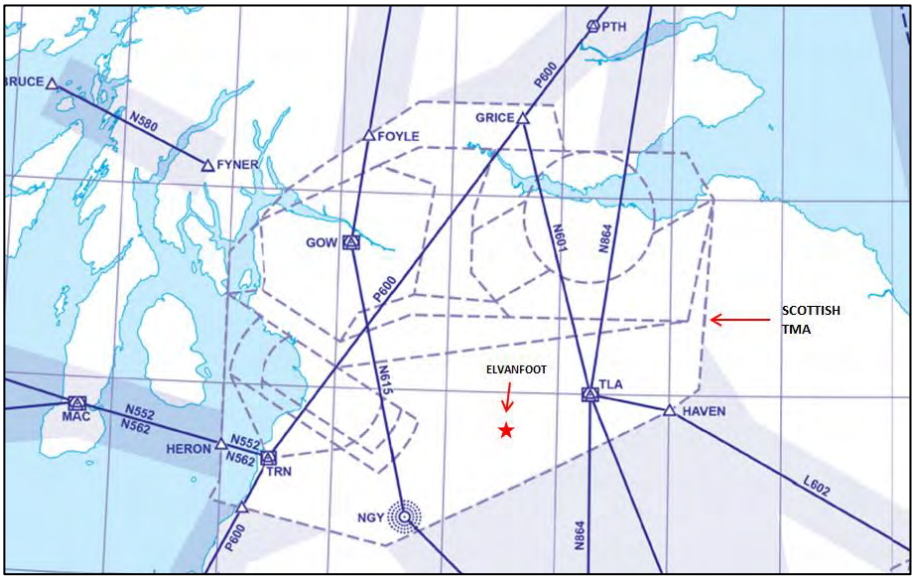

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Figure 8 Elvanfoot Wind Farm in relation to lower airways route structure (not to scale)

Figure 9 illustrates the Elvanfoot development area and the position of the upper airways structure adjacent to the development.

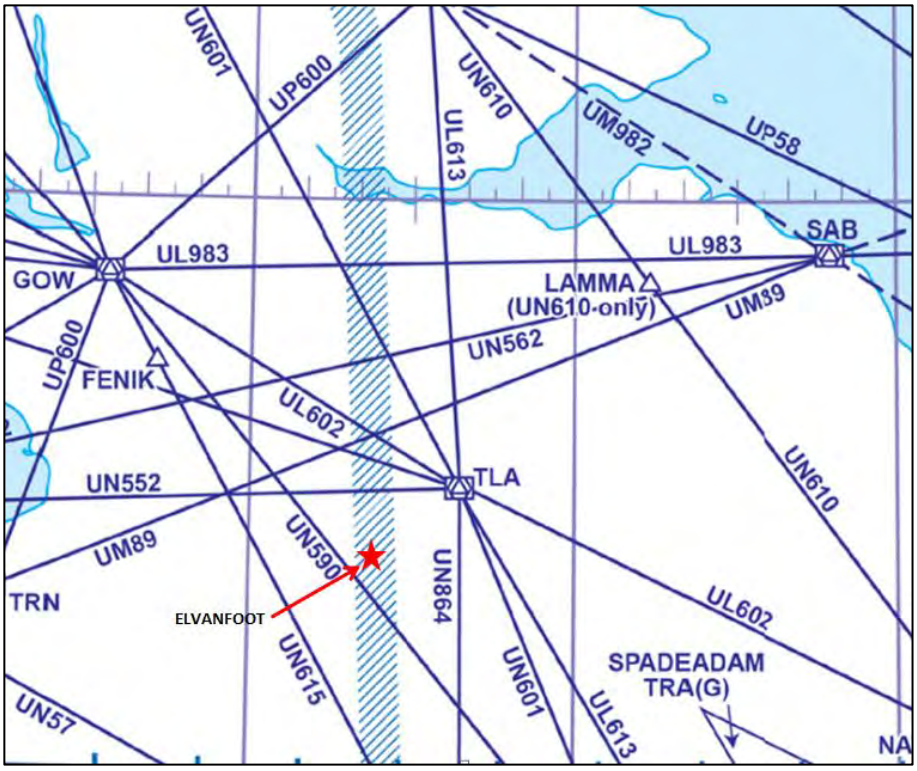

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Figure 9 Wind Farm in relation to upper airways route structure (not to scale)

It is considered likely that NATS will object to the development based on the theoretical detection of the Wind Farm to the Lowther Hill PSR.

5.4. Cumulative Effect

The combined effect of numerous individual turbines or multiple wind turbine developments can be difficult to mitigate[5]. It is therefore feasible that air traffic service providers may lodge objections to subsequent developments in areas where they had previously been able to accommodate wind farm developments.

It is highly likely that NATS will take into account the overall cumulative impact of the existing and anticipated radar screen clutter, when assessing the impact the proposed Elvanfoot Wind Farm turbines may have upon their operations and in determining the applicability of any suitable mitigation solutions.

5.5. Design Mitigation Options

Not all of the turbines are predicted to be detected by the Lowther Hill PSR and therefore it may be possible to design out the impact. Four of the ten turbines are theoretically expected to be detected at least intermittently – removal, relocation or reduction in blade tip height of the detectable turbines may offer as valid option for mitigating the impact. If it is not possible to design out the issue and maintain a viable development site, then options for technical mitigation are offered in Section 5.6.

5.6. Brief Outline of Technical Mitigation Options

5.6.1. Project Raytheon Modifcation (Project RM)

NATS in conjunction with the supplier of their PSR systems, Raytheon, are in a process of developing a technical solution so that clutter generated by wind turbines can be removed from a controllers' display whilst ensuring that the current ability to detect, track and provide navigational assistance to aircraft is not degraded [Reference 5].

It is anticipated that upgrading their fleet of Raytheon PSRs will significantly reduce the number of NATS objections to wind energy proposals. Two key criteria need to be met in order for the mitigation to be successful:

1. The wind turbines must be further than 9 NM from the radar; and
2. Aircraft must be flying greater than 1.2° or higher in elevation above the blade tips.

The Elvanfoot Wind Farm would be located within 9 NM from the NATS Lowther Hill PSR and therefore Project RM is not expected to be a suitable mitigation solution for Elvanfoot.

[5] Note: The adjacent proposed Elvanfoot Wind Farm is theoretically not detectable to the Prestwick Airport PSR.

5.6.2. Blocking Infill

The Kincardine and Cumbernauld PSRs are examples of blocking infill radar which have been designed and implemented for large-scale wind farm mitigation at Glasgow Airport, Edinburgh Airport and with NATS PSRs. The Cumbernauld PSR is provided to mitigate against effects of the adjacent Clyde Wind Farm to NATS radars [Reference 4].

Blocking Infill Mitigation is discussed further in Section 6.

5.6.3. SSR

There is no known technical mitigation available against the effects on the Lowther Hill SSR, however the effects of turbines on SSR systems are also relatively poorly understood and there is little, if any, recorded specific research. Consultation with NATS is required to investigate potential effects to the Lowther Hill SSR.

5.7. Conclusions

The Elvanfoot Wind Farm is below the Scottish TMA, a complex airways structure heavily utilised by aircraft under the control of NATS; and is an area where normal and regular handover of aircraft between NATS and the Scottish Airports air traffic control will take place. It is considered that the anticipated effects of the four detectable turbines to the Lowther Hill PSR, is likely to be considered to pose a detrimental effect on routine NATS operations.

The Wind Farm would be located within 9 NM of the Lowther Hill PSR therefore Project RM would not be suitable for mitigation of the effects to this radar.

The potential exists that the implementation of an additional supply of data from another PSR in the region may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

Consultation will be required with NATS to understand any potential effects the Wind Farm may have on the Lowther Hill SSR.

At this early stage in the planning process for Elvanfoot, Osprey recommends that RWE NRL gives serious thought to the potential for designing out the impact on NATS Lowther Hill through removal or relocation of the four detectable turbines. Consultation with NATS could then concentrate on the tolerability of any potential impact on the Cumbernauld PSR.

6. MITIGATION: BLOCKING INFILL TECHNOLOGY

6.1. Overview

Blocking infill uses an additional alternative PSR sensor, located remotely from the effected PSR. This strategy uses 'terrain shielding' such that the remote sensor cannot see the Wind Farm due to intervening terrain providing a 'Blocking Point', and hence can provide clutter-free returns from the area above the Wind Farm. This data can then be used to replace the area affected by wind farm clutter on the radar display system ('Cut and Paste').

The potential exists that another PSR in the region that does not detect the Elvanfoot Wind Farm may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

NATS will require that the radar coverage provided by an alternative source of radar data would be low enough to support the provision of navigation services by NATS to aircraft operating in proximity to the development.

6.2. System Principles

The principle is based on creating an infill 'patch' on the affected PSR display using an alternative source of PSR data that satisfies the following two requirements:

Intervening terrain is sufficient to block line of sight to the Wind Farm; and

Base of coverage is sufficient to meet the operational requirements of the affected PSR system.

The advantage is that the technology is available now and there are a number of current examples where it is used, however, it is viewed with some suspicion by aviation stakeholders due to the fact that there will be areas of loss of radar coverage. Costs can also be prohibitive with the procurement of a new radar system costing in the region of £2.5million to £5 million and the purchase of data from an existing PSR being in the region of £100K-£150K per year.

6.3. Methodology

Radar coverage analysis is required to determine the suitability of infill radar, and has been used in this instance for modelling the regional PSRs within operational coverage.

Osprey also uses its own in-house calculation tool and ATDI ICS LT (Version 2) to model coverage from radar. Using our assumed likely radar performance characteristics for radar, a field strength threshold level is calculated. This threshold is used by ATDI ICS LT (Version 2) for displaying coverage calculation results. For coverage analysis, we use the Fresnel Method + model built into ATDI ICS LT (Version 2), using the Deygout 94 method for diffraction geometry, and the standard method for sub-path attenuations. The field strength threshold has been calculated using a target Radar Cross Section (RCS) of $1m^2$.

Coverage diagrams have been included within this report to support our opinion on the possible suitability of radars to infill the affected area of the impacted radar, which is also further explained at 6.6. For areas in the coverage diagrams overlaid with a blue colour, the signal field strength is predicted to be high enough such that if it was reflected back at the radar from a target with an RCS of $1m^2$, the signal received back at the radar would be at or above the receiver's threshold, and it is likely that the radar would see the target. Coverage diagrams have been produced at a height with a 'receiver' reference of agl or amsl.

Although every care is taken during the modelling and analysis process, modelling limitations and assumptions obviously lead our conclusions to be based on theoretical results. The results are therefore indicative, and actual radar performance may differ from this analysis.

6.4. Challenges

Slant range errors need to be considered for traditional infill radar solutions: slant range is defined as the line of sight distance from ground radar to a target. Without altitude information, the aircraft range would be calculated farther from the antenna than its actual ground track (a variable error depending on unknown aircraft altitude). The effect of slant range, as illustrated in Figure 10, is most significant when the infill radar and the affected radar are at notable different distances from the Wind Farm area.

Slant range is defined as the line of sight distance between radar and an air target. Without altitude information, the aircraft range would be calculated farther from the antenna than its actual ground track.

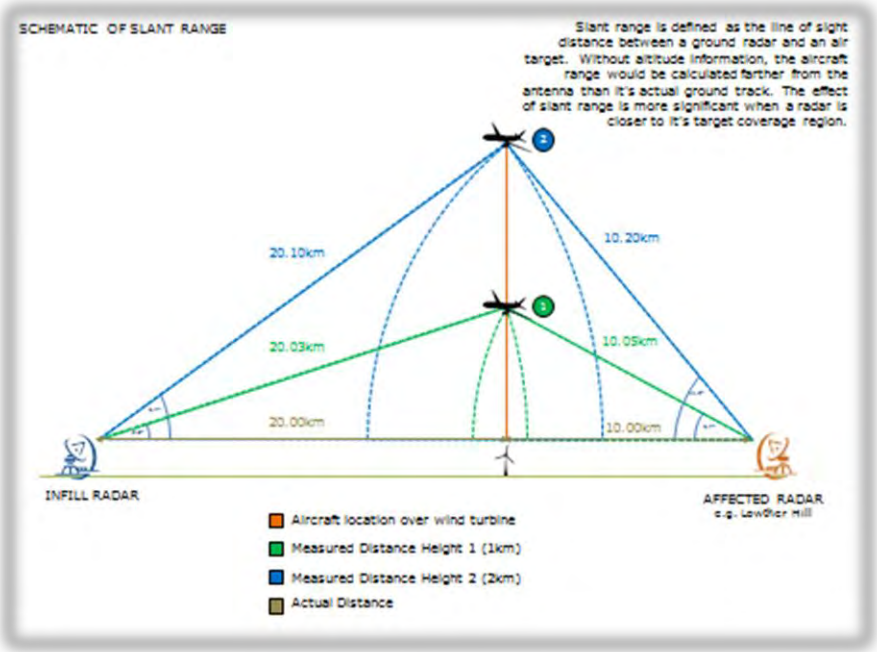

Figure 10 Example: Slant range error for traditional radar infill

6.5. Resolution of Slant Range Errors

NATS MRT commutes best position of aircraft from a number of sensors and algorithms are utilised to display best sensor first and then to available sensors in order of quality of coverage provided. Within MRT slant range errors are insignificant and manageable.

6.6. Coverage Analysis

The potential exists that the implementation of an additional supply of data from another PSR in the region that does not detect the Elvanfoot Wind Farm may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

An assessment was conducted by Osprey to establish the base of radar coverage of existing radar systems which theoretically do not detect the turbines, to assess their capability to be utilised for such purposes.

The radar sites that were assessed are as follows:

Edinburgh Airport PSR;
Glasgow Airport PSR;
Great Dun Fell PSR;
Kincardine PSR;
Perwinnes PSR;
Prestwick Airport PSR; and
Tiree PSR.

6.7. Applicability

It is anticipated that the base of radar cover required by the Lowther Hill PSR in the vicinity of the Elvanfoot Wind Farm is approximately 3,500 ft (2,000 ft below the base of controlled airspace); however, the operational requirement may be lower and will require confirmation from NATS.

Radar	Theoretical Detection of a small target 1m^2 Radar Cross Section (RCS)	Radar	Theoretical Detection of a small target 1m^2 Radar Cross Section (RCS)
Edinburgh	5,249 ft amsl	Perwinnes	6,561 ft amsl
Glasgow	2,952 ft amsl	Prestwick	2,460 ft amsl
Great Dun Fell	6,561 ft amsl	Tiree	6,561 ft amsl
Kincardine	6,561 ft amsl		

Table 6 Theoretical Detection of a small target 1m^2 Radar Cross Section (RCS) over the location of the Elvanfoot Wind Farm

Theoretically the Glasgow PSR could provide a suitable base of cover capability above the Elvanfoot development and may provide a mitigation solution for the Lowther Hill PSR within NATS MRT system.

This analysis has not considered the cumulative/operational impact of extending any current patch or creating an additional patch nearby but illustrates in isolation that the Glasgow Airport radar solution may be a feasible mitigation solution for the affected radar.

6.7.1. Glasgow Airport Coverage Analysis

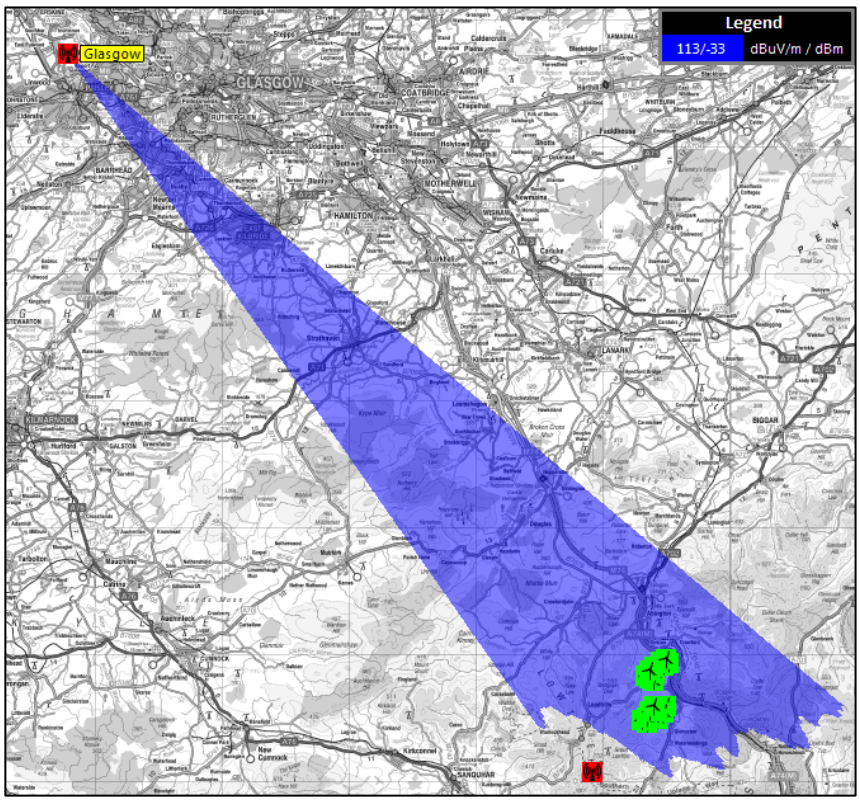

Figure 11 Glasgow Airport PSR - Theoretical Coverage at 2,952 ft amsl

Figure 11 indicates that the Glasgow Airport PSR has a theoretical base of coverage (to detect a $1m^2$ target) at the Elvanfoot Wind Farm site of approximately 2,952 ft (900 m) amsl.

6.7.2. Prestwick Airport Coverage Analysis

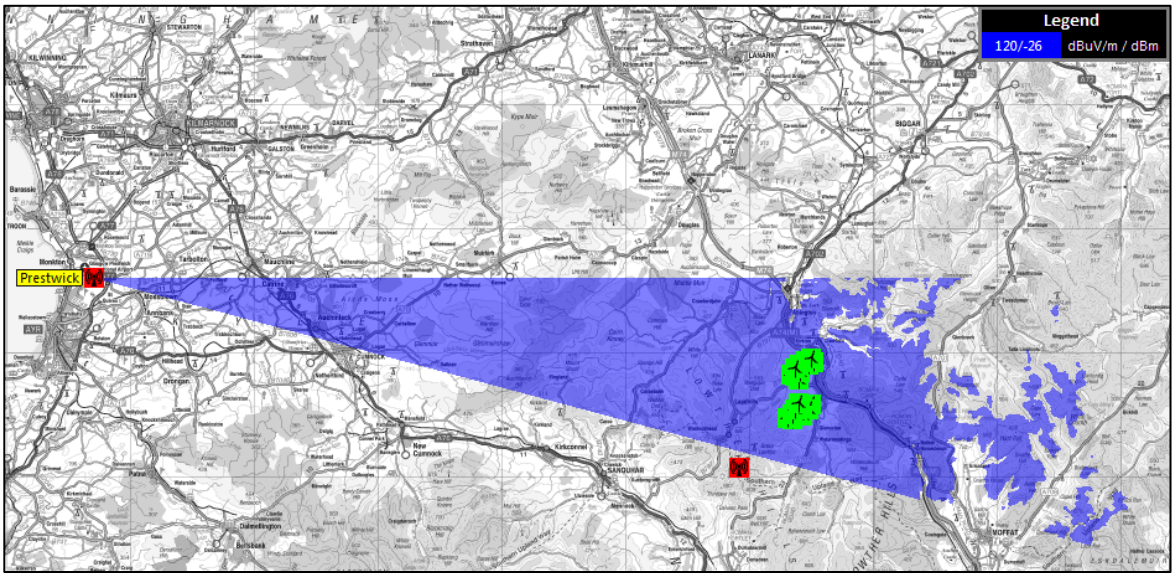

Figure 12 Prestwick Airport PSR - Theoretical Coverage at 2,460 ft amsl

The Prestwick Airport Radar will not detect the Elvanfoot Wind Farm and Figure 12 illustrates that clear, unimpeded coverage of the airspace above the Wind Farm begins at approximately 2,460 ft (750 m) amsl.

It must be noted that data from the PSR currently in operation at Prestwick Airport is unsuitable to be fed into the MRT system at Prestwick ATCC. Prestwick Airport is believed to be in the early stages of a process to upgrade their PSR system; however there will be commercial challenges that will need to be met with both NATS and GPA that may or may not make integration into the NATS MRT system possible.

6.8. NATS Multi Radar Tracker

In conjunction with NATS owned/operated PSR systems, a number of regional radars (Edinburgh, Glasgow, Kincardine and Cumbernauld) provide data to the Multi-Radar Tracker (MRT) used for surveillance of aircraft within the NATS Prestwick Air Traffic Control Centre (ATCC)[6].

NATS will require that the radar coverage provided by an alternative source of radar data to be low enough to support the provision of navigation services by NATS to aircraft operating in proximity to the development.

The potential exists that the implementation of an additional supply of data from another PSR in the region that does not detect the Elvanfoot Wind Farm may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

[6] Note that the NATS Prestwick ATCC is also known as Scottish Control and not related to Prestwick Airport in any way.

6.9. Conclusions

The Elvanfoot Wind Farm will theoretically be detectable by the NATS Lowther Hill PSR and the Cumbernauld PSR which supplies radar data to the Prestwick ATCC MRT.

The Glasgow Airport PSR has a base of coverage in the area of the development of approximately 2,952, ft amsl. It is therefore considered that data from this PSR may be suitable to provide appropriate coverage in the NATS MRT to support their operations in mitigation of the effect on the Lowther Hill PSR.

Consultation with NATS will be essential to determining if this option will be acceptable for the Lowther Hill PSR and on the tolerability of any potential effects on the Cumbernauld PSR.

7. MINISTRY OF DEFENCE

7.1. Low Flying Overview

Low flying is an extremely demanding but essential skill for military aircrew gained through progressive training and continuous practice within the United Kingdom Low Flying System (UKLFS). The ability to operate effectively at low-level by day and night is vital to fast jet, transport aircraft and helicopters as they support forces on the ground.

7.2. UKLFS Dimensions and Uses

The UKLFS covers the open airspace of the whole UK and surrounding overseas areas outside of major cities, towns and specific avoidance areas, from surface up to an altitude of 2,000 ft. Additionally, there are three areas, known as Tactical Training Areas (TTA), which are considered suitable for flying lower than the standard training heights due to their challenging terrain and generally sparse population. The capability of Low Flying training in the TTAs allows aircrews to enhance their skills in preparation for deployment onto operations.

Height in the UKLFS can be referred to in terms of minimum separation distance (MSD). This is the distance that must be maintained between any part of an aircraft in flight and the ground, the water or any other ground based object.

Military fixed-wing aircraft are deemed to be low flying if they are less than 2,000 ft MSD and can operate down to 250 ft MSD; light propeller driven aircraft and helicopters are low flying below 500 ft MSD. In the TTAs fast-jets can fly at 100 ft MSD and helicopters can fly down to 100 ft agl or down to ground level. Hercules aircraft can fly at 150 ft MSD in the TTAs.

7.3. Impact on Low Flying Operations

The proposed Elvanfoot Wind Farm would be located within Low Flying Area (LFA) 16 and when the area is active, within TTA 20T. These areas are located in the south of Scotland, including the Borders Region, Dumfries and Galloway and other counties up to and including those within the central belt of Scotland. The Royal Navy Search and Rescue helicopter base at Prestwick Airport, the QinetiQ range facilities at West Freugh, and the Army training area at Kirkcudbright are located in the area.

LFA 16 and TTA 20T are considered by the MoD to be areas of key importance for military low flying training[7] due to the area having challenging terrain and a generally sparse population. In addition, the area has a high incidence of unrestricted airspace above 2,000 ft, which gives increased flexibility to military aircraft to enter and leave the Low Flying environment, and better than average weather conditions.

[7] https://restats.decc.gov.uk/cms/assets/SiteFiles/datasets/LowFlyingConsultationZones23Nov2011.pdf

Additionally, the area is close to the Army Field training centre at Otterburn, and it borders on the Electronic Warfare Tactics Range at RAF Spadeadam.

Aircraft completing low flying training in these areas would be considered to be operating in visual meteorological conditions (VMC). This means that aircraft will be operating in weather conditions in which pilots would have sufficient visibility to fly the aircraft maintaining visual separation from terrain, obstacles and other aircraft. Furthermore, such aircraft must also carry appropriate mapping detailing the relevant terrain and any obstacles; this mapping would display the Wind Farm in the event of it being constructed.

Figure 13 below shows an extract of the MoD Low Flying consultation map showing the approximate location of the Elvanfoot Wind Farm.

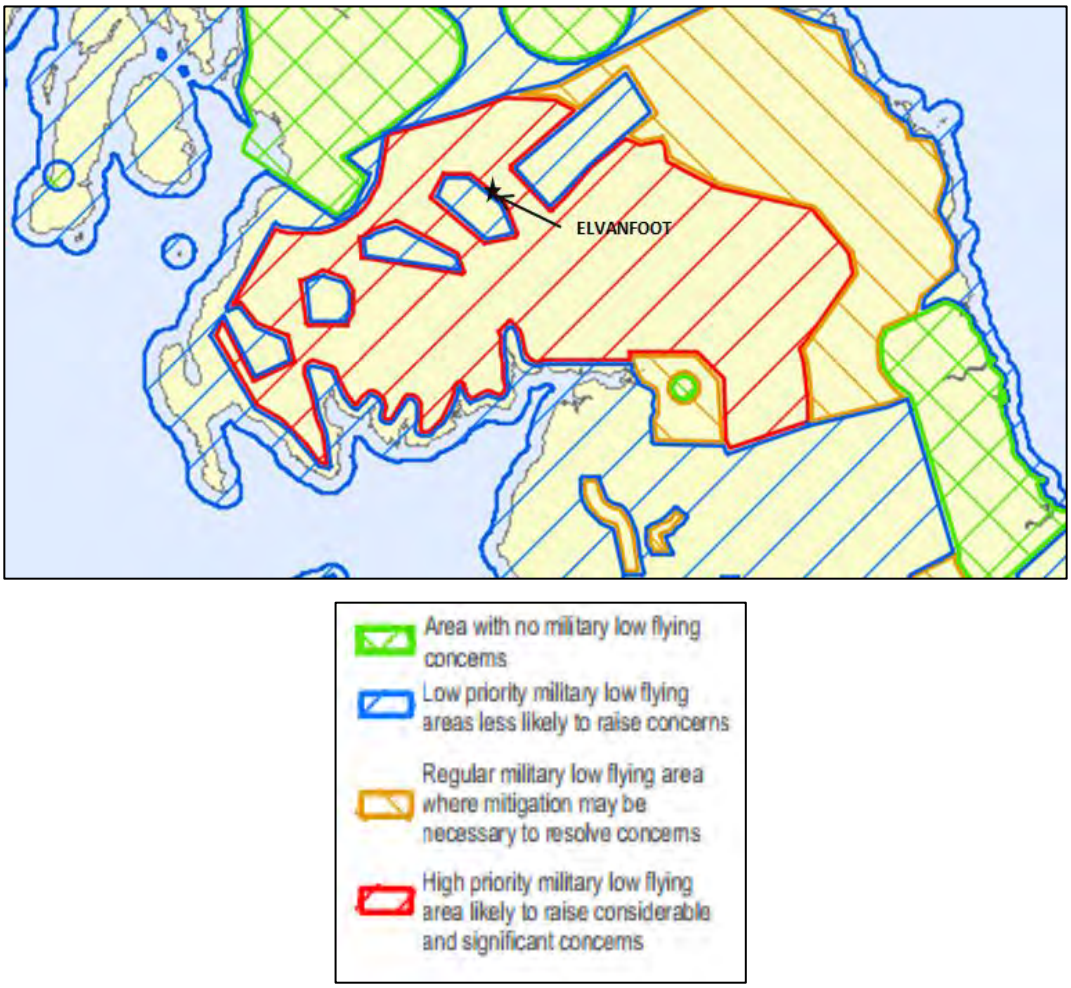

Figure 13 Military Low Flying Consultation Areas (not to scale)

Figure 13 illustrates that the Elvanfoot Wind Farm would be located in an area which is bounded by a high priority low flying area (red) and an area which is less likely to raise MoD concerns (blue).

7.4. UKLFS Conclusions

The issue of the proliferation of wind turbines in both LFA 16 and TTA 20T is of key concern to the MoD. The MoD specification for infrared and low intensity red vertical obstruction lighting has been detailed in a letter dated 17th December 2010 [Reference 6]. It is considered important that wind developers initiate consultation with the MoD as soon as practicable within the site design process.

The Elvanfoot Wind Farm would be located in an important and busy area for low flying training, thereby potentially having a detrimental impact on Low Flying training for military aircrews. The MoD may object to the development based on the proliferation of obstacles and the impact to utilisation of the areas to complete essential low flying training; consultation with the MoD is recommended within the site design process.

7.5. Eskdalemuir Seismic Array Overview

The Elvanfoot Wind Farm would be located approximately 32.9 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area (50 km). The MoD, on behalf of the British Geological Survey, the site operator, is likely to object to the proposal based on effect to the operational functionality of the Eskdalemuir Seismic Array.

The MoD is currently objecting to over 950 Megawatts (MW) of wind farms within a 50 km radius of the Eskdalemuir Seismic Array: the Scottish Government has established a Working Group to review methodologies for calculating the impact of wind turbines on the Eskdalemuir Seismic Array. The first stage of the work ('Stage 0') was completed in July 2013, and initial results appear very encouraging. There is an indication that the station may be able to tolerate more development than the limits identified through earlier studies. Further work is being conducted (Stage 1) to consider: direction and/or site effects; separation of turbine generated Seismic Ground Vibration (SGV) from ambient background noise; turbine blade sizes and rotation speeds; and different propagation models. The Stage 1 work will be necessary to inform future policy and the research and generation of a revised safeguarding model; this work is anticipated to be concluded by the end of January 2014.

7.6. Eskdalemuir Conclusions

The Elvanfoot Wind Farm would be located approximately 32.9 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area. MoD is likely to object to the development based on its proximity to the station at Eskdalemuir, however first stage work in reviewing the methodologies used for calculating the impact of wind turbines on the Eskdalemuir Seismic Array appears very encouraging; there is an indication that the station may be able to tolerate more development.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Overview

RWE NRL is proposing the Elvanfoot Wind Farm consisting of ten turbines on land located approximately 10 km northwest of the Daer Reservoir, South Lanarkshire, Scotland. The candidate turbines have a maximum anticipated blade tip height of 130 m.

8.2. Prestwick Airport Conclusions

LoS analysis has determined that the Elvanfoot Wind Farm would theoretically be undetectable by the Prestwick Airport PSR due to intervening terrain features. Osprey does not predict any impact to Prestwick Airport operations due to the development of Elvanfoot Wind Farm.

8.3. NATS Impact Conclusions

No predicted impact is anticipated on NATS En-Route navigational aids or radio communication infrastructure; however, as a consequence of radar detectability to the Lowther Hill and Cumbernauld PSRs, it is considered that NATS may consider the Wind Farm presents an unacceptable impact to NATS en-route operations.

There is a collocated Secondary Surveillance Radar (SSR) located at Lowther Hill and at 8.6 km (estimated measurement from radar antenna) the Wind Farm is inside the 24 km consultation zone for SSR. Consultation will be required with NATS to understand any potential effects the Wind Farm may have on the Lowther Hill SSR.

The Wind Farm is below the Scottish TMA, a complex airways structure heavily utilised by aircraft under the control of NATS; and is an area where normal and regular handover of aircraft between NATS and the Scottish Airports air traffic control will take place. It is considered that the anticipated turbine effects are highly likely to be considered to pose a detrimental effect on routine NATS operations.

Any Project RM upgrade to Lowther Hill is considered not to be a suitable mitigation strategy due to the close proximity of the development to the location of the Lowther Hill PSR.

The potential exists that the implementation of an additional supply of data from the Glasgow Airport PSR may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR within the NATS MRT system.

Only four of the ten proposed turbines are predicted to be detectable by the Lowther Hill PSR. RWE NRL should consider whether the site could be re-designed to eliminate the potential impact; removal or relocation of the four detectable turbines should be considered. Redesigning the site could eliminate the need for technical mitigation. Consultation with NATS could then concentrate on the tolerability of the impact on Cumbernauld within the MRT environment.

8.4. MoD Conclusions

The site would be located in an important and busy area for low flying training, thereby potentially having a detrimental impact on Low Flying training for military aircrews. The MoD may object to the Elvanfoot Wind Farm proposal based on the proliferation of obstacles and the impact to utilisation of the areas to complete essential low flying training.

The Elvanfoot Wind Farm would be located approximately 32.9 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area. MoD is likely to object to the development based on its proximity to the station at Eskdalemuir, however Stage 0 research work in reviewing the methodologies used for calculating the impact of wind turbines on the Eskdalemuir Seismic Array appears very encouraging; there is an indication that the station may be able to tolerate more development.

It is highly unlikely that the wind industry will see any change in MOD Policy until the second stage research work, validating the first stage work, has been completed. The detailed research and generation of a revised safeguarding model (Stage 1) is anticipated to be concluded by the end of January 2014.

Any change in MOD Policy will most likely come after a Scottish Government led consultation and cross-Government department collaboration on working to develop a new Eskdalemuir Safeguarding Policy.

8.5. Recommendations

Osprey first recommends that RWE NRL consider potential for redesigning the site to eliminate the potential impact on Lowther Hill PSR.

RWE NRL considers further investigation with NATS regarding the viability of implementing the suggested mitigation scheme for the Lowther Hill and consultation is completed to understand any potential effect to the Cumbernauld PSR;

PSR – data from the Glasgow Airport PSR fed into the NATS MRT system; and

Consultation with NATS to investigate any potential effects to the Lowther Hill SSR.

To limit the effect of the Wind Farm on Military Low Flying activities, RWE NRL considers early engagement with the MoD to ascertain the potential for MoD constraints. Additionally, consideration should be given to satisfying any request from the MoD to fit the Wind Farm with a form of aviation obstruction lighting.

REFERENCES

Ref	Title	Origin
1	CAP 764: Policy and Guidelines on Wind Turbines Fifth Edition June 2013	Civil Aviation Authority
2	Guidance on Low Flying Aircraft and Onshore Tall Structures Including Anemometer Masts and Wind Turbines. July 2012	RenewableUK
3	UK Integrated Aeronautical Information Package (UK IAIP) Amended to AIRAC 10/13	National Air Traffic Services
4	SSE Clyde Wind Farm http://www.sse.com/Clyde/ProjectInformation/ Accessed 29 October 2013	SSE
5	NATS Project RM: Wind turbine mitigation Briefing note for developers December 2012 http://www.nats.co.uk/wp-content/uploads/2012/12/ProjectRM.pdf	National Air Traffic Services
6	MoD Specification for IR and Low Intensity Red Vertical Obstruction Lighting WITT/605/LFOPS dated 17th December 2010	Ministry of Defence

ANNEX A: INDIVIDUAL VIABILITY OF THE ELVANFOOT AND LEADHILL WIND FARMS

The following Annex provides information and comparison of the two proposed and adjacent Elvanfoot and Leadhills Wind Farms.

The following table compares the potential impact both wind farms, individually and combined may present to aviation stakeholders in the region.

	Elvanfoot	Leadhills
Detectability to Prestwick Airport PSR	NIL	2 turbines
Potential to affect Prestwick Airport Operations		✓
Detectability to the Lowther Hill PSR	4 turbines	All turbines
Range from Lowther Hill PSR/SSR	8.65 km	5.65 km
Detectability to the Cumbernauld PSR	7 turbines	All turbines
Potential to affect NATS Operations	✓	✓
Potential to create a higher cumulative effect		✓
Possibility of site redesign to reduce detectability	✓	
Within Safeguarded Range of Eskdalemuir	✓	✓
Potential for Low Flying Objection	✓	✓

Although the potential of an objection from an aviation stakeholder exists for both developments, the greater line of sight detectability, and the lack of feasible site redesign of the Leadhills development indicates the greater potential of the Elvanfoot Wind Farm.

Consultation should be undertaken to understand the potential impact on the operations of stakeholders identified and the mitigation possibilities available.

Osprey
Consulting Services Ltd

Leadhills Wind Farm Aviation Impact Assessment

Ref: 7677/003 Issue 2

Date: 23rd March 2017

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Approval Level	Authority	Name	Signature
Author	Osprey CSL	Stewart Heald	
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EXECUTIVE SUMMARY

RWE Npower Renewables (RWE NRL) are planning a wind energy development known as Leadhills Wind Farm, on land approximately 7 kilometres (km) northwest of Daer Reservoir, South Lanarkshire, Scotland. Nine turbines are planned for the site with a blade tip height of 130 metres (m). Another wind farm is proposed by RWE NRL, Elvanfoot Wind Farm, is adjacent to the Leadhills Wind Farm; a separate assessment has been completed on the Elvanfoot Wind Farm. A summary comparison of the two wind farms can be found in Annex A to this document.

RWE NRL has commissioned Osprey Consulting Services Ltd (Osprey) to complete this analysis.

Operational Impact

Prestwick Airport

The Leadhills Wind Farm would be located approximately 57 km (30.8 NM) from the Prestwick Airport PSR. Although the standard consultation distance for an aerodrome with surveillance radar facilities is 30 km, Osprey allows a significant margin as we recognise that valid objections can come from beyond these areas. In addition, Prestwick PSR is often considered as future source of mitigation for NATS issues in this area; hence it is prudent to include it in the assessment.

Radar Line of Sight (LoS) analysis indicates that theoretically, two turbines are detectable to the Prestwick Airport Primary Surveillance Radar (PSR) and analysis cannot rule out occasional detection of a further two turbines.

The location of the Leadhills Wind Farm and the expected radar clutter associated with it may affect the published standard arrival routes via the TRN 1D and the ENOKA waypoints. Aircraft will route aircraft within approximately 5 nautical miles (NM) of the Wind Farm as the aircraft proceed to Runway 31 at the Airport.

Air traffic controllers are required to maintain 5 NM standard separation between aircraft under their control and unknown aircraft (or clutter that looks like a real aircraft or could be assumed to be masking returns from a real aircraft). Any clutter created by the development will lead to a restriction of manoeuvring airspace to sequence aircraft.

National Air Traffic Services (NATS)

As a consequence of theoretical radar detectability to the Lowther Hill and Cumbernauld PSRs, NATS may consider the Wind Farm to present an unacceptable impact on NATS en-route operations. All of the turbines are theoretically detectable by these two radars.

The Wind Farm is below the Scottish Terminal Control Area (TMA), a complex airways structure heavily utilised by aircraft under the control of NATS; and is an area where normal and regular handover of aircraft between NATS and the Scottish Airports air traffic control will take place. It is considered that the anticipated turbine effects are highly likely to be considered to pose a detrimental effect on routine NATS operations.

There is a collocated Secondary Surveillance Radar (SSR) located at Lowther Hill and at 5.6 km (estimated measurement from radar antenna) the Wind Farm is inside the 24 km consultation zone for SSR. SSR works by interrogating aircraft transponders to obtain information on aircraft heading, height, identification etc. Mode-S is a modern implementation of SSR which is less susceptible to 'reflections' from large structures/turbines than the traditional Mode-A/C SSR. All NATS radars have been upgraded to Mode-S but because all aircraft are not yet Mode-S compatible there are some residual effects linked to continued use of Mode-A/C.

Mitigation Option Capability:

1. The use of infill data from the Glasgow Airport PSR is considered as a potential technical mitigation option. This will effectively suppress/remove the radar returns in the vicinity of the Wind Farm and prevent the turbines producing clutter on NATS radar displays. Consultation with NATS could then concentrate on the tolerability of any potential impact on the Cumbernauld PSR;
2. Raytheon Modification (Project RM) is however considered unsuitable for mitigation of Leadhills: The close location of the development to the Lowther Hill PSR is expected to rule out this form of mitigation solution for the Leadhills Wind Farm. It is a requirement of the mitigation that the Wind Farm be located outside 9 NM (16.6 km) from the PSR; and
3. There is no known technical mitigation available against the effects on the Lowther Hill SSR, however the effects of turbines on SSR systems are also relatively poorly understood and there is little, if any, recorded specific research. Consultation with NATS is required to investigate potential effects to the Lowther Hill SSR.

MoD Low Flying

The MoD may object to the Leadhills Wind Farm proposal based on the proliferation of obstacles and the impact to utilisation of the areas to complete essential low flying training. The proposed turbines would be located within Low Flying Area (LFA) 16 and Tactical Training Area (TTA) 20T which are considered by the MoD to be high priority low flying training areas. Therefore, turbine construction in this region could raise considerable and significant MoD concerns.

The issue of the proliferation of wind turbines in both LFA 16 and TTA 20T is of key concern to the MoD. MoD may request that all turbines are fitted with 25candela omni-directional red lighting or infrared lighting with an optimised flash pattern of 60 flashes per minute of 200ms to 500ms duration at the highest practicable point; it is considered important that wind developers initiate consultation with the MoD as soon as practicable within the site design process.

Eskdalemuir Seismic Array

The Leadhills Wind Farm would be located approximately 31.5 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area. It is highly likely that the MoD will object to the development based on its proximity to Eskdalemuir; however initial stage 0 research work, conducted by the Eskdalemuir Working Group (EWG) indicates that there is significant headroom budget available. The detailed research and generation of a revised

safeguarding model (Stage 1) is anticipated to be concluded by the end of January 2014.

Any change in MOD Policy will most likely come after a Scottish Government led consultation and cross-Government department collaboration on working to develop a new Eskdalemuir Safeguarding Policy.

Recommendations

RWE NRL considers a redesign of the development to eliminate the potential impact to the Prestwick Airport PSR, redesigning the site could remove any requirement for technical mitigation. If redesign is not possible Osprey recommends that RWE NRL consult Prestwick Airport on the findings of this assessment and to discuss any requirement to mitigate the effects that the Leadhills development is anticipated to have on their PSR.

Consideration of investigation with NATS regarding the viability of implementing the suggested mitigation scheme for the Lowther Hill PSR;

PSR – data from the Glasgow Airport PSR; and

Consultation with NATS to investigate any potential effects to the Lowther Hill SSR.

To limit the effect of the Wind Farm on Military Low Flying activities, early engagement with the MoD is recommended to ascertain the potential for MoD constraints. Additionally, consideration should be given to satisfying any request from the MoD to fit the Wind Farm with a form of aviation obstruction lighting.

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1. INTRODUCTION

1.1. General

RWE Npower Renewables (RWE NRL) are planning a wind energy development known as Leadhills Wind Farm, on land located in South Lanarkshire, Scotland, approximately 7 kilometres (km) northwest of the Daer Reservoir. Nine turbines are planned for the site with a blade tip height of 130 metres (m). Another wind farm is proposed by RWE NRL, Elvanfoot Wind Farm, adjacent to the Leadhills Wind Farm; a separate assessment has been completed for Elvanfoot Wind Farm. A summary comparison of the two wind farms can be found in Annex A to this document.

All analysis has been carried out in accordance with Civil Aviation Authority (CAA) guidance in Civil Aviation Publication (CAP) 764 [Reference 1].

RWE NRL has commissioned Osprey Consulting Services Ltd (Osprey) to complete this analysis. Over the past five years, Osprey has developed a reputation for excellence in the field of wind energy and aviation impact. Osprey applies a combination of Air Traffic Control (ATC) operational and engineering expertise to projects in order to identify and deliver credible mitigation solutions that are proportional to the scale of the wind development. Osprey has extensive experience in integrating equipment into an Air Traffic Control environment and working with wind farm mitigation suppliers. Of particular note, Osprey has specialised in the specification, procurement and systems integration of communication, navigation and surveillance systems, having completed in excess of 30 projects in this area in the past five years. Osprey has a credible reputation for gaining regulatory approvals for new technologies and wrote the 'first' Safety Cases for all Thales ATM products (including the STAR 2000), the Safety Case Part 1 for Aveillant HR™ and the C Speed LightWave radar.

1.2. Background

This report presents the results of Osprey's independent assessment of the likely operational impact on the Aviation Stakeholders listed in Table 1 below.

Stakeholder	Type	Approximate Distance	Approximate Bearing to wind farm
Prestwick Airport	Civil Airport with Radar	57.0 km/30.8 NM	099°
Edinburgh Airport	Civil Airport with Radar	61.2 km/33.0 NM	197°
Glasgow Airport	Civil Airport with Radar	68.8 km/37.7 NM	136°
NATS Lowther Hill	Civil En-Route Radar	5.6 km/3.0 NM	042°

Stakeholder	Type	Approximate Distance	Approximate Bearing to wind farm
NATS Great Dun Fell	Civil En-Route Radar	112.9 km/61.0 NM	316°
NATS Tiree	Civil En-Route Radar	232.7 km/125.6 NM	118°
NATS Perwinnes	Civil En-Route Radar	220.3 km/118.9 NM	206°
Cumbernauld	Civil En-Route Radar	61.9 km/33.4 NM	157°
Kincardine	Civil En-Route Radar	72.1 km/38.9 NM	177°
Eskdalemuir	Seismic Array	31.5 km/17.0 NM	293°

Table 1 Identified Aviation Stakeholders

No other Aviation Stakeholders in the region of the development were identified.

1.3. Wind Turbine Effects on Aviation

While the effects of wind turbines on aviation interests have been widely publicised, the primary concern is one of safety. There are innumerable subtleties in the actual effects but there are two dominant scenarios that lead to objection from aviation stakeholders:

1. Physical: Turbines can present a physical obstruction at or close to an aerodrome; and
2. Radar/Air Traffic Services (ATS): Turbine clutter appearing on radar displays can affect the safe provision of ATS as it can mask unidentified aircraft from the air traffic controller and/or prevent the controller from accurately identifying aircraft under control. In some cases, radar reflections from the turbines can affect the performance of the radar system itself.

1.4. Purpose, Methodology and Scope

1.4.1. Purpose

This assessment considers the impact of the turbines once they are fully installed and does not consider any safety issues relating to the construction, installation, through life support or visibility of the turbines on the site. However, Osprey recommends that the developer considers the information in this report when assessing the safety of any installation, construction or maintenance phases with respect to aviation interests.

1.4.2. Notification and Lighting Requirements

Tall slender constructions such as wind turbines or anemometer masts, despite their size, can be difficult to see from the air in certain weather conditions. Guidance has been issued by RenewableUK [Reference 2], which recommends that to facilitate safe visual flight, day or night, in the vicinity of anemometer masts and/or turbines:

> Information regarding construction should be passed to the Defence Geographic Centre and the General Aviation Awareness Council at least 6 weeks in advance of the erection or removal of an anemometer mast or first turbine and to follow up on the day with a confirmation that the activity has taken place;
>
> - Data should include location, height (of all structures over 150 feet (ft)), date of erection, date of removal and lighting type (none, infra-red or lighting brightness);
> - Local aerodromes identified during consultation should be notified, particularly any police helicopter or air ambulance unit; and
> - RenewableUK should be copied on the submission of all such information as an independent record and that they might share the information with other relevant official agencies.
>
> Appropriate information about the site construction and any associated lighting (where applicable), for example the height and temporary location of construction cranes, should be provided to the UK Aeronautical Information Service (NATS AIS) for promulgation in applicable aviation publications including the UK Integrated Aeronautical Information Package (UKIAIP) [Reference 3].

Other relevant existing legislation regarding land-based obstacles to air navigation includes the following:

> Obstacles close to licensed aerodromes: Section 47, Civil Aviation Act 1982;
>
> Obstacles close to government aerodromes: Town and Country Act, (Government permitted development) Order 2000; and
>
> Lighting of land-based tall structures (outside of aerodrome safeguarded areas): Article 219, Air Navigation Order 2012 (CAP 393).

1.4.3. Radar Line of Sight (LoS) Analysis and Caveat

Osprey used the ATDI ICS LT (Version 2) tool to model the terrain elevation profile between the identified radar systems and the Leadhills Wind Farm. Otherwise known as a point-to-point LoS analysis the result is a graphical representation of the intervening terrain and the direct signal LoS (taking into account earth curvature and radar signal properties).

Caveat: This is a limited and theoretical desk based study; in reality there are unpredictable levels of signal diffraction and attenuation within a given radar environment (ambient air pressure, density and humidity) that can influence the probability of a turbine being detected. Our analysis is designed to give an indication of the likelihood of the turbine being detected such that the operational significance of the turbine relative to nearby aviation assets can be assessed.

Although every care is taken during the line of sight modelling and analysis process, modelling limitations and assumptions obviously lead our conclusions to be based on theoretical results. The results are therefore indicative, and actual radar performance may differ from this analysis.

The qualitative definitions used in our assessment are defined in Table 2 below.

Result	Definition
Yes	the turbine is highly likely to be detected by the radar: direct LOS exists between the radar and the turbine
Likely	the turbine is likely to be detected by the radar at least intermittently
Unlikely	the turbine is unlikely to be detected by the radar but cannot rule out occasional detection
No	the turbine is unlikely to be detected by the radar as significant intervening terrain exists

Table 2 Qualitative Definitions of LoS results

The complete LoS results are contained in 7677/002 RWE NRL Leadhills Report LoS Diagrams Issue 1 attached with this assessment.

1.5. Document Structure

The document utilises the following structure:

Section 1 gives an introduction to the report;

Section 2 provides details of the Leadhills Wind Farm, its parameters and location;

Section 3 introduces the existing Aviation environment in the vicinity of the development;

Section 4 considers the potential of the development to affect operations at Glasgow Prestwick Airport;

Section 5 looks at the potential effect on NATS infrastructure and operations;

Section 6 studies potential mitigation options;

Section 7 assesses the potential for impact on MoD operations in the region;

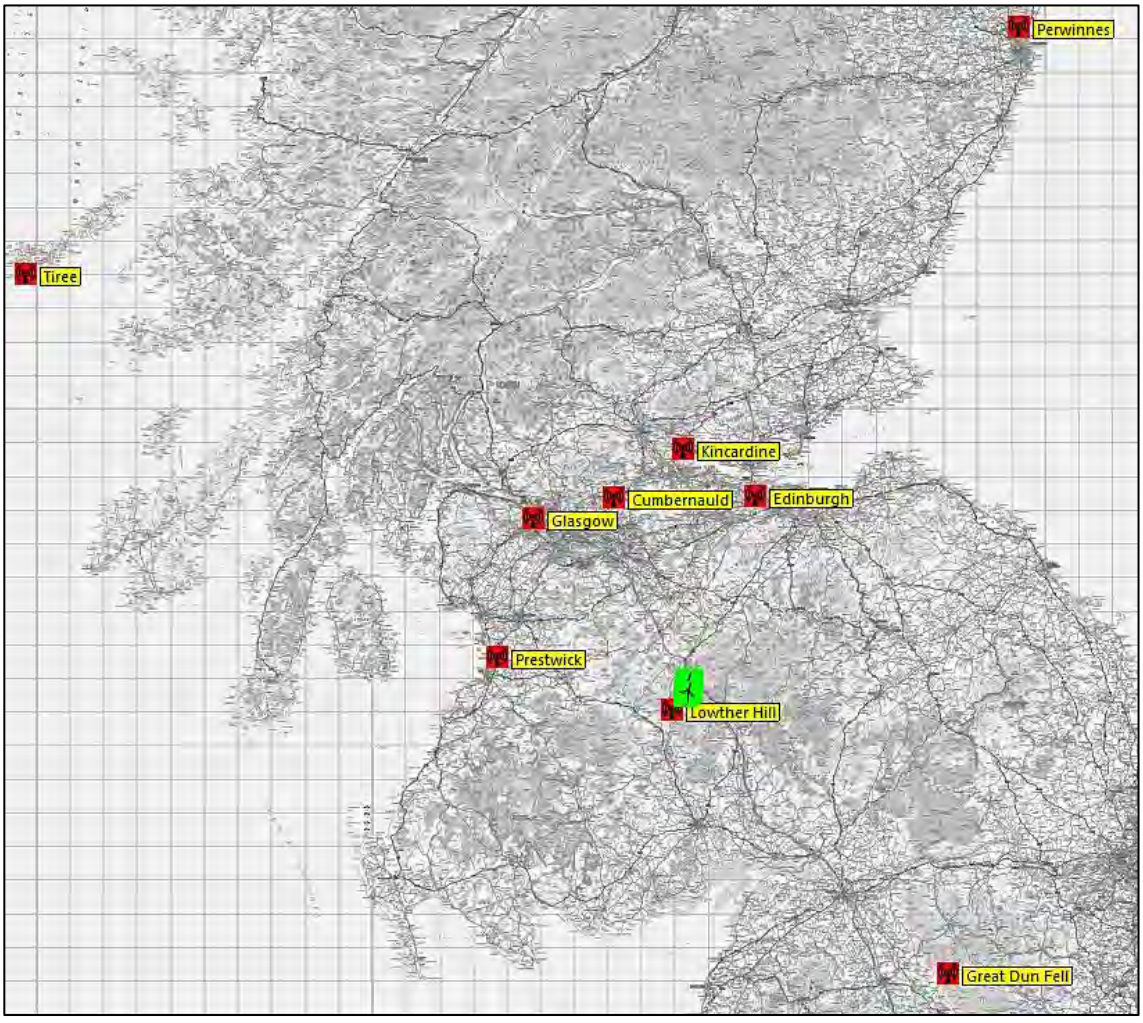
Section 8 gives the conclusions and recommendations and is followed by a list of references used throughout the analysis; and

There is one Annex which compares and contrasts the viability of the Leadhills and Elvanfoot Wind Farms.

2. LEADHILLS WIND FARM

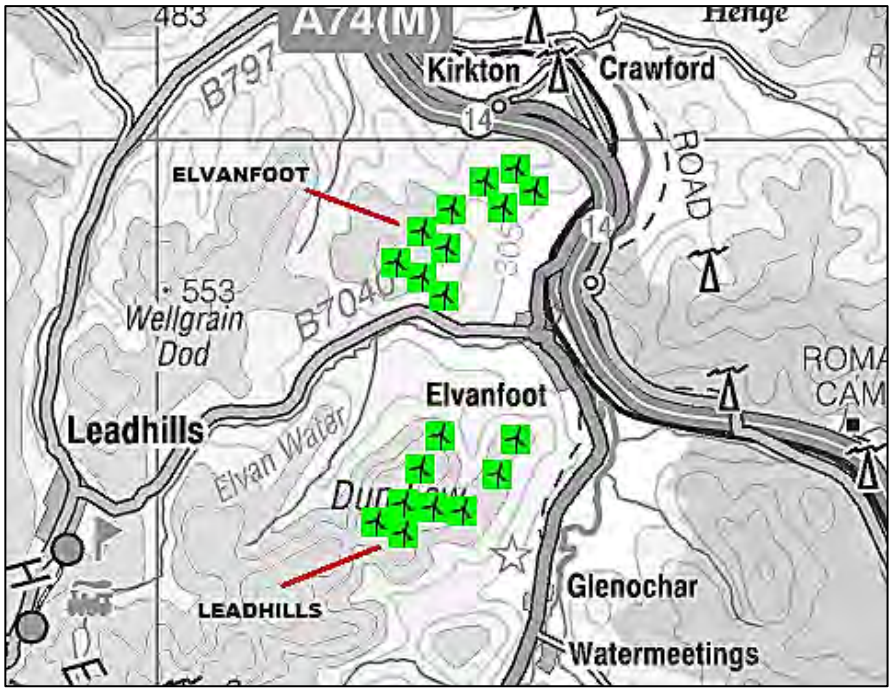
2.1. Overview

RWE NRL is proposing the Leadhills Wind Farm consisting of nine turbines on land located approximately 7 km northwest of the Daer Reservoir, South Lanarkshire, Scotland. Figure 1 below illustrates the regional radar assessed within this document in relation to the location of the proposed wind farm and Figure 2 gives an indicative layout of the Wind Farm, together with the layout of the adjacent proposed Elvanfoot development.



This map shows estimated location data which may be subject to error and is provided for reference only. This map has been produced by Osprey Consulting Services Ltd using the OS OpenData 1:250000 2009 Scale Raster. Contains Ordnance Survey Data © Crown Copyright and database right 2013.

Figure 1 Regional Radar Locations and position of Leadhills Wind Farm (not to scale)



This map shows estimated location data which may be subject to error and is provided for reference only. This map has been produced by Osprey Consulting Services Ltd using the OS OpenData 1:250000 2009 Scale Raster. Contains Ordnance Survey Data © Crown Copyright and database right 2013.

Figure 2 Leadhills Wind Farm Indicative Layout

2.2. Turbine Parameters

The candidate turbines have a maximum anticipated blade tip height of 130 m and the individual turbine coordinates are given in Table 3.

Ref	Easting	Northing	Lat/Long
T1	294836	615897	N55°25′32.34″ W003°39′47.56″
T2	294599	615434	N55°25′17.18″ W003°40′00.40″
T3	294125	614921	N55°25′00.23″ W003°40′26.65″
T4	293724	614984	N55°25′01.95″ W003°40′49.53″
T5	293327	614621	N55°24′49.91″ W003°41′11.59″
T6	292394	614776	N55°24′54.61″ W003°41′34.14″
T7	293322	615042	N55°25′03.51″ W003°41′12.46″
T8	293541	615498	N55°25′18.43″ W003°41′00.63″
T9	293809	615953	N55°25′33.35″ W003°40′46.02″

Table 3 Leadhills Wind Farm Turbine Coordinates

2.3. Development Footprint

The physical size of the Leadhills Wind Farm on the ground is approximately 1.38 km (north to south) by 1.70 km (east to west)[1]. Assuming a nominally accepted 100m wide[2] margin for unwanted radar returns either side of a single turbine, the potential size of the Wind Farm footprint as represented on a typical Primary Surveillance Radar (PSR) display system is around 1.58 km by 1.90 km. Therefore, the radar footprint could equal an approximate total area of 3.00 km^2 (1.05 square nautical miles (NM^2)); however, dependent on the detectability of the wind farm will dictate the radar footprint presented.

[1] Note that in the aviation industry, an apparently curious mix of measurement units is used. Air Traffic Controllers and pilots use feet (ft) and nautical miles (NM) for measurement in the air (altitude, range) but lengths on the ground e.g. runway lengths, are given in metres (m). Equivalent alternative units will be given only when it is appropriate to do so.

[2] This is an estimate; the size of the clutter will depend on range and the specific operating parameters of the radar (e.g. range-azimuth cell size) i.e. the clutter could appear larger at a greater range from the radar.

3. AIRSPACE BASELINE ENVIRONMENT

3.1. Overview

The airspace in the vicinity of, and above the Leadhills Wind Farm is categorised as follows, and a cross section is shown in Figure 3.

Class G uncontrolled airspace from surface level to 5,500 feet (ft), anyone can fly here without permission of air traffic control;

Class D controlled airspace is established above from 5,500 ft above mean sea level (amsl) to Flight Level (FL) 195 (approximately 19,500 ft) which forms the Scottish Terminal Control Area (TMA); airspace which is used for the protection of flights into and out of Edinburgh, Glasgow and Glasgow Prestwick Airports. All aircraft operating in this airspace must be in receipt of an air traffic service from NATS, Military controllers located at a NATS control centre, or a controller from the three airports if required; and

Class C controlled airspace is established above the Scottish TMA; all aircraft operating in this airspace must be in receipt of an air traffic service from NATS or Military controllers located at a NATS control centre.

In addition, the proposed turbines would be located within Low Flying Area (LFA) 16 and when the area is active, within Tactical Training Area (TTA) 20T. These areas are located in southern Scotland, which includes the Borders Region, Dumfries and Galloway and other counties up to and including those within the central belt of Scotland.

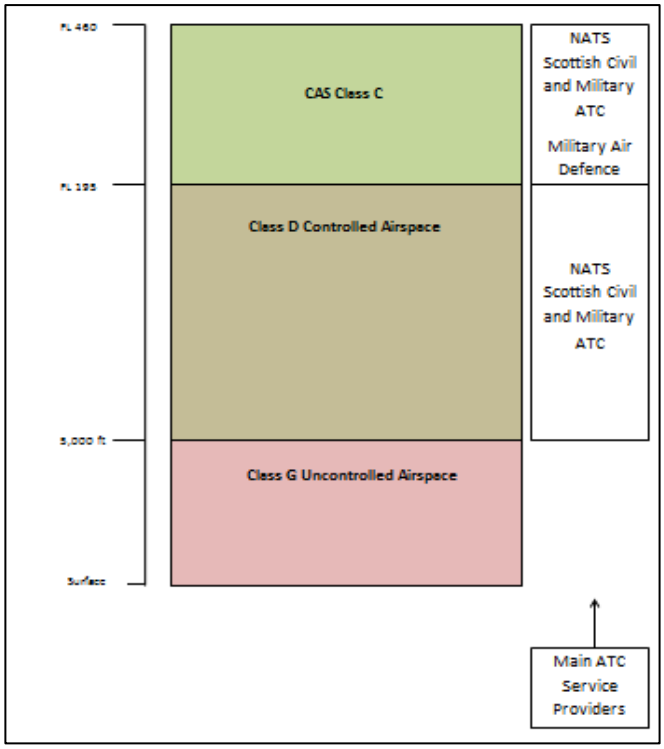


Figure 3 Categorisation of Airspace in the vicinity of Leadhills Wind Farm

Figure 4 below shows the approximate position of the Leadhills Wind Farm in relation to the established Scottish TMA Controlled Airspace.

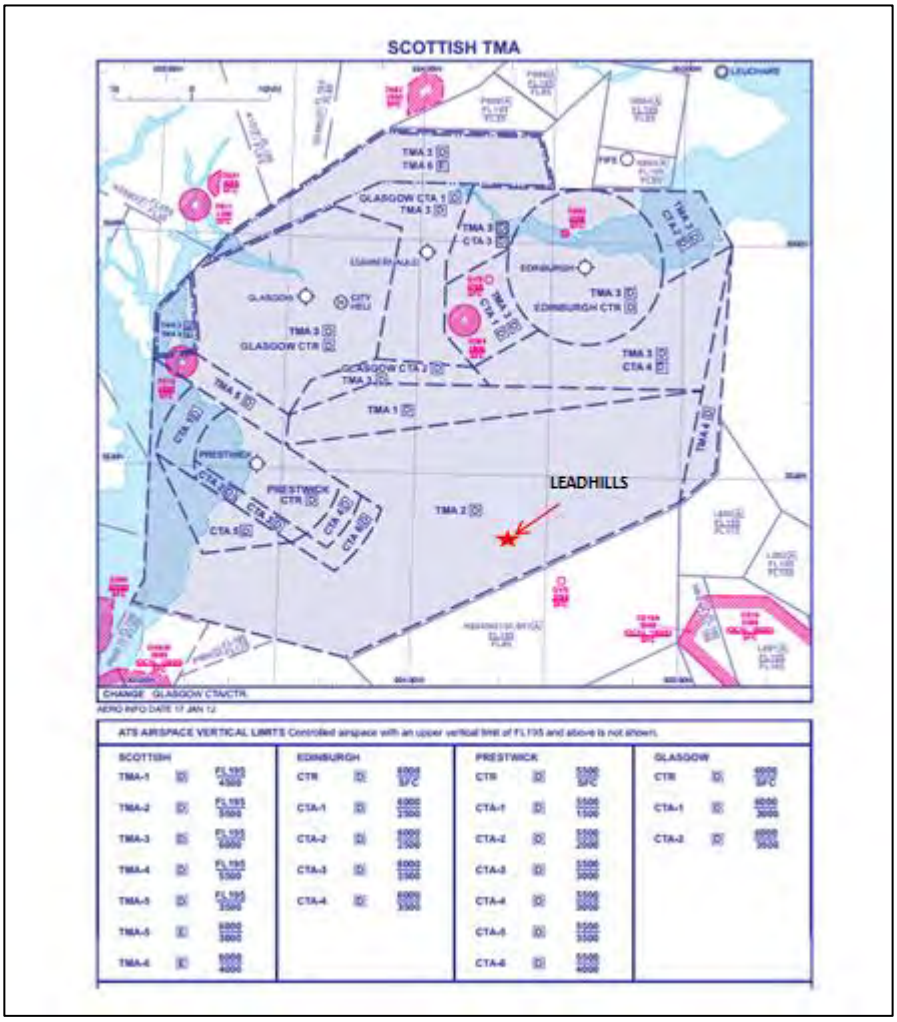


Figure 4 Airspace in the vicinity of Leadhills Wind Farm (not to scale)

4. GLASGOW PRESTWICK AIRPORT

4.1. Overview

Glasgow Prestwick Airport (Prestwick Airport) is an international airport situated on the coast of Ayrshire, approximately 50 km from the city centre of Glasgow. Low cost airline Ryanair utilises its facilities as a hub for operations. Part of the Prestwick Airport site is occupied by the Royal Navy Fleet Air Arm, where a detachment of three Sea King helicopters provide a Search and Rescue role.

4.2. Runways and Airspace

Prestwick Airport operates two runways. The primary runway is of length 2,986 m and designated 13/31; the secondary runway is designated 03/21 and is of length 1,905 m.

Prestwick also has airspace allocated as the Prestwick Control Area (CTA) and Zone (CTR), which provides protection to aircraft lining up with the runway for final approach and for providing connectivity with the Class D airways structure of the Scottish Terminal Control Area (TMA) which is established above the airport. The CTA and CTR are Class D controlled airspace.

The Leadhills Wind farm would be located approximately 57.0 km (30.8 NM) from the Prestwick Airport PSR and outside the lateral limits of the Prestwick Airport controlled airspace. Although the standard consultation distance for an aerodrome with surveillance radar facilities is 30 km, Osprey allows a significant margin as we recognise that valid objections can come from beyond these areas. In addition, Prestwick PSR is often considered as future source of mitigation for NATS issues in this area; hence it is prudent to include it in the assessment.

4.3. Radar Line of Sight (LoS)

The PSR in operation at Prestwick Airport is a hybrid consisting of a Marconi processor and Watchman antenna system. The PSR is sited on the airport at approximately 55′30″05°N 04′35″58°W and the antenna is estimated as being approximately 20 m above ground level (agl). The radar is due for replacement but for the purpose of this assessment the new radar is assumed to be located in the same place and with similar nominal operating parameters.

The LoS terrain elevation profile between the Prestwick Airport PSR (to the left of the diagram) and the nearest Leadhills Wind Farm development wind turbine T6, to the right of the diagram, is given at Figure 5. The grey area represents any intervening terrain. The direct LoS, which takes into account the curvature of the earth, is represented by the red straight line and the orange ellipse around the signal is known as the 1st Fresnel zone. The Fresnel zone is an area around the direct LoS where the signal remains strong; Osprey looks at the degree to which the direct LoS and the Fresnel ellipse are blocked by the terrain in order to make a qualitative assessment of the likelihood that turbines will be detected. The magenta and cyan curves on the upper part of the graph are not relevant to this type of assessment.

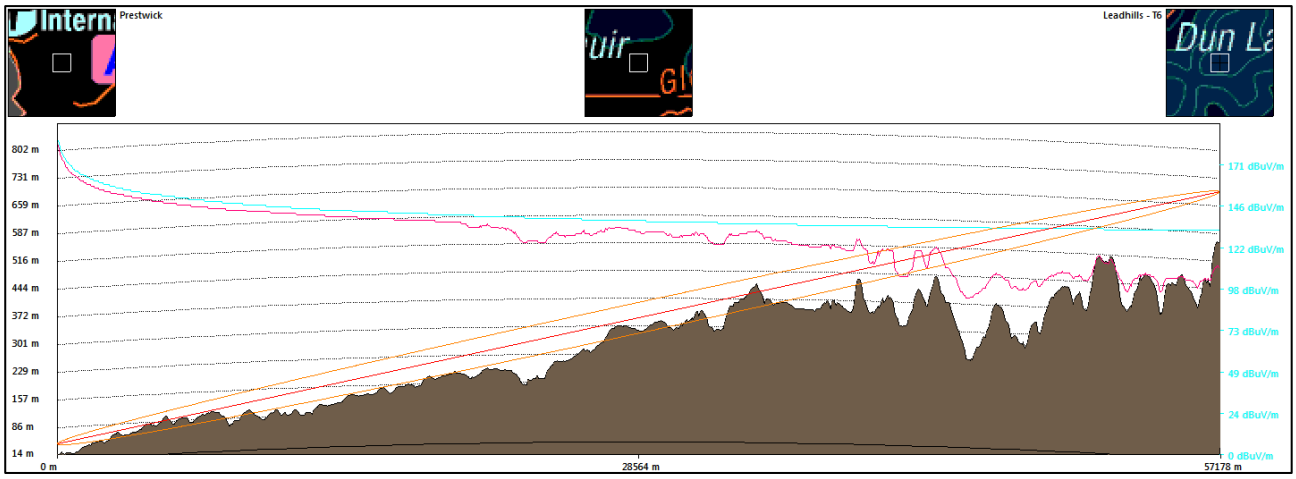


Figure 5 Theoretical LoS elevation profile between the Prestwick Airport PSR and Leadhills Wind Farm T6

LoS analysis indicates that turbine T6 of height 130 m would theoretically likely to be detected by the Prestwick Airport PSR; the turbine is likely to be detected by the radar at least intermittently, only a small part of the 1st Fresnel Zone is blocked by intervening terrain.

The full set of line of sight profiles is contained in Osprey document 7677/002; these profiles indicate that the results vary by turbine as indicated in Table 4 below.

Turbine	Detectability by Prestwick Airport PSR
1	No
2	No
3	No
4	No
5	Unlikely
6	Likely
7	Likely
8	Unlikely
9	No

Table 4 Theoretical indicative visibility of the Leadhills turbines to the Prestwick Airport PSR

Turbines 6 and 7 are likely to be detected by the PSR at least intermittently; direct line of sight skims terrain and only a small part of the 1st Fresnel Zone is blocked.

4.4. Impact on Operations

Prestwick Airport publishes a number of standard arrival and departure procedures within the UK IAIP [Reference 3] and Osprey has studied each of these to identify those that might be affected by the turbine clutter. Only one procedure for the Airport was identified which has the potential to be impacted by the location of the Leadhills development. Figure 6 below illustrates the Prestwick Airport Standard Arrival Chart – Instrument (STAR), for aircraft arriving at the Airport via the Turnberry navigation beacon together with the approximate location of the Leadhills Wind Farm.

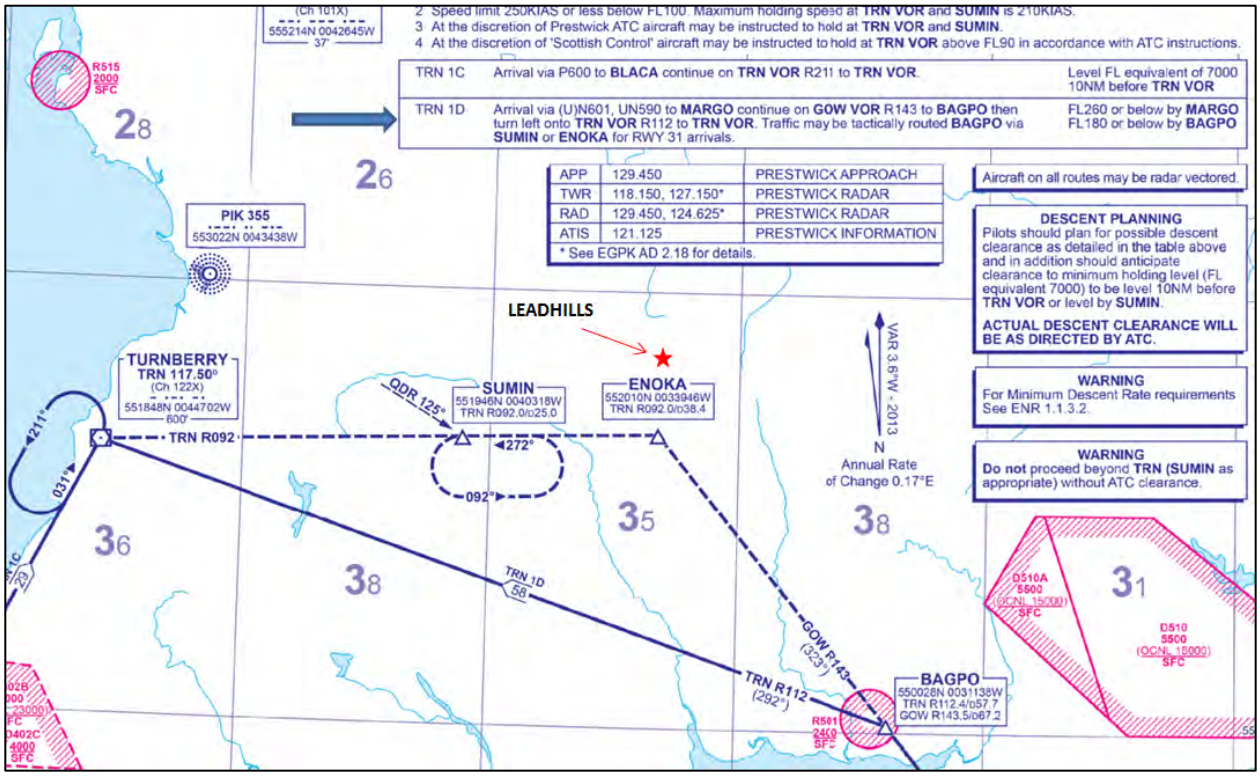


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Figure 6 Approximate Leadhills location in relation to the Turnberry STAR to Prestwick Airport (not to scale)

The published procedures for the Airport do not describe the full extent of the air traffic controllers' task. They are often required to provide radar vectors (headings to fly) to sequence the arrival of aircraft into the recovery stream. Aircraft arriving via the Turnberry (TRN) 1D arrival may be tactically routed via the ENOKA waypoint position for arrival at the Airport. Turbines 3, 4, 5 and 6 at Leadhills would be located within 5 NM of the position of ENOKA, although turbines 3 and 4 are not theoretically detectable to the Prestwick Airport PSR.

As a PSR cannot distinguish between returns from wind turbines and those representing a real aircraft, the air traffic controller is required to assume that actual aircraft targets could potentially be lost over the location of a wind farm. In many cases the controller will need to provide a minimum 5 NM separation between an aircraft receiving a radar service and any unwanted radar returns that have the potential to obscure unknown aircraft targets. The possibility exists that aircraft,

undetected by the PSR, could operate over the area of the proposed turbines. As a consequence, the clutter associated with the Wind Farm is considered to produce an impact on the provision of ATS to aircraft arriving at the Airport via the ENOKA area.

4.5. Cumulative Effect

The combined effect of numerous individual turbines or multiple wind turbine developments can be difficult to mitigate[3]. It is therefore feasible that air traffic service providers may lodge objections to subsequent developments in areas where they had previously been able to accommodate wind farm developments.

It is highly likely that the operators at Prestwick Airport will take into account the overall cumulative impact of the existing and anticipated radar screen clutter, when assessing the impact the proposed Leadhills Wind Farm turbines may have upon their operations and in determining the applicability of any suitable mitigation solutions. Early consultation with the Airports operators is advised to ascertain any limiting cumulative impacts as a result of the development of Leadhills in this area.

4.5.1. Mitigation Options

LoS analysis has determined that two of the turbines proposed for the Leadhills Wind Farm would theoretically, likely to be detectable by the Prestwick Airport PSR. Not all of the turbines are predicted to be detected by the Prestwick Airport PSR and therefore it may be possible to design out the impact. Two of the nine turbines are theoretically expected to be detected at least intermittently – removal, relocation or lowering of turbine blade tip heights of these turbines may offer a valid option for mitigating the potential impact.

Prestwick Airport is understood to be working on a 'regional solution' with a number of developers and it is worth engaging the Airport to investigate whether the Leadhills development could benefit. Prestwick Airport has indicated the area where wind farm mitigation is most likely to be provided, known as the 'Prestwick Arc'. Leadhills sits outside of this area. It is not known Prestwick Airport will consider a requirement for mitigation outside of this area; consultation with the airport will be essential to determine this.

There is currently intense activity by a number of potential mitigation providers to bring their solutions to market, and it is expected that many of these will deliver during 2014. This will allow greater certainty around market costs for various mitigation solutions, and the programme of work necessary for CAA Safety Regulation Group approval. The issue of technical certainty is being addressed through trial and demonstration programmes which have already been initiated with a number of stakeholders in the UK.

4.6. Prestwick Airport Conclusions

The location of the Leadhills Wind Farm and the expected radar clutter associated with it may affect the published standard arrival routes via the TRN 1D and the ENOKA

[3] Note: The adjacent proposed Elvanfoot Wind Farm is theoretically not detectable to the Prestwick Airport PSR.

waypoint. Aircraft will route within approximately 5 NM of the Wind Farm on arrival to the Airport via the ENOKA waypoint.

Air traffic controllers are required to maintain 5 NM standard separation between aircraft under their control and unknown aircraft (or clutter that looks like a real aircraft or could be assumed to be masking returns from a real aircraft). The restriction of manoeuvring airspace to sequence aircraft has the potential to raise an objection to the development by the operators of the Airport.

4.7. Recommendations

Osprey recommends that RWE NRL considers a redesign of the development to eliminate the potential impact to the Prestwick Airport PSR; redesigning the site could remove any requirement for technical mitigation. If redesign is not possible Osprey recommends that RWE NRL consult Prestwick Airport on the findings of this assessment and to discuss any requirement to mitigate the effects that the Leadhills development is anticipated to have on their PSR and operations.

5. NATIONAL AIR TRAFFIC SERVICES

5.1. Overview

National Air Traffic Services Ltd (NATS) provides air traffic services at some airports in the UK and to traffic en-route within UK airspace. NATS operate a number of long range primary and secondary radars positioned to provide maximum coverage of UK airspace. Additionally, military controllers operate at NATS Air Traffic Control Centres; in conjunction with their civilian counterparts, they manage the coordination between civilian and military flights. Surveillance data is also used by other air traffic service providers such as the MoD and airports. NATS has a licence obligation to provide these services to a high quality and performance standard for the benefit of UK aviation as a whole. Any effect the proposed development might have on NATS radars must be considered both in terms of effect on the civilian and military en-route services and in the context of its remote users.

The Leadhills Wind Farm is on an approximate range and bearing of 5.6 km (3.0 NM) and 042° from the Lowther Hill PSR.

5.2. Radar Line of Sight Analysis

5.2.1. Lowther Hill PSR

Figure 7 presents the theoretical radar LoS terrain elevation profile between the NATS Lowther Hill PSR (left of the diagram) and the blade tip height of Leadhills T6 (right of the diagram).

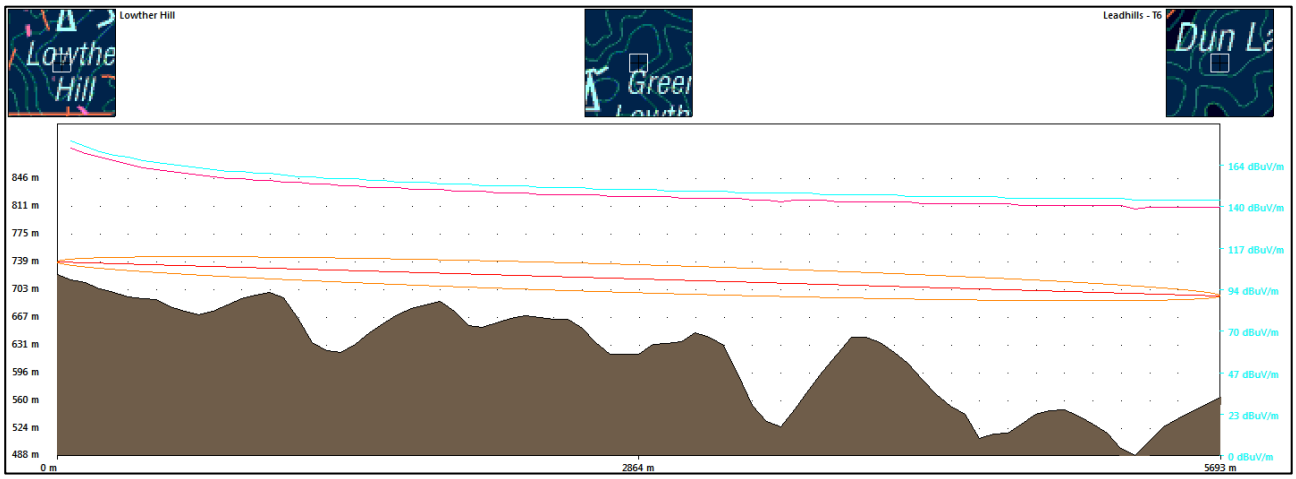

Figure 7 Terrain Elevation profile – NATS Lowther Hill PSR to Leadhills T6

The line of sight diagram shows that, theoretically, Turbine 6 will be detected by the Lowther Hill PSR; the result in Figure 7 is indicative for all turbines in the development. Full line of sight profiles are contained in 7677/002 attached to this document; these profiles indicate that all of the turbines will be theoretically detectable to the Lowther Hill PSR.

5.2.2. Cumbernauld PSR

The Cumbernauld PSR is provided to mitigate against effects of the adjacent Clyde Wind Farm to NATS radars [Reference 4].

Figure 8 presents the LoS terrain elevation profile for the Cumbernauld PSR to T9 at the Leadhills Wind Farm, the closest turbine to the Cumbernauld PSR.

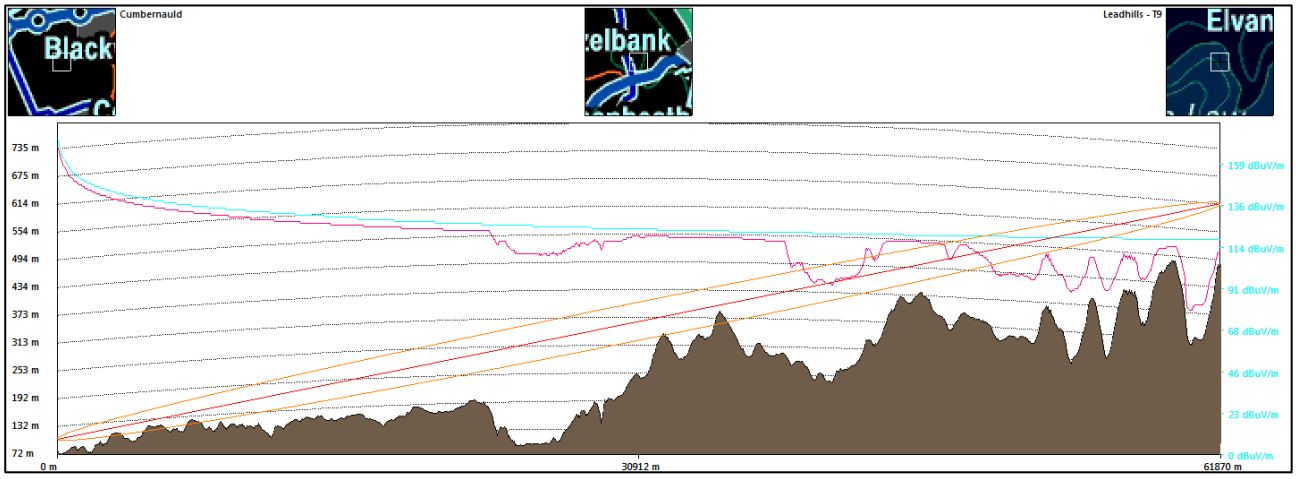

Figure 8 Terrain Elevation profile – Cumbernauld PSR to Leadhills T9

Figure 8 indicates the turbine is highly likely to be detected by the radar: direct LoS exists between the turbine blade tip and the radar. The results in Figure 8 is indicative for the majority of turbines in the development; however, turbine 1 may be detected intermittently as direct line of sight to the turbine skims the top of terrain features, only a small part of the 1st Fresnel Zone is blocked. The full set of line of sight profiles is contained in Osprey document 7677/002 attached with this document.

5.2.3. Other Regional NATS Radars

LoS analysis indicates, theoretically, that the following NATS PSR will theoretically, not detect the proposed turbines at the Leadhills Wind Farm:

Great Dun Fell;

Perwinnes; and

Tiree.

5.2.4. Secondary Surveillance Radar (SSR)

There is a Secondary Surveillance Radar (SSR) co-located at the Lowther Hill PSR. The closest turbine would be located approximately 5.6 km from the facility. The CAA advises that:

"24 km should be used as the trigger point for further discussion with the appropriate service provider who can make a more detailed, accurate assessment of the likely effect on their SSR. The majority of effects are likely to be within 10 km but, because the possibility exists for effects out to 24 km, the greater distance should be utilised for consultation. It must be noted that this is not intended as a range within which all turbines should be objected to".

SSR works by interrogating aircraft transponders to obtain information on aircraft heading, height, identification etc. Mode-S is a modern implementation of SSR which is less susceptible to 'reflections' from large structures/turbines than the traditional Mode-A/C SSR. All NATS SSR have been upgraded to Mode-S but because all aircraft are not yet Mode-S compatible there are some residual effects linked to continued use of Mode-A/C. Consultation with NATS will be required to investigate any potential effects further.

5.3. Operational Impact Analysis

In conjunction with NATS owned/operated PSR systems, a number of regional radars (Edinburgh, Glasgow, Kincardine and Cumbernauld) provide data to the Multi-Radar Tracker (MRT)[4] used for surveillance of aircraft within the NATS Prestwick ATCC[5].

As radar cannot distinguish between returns from wind turbines and those representing a real aircraft, the air traffic controller is required to assume that the turbine induced radar returns could harbour a real aircraft. In providing safe air traffic (radar) services, an air traffic controller must maintain a standard separation distance (5 NM laterally) between aircraft he is controlling and those that are unknown or not in receipt of a radar service, therefore the provision of navigational services by NATS has potential to be impacted in the area of the Wind Farm.

NATS will require that the radar coverage provided by an alternative source of radar data would be low enough to support the provision of navigation services to aircraft operating in proximity to the development.

NATS located at the Prestwick Air Traffic Control Centre (ATCC) are responsible for the provision of air traffic services to aircraft operating within the civil airways structure in the region. The Wind Farm would be situated beneath airspace which is heavily utilised for the protection of flights predominantly into and out of the main Scottish Airports, NATS utilise this airspace in the area in support of these tasks.

Additionally, the air routes above FL 195 are predominantly used by aircraft transiting UK airspace between Continental Europe, the UK and North America and are provided an Air Traffic Service (ATS) by NATS.

Figure 9 below illustrates the Leadhills development area and the position of the lower airways structure adjacent to the development.

[4] MRT: A means of integrating data from multiple radar sources into a single recognised air picture. NATS maintains a network of long range radars, as well as accepting feeds from a number of airfield radars. Data from these radars is fed into NATS MRT systems to produce integrated air pictures at the relevant ATCC.

[5] Prestwick ATCC provides radar services to aircraft in transit and should not be confused with operations completed at Prestwick Airport.

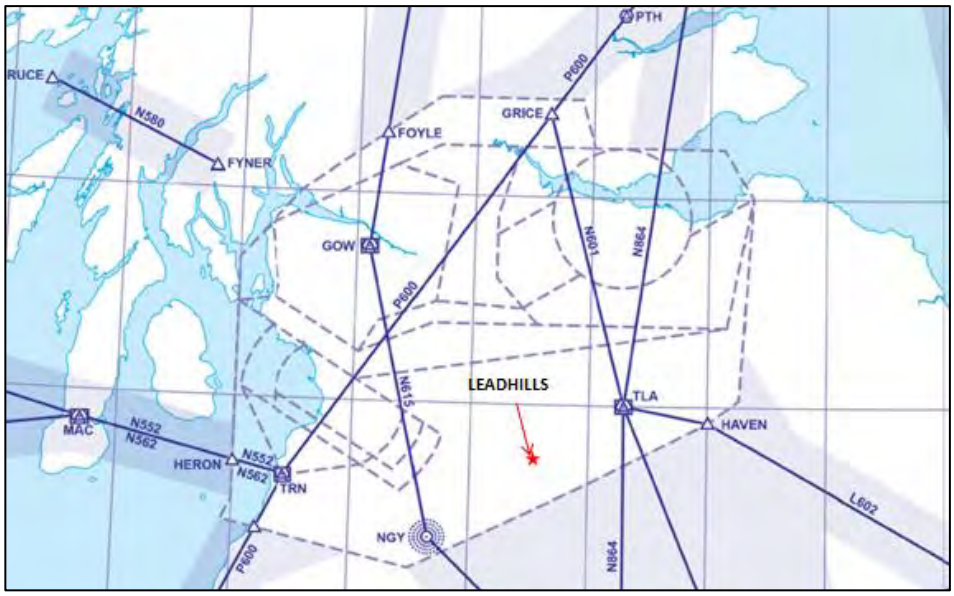

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Figure 9 Leadhills Wind Farm in relation to lower airways route structure (not to scale)

Figure 10 below illustrates the Leadhills development area and the position of the upper airways structure adjacent to the development.

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Figure 10 Wind Farm in relation to upper airways route structure (not to scale)

It is considered likely that NATS will object to the development based on the theoretical detection of the Wind Farm to the Lowther Hill PSR.

5.4. Cumulative Effects

The combined effect of numerous individual turbines or multiple wind turbine developments can be difficult to mitigate. It is therefore feasible that air traffic service providers may lodge objections to subsequent developments in areas where they had previously been able to accommodate wind farm developments.

It is highly likely that NATS will take into account the overall cumulative impact of the existing and anticipated radar screen clutter, when assessing the impact the proposed Leadhills Wind Farm turbines may have upon their operations and in determining the applicability of any suitable mitigation solutions.

5.5. Design Mitigation Options

All of the turbines are predicted to be detected by the Lowther Hill PSR and the LoS analysis indicates that a significant reduction in turbine blade tip height will be required to remove the turbine from detectability[6] and this option is unlikely to be feasible.

5.6. Brief Outline of Technical Mitigation Options

5.6.1. Project Raytheon Modifcation (Project RM)

NATS in conjunction with the supplier of their PSR systems, Raytheon, are in a process of developing a technical solution so that clutter generated by wind turbines can be removed from a controllers' display whilst ensuring that the current ability to detect, track and provide navigational assistance to aircraft is not degraded [Reference 5].

It is anticipated that upgrading their fleet of Raytheon PSRs will significantly reduce the number of NATS objections to wind energy proposals. Two key criteria need to be met in order for the mitigation to be successful:

1. The wind turbines must be further than 9 NM from the radar; and
2. Aircraft must be flying greater than 1.2° or higher in elevation above the blade tips.

The Leadhills Wind Farm would be located within 9 NM from the NATS Lowther Hill PSR and therefore Project RM is not expected to be a suitable mitigation solution for Leadhills.

5.6.2. Blocking Infill

The Kincardine and Cumbernauld PSRs are examples of blocking infill radar which have been designed and implemented for large-scale wind farm mitigation at Glasgow Airport, Edinburgh Airport and with NATS PSRs. The Cumbernauld PSR is provided to mitigate against effects of the adjacent Clyde Wind Farm to NATS radars [Reference 4].

[6] Note: Two of the turbines in the adjacent Elvanfoot development are theoretically detectable to the Lowther Hill PSR and analysis cannot rule out intermittent detection of a further two turbines at the Elvanfoot Wind Farm.

Blocking Infill Mitigation is discussed further in Section 6.

5.6.3. SSR

There is no known technical mitigation available against the effects on the Lowther Hill SSR, however the effects of turbines on SSR systems are also relatively poorly understood and there is little, if any, recorded specific research. Consultation with NATS is required to investigate potential effects to the Lowther Hill SSR.

5.7. Conclusions

The Leadhills Wind Farm is below the Scottish TMA, a complex airways structure heavily utilised by aircraft under the control of NATS; and is an area where normal and regular handover of aircraft between NATS and the Scottish Airports air traffic control will take place. It is considered that the anticipated effect of the detectability of the Leadhills Wind Farm to the Lowther Hill PSR is likely to be considered to pose a detrimental effect on routine NATS operations.

The Wind Farm would be located within 9 NM of the Lowther Hill PSR therefore Project RM would not be suitable for mitigation of the effects to this radar.

The potential exists that the implementation of an additional supply of data from another PSR in the region may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

Consultation will be required with NATS to understand any potential effects the Wind Farm may have on the Lowther Hill SSR.

All of the turbines are predicted to be detected by the Lowther Hill PSR and the LoS analysis indicates that a significant reduction in turbine blade tip height will be required to remove the turbine from detectability. Consultation with NATS should be undertaken on the tolerability of the impact on the Cumbernauld PSR.

6. MITIGATION: BLOCKING INFILL TECHNOLOGY

6.1. Overview

Blocking infill uses an additional alternative PSR sensor, located remotely from the effected PSR. This strategy uses 'terrain shielding' such that the remote sensor cannot see the Wind Farm due to intervening terrain providing a 'Blocking Point', and hence can provide clutter-free returns from the area above the Wind Farm. This data can then be used to replace the area affected by wind farm clutter on the radar display system ('Cut and Paste').

The potential exists that another PSR in the region that does not detect the Leadhills Wind Farm may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

NATS will require that the radar coverage provided by an alternative source of radar data would be low enough to support the provision of navigation services by NATS to aircraft operating in proximity to the development.

6.2. System Principles

The principle is based on creating an infill 'patch' on the affected PSR display using an alternative source of PSR data that satisfies the following two requirements:

Intervening terrain is sufficient to block line of sight to the Wind Farm; and

Base of coverage is sufficient to meet the operational requirements of the affected PSR system.

The advantage is that the technology is available now and there are a number of current examples where it is used, however, it is viewed with some suspicion by aviation stakeholders due to the fact that there will be areas of loss of radar coverage. Costs can also be prohibitive with the procurement of a new radar system costing in in the region of £2.5 to £5 million, the purchase of data from an existing PSR being in the region of £100K-£150K per year.

6.3. Methodology

Radar coverage analysis is required to determine the suitability of infill radar, and has been used in this instance for modelling the regional PSRs within operational coverage.

Osprey also uses its own in-house calculation tool and ATDI ICS LT (Version 2) to model coverage from radar. Using our assumed likely radar performance characteristics for radar, a field strength threshold level is calculated. This threshold is used by ATDI ICS LT (Version 2) for displaying coverage calculation results. For coverage analysis, we use the Fresnel Method + model built into ATDI ICS LT (Version 2), using the Deygout 94 method for diffraction geometry, and the standard method for sub-path attenuations. The field strength threshold has been calculated using a target Radar Cross Section (RCS) of $1m^2$.

Coverage diagrams have been included within this report to support our opinion on the possible suitability of radars to infill the affected area of the impacted radar, which is also further explained at 6.5. For areas in the coverage diagrams overlaid with a blue colour, the signal field strength is predicted to be high enough such that if it was reflected back at the radar from a target with an RCS of $1m^2$, the signal received back at the radar would be at or above the receiver's threshold, and it is likely that the radar would see the target. Coverage diagrams have been produced at a height with a 'receiver' reference of agl or amsl.

Although every care is taken during the modelling and analysis process, modelling limitations and assumptions obviously lead our conclusions to be based on theoretical results. The results are therefore indicative, and actual radar performance may differ from this analysis.

6.4. Challenges

Slant range errors need to be considered for traditional infill radar solutions: slant range is defined as the line of sight distance from ground radar to a target. Without altitude information, the aircraft range would be calculated farther from the antenna than its actual ground track (a variable error depending on unknown aircraft altitude). The effect of slant range, as illustrated in Figure 11, is most significant when the infill radar and the affected radar are at notable different distances from the Wind Farm area.

Slant range is defined as the line of sight distance between radar and an air target. Without altitude information, the aircraft range would be calculated farther from the antenna than its actual ground track.

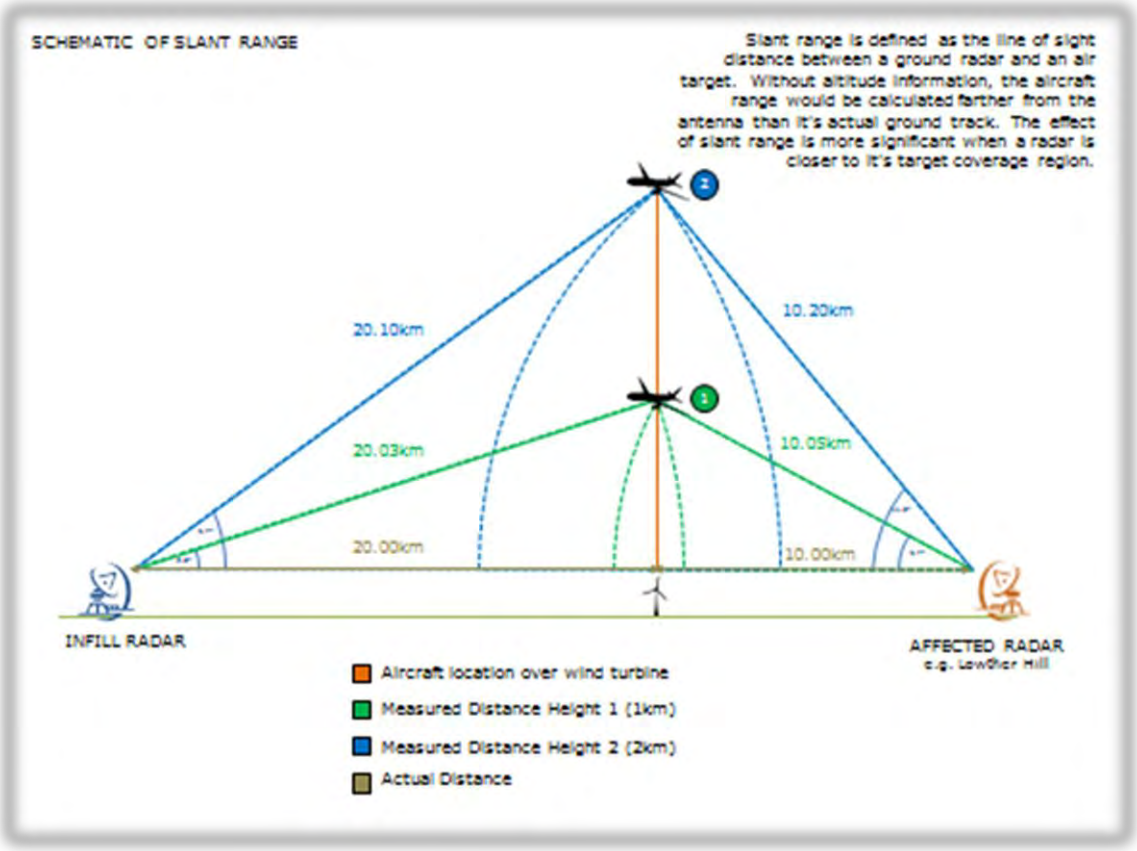


Figure 11 Example: Slant range error for traditional radar infill

6.5. Resolution of Slant Range Errors

NATS MRT commutes best position of aircraft from a number of sensors and algorithms are utilised to display best sensor first and then to available sensors in order of quality of coverage provided. Within MRT slant range errors are insignificant and manageable.

6.6. Coverage Analysis

The potential exists that the implementation of an additional supply of data from another PSR in the region that does not detect the Leadhills Wind Farm may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

An assessment was conducted by Osprey to establish the base of radar coverage of existing radar systems which theoretically do not detect the turbines, to assess their capability to be utilised for such purposes.

The radar sites that were assessed are as follows:

Edinburgh Airport PSR;

Glasgow Airport PSR;

Great Dun Fell PSR;

Kincardine PSR;

Perwinnes PSR; and

Tiree PSR.

6.7. Applicability

It is anticipated that the base of radar cover required by the Lowther Hill PSR in the vicinity of the Leadhills Wind Farm is approximately 3,500 ft (2,000 ft below the base of controlled airspace); however the operational requirement may be lower and will require confirmation from NATS.

Radar	Theoretical Detection of a small target 1m^2 Radar Cross Section (RCS)	Radar	Theoretical Detection of a small target 1m^2 Radar Cross Section (RCS)
Edinburgh	5,249 ft amsl	Kincardine	6,561 ft amsl
Glasgow	2,952 ft amsl	Perwinnes	6,561 ft amsl
Great Dun Fell	6,561 ft amsl	Tiree	6,561 ft amsl

Table 5 Theoretical Detection of a small target 1m^2 Radar Cross Section (RCS) over the location of the Leadhills Wind Farm

Theoretically the Glasgow Airport PSR could provide a suitable base of cover capability above the Leadhills development and may provide a mitigation solution for the Lowther Hill PSR within the NATS MRT system.

This analysis has not considered the cumulative/operational impact of extending any current patch or creating an additional patch nearby but illustrates in isolation that the Glasgow Airport radar solution may be a feasible mitigation solution for the affected radar.

6.7.1. Glasgow Airport Coverage Analysis

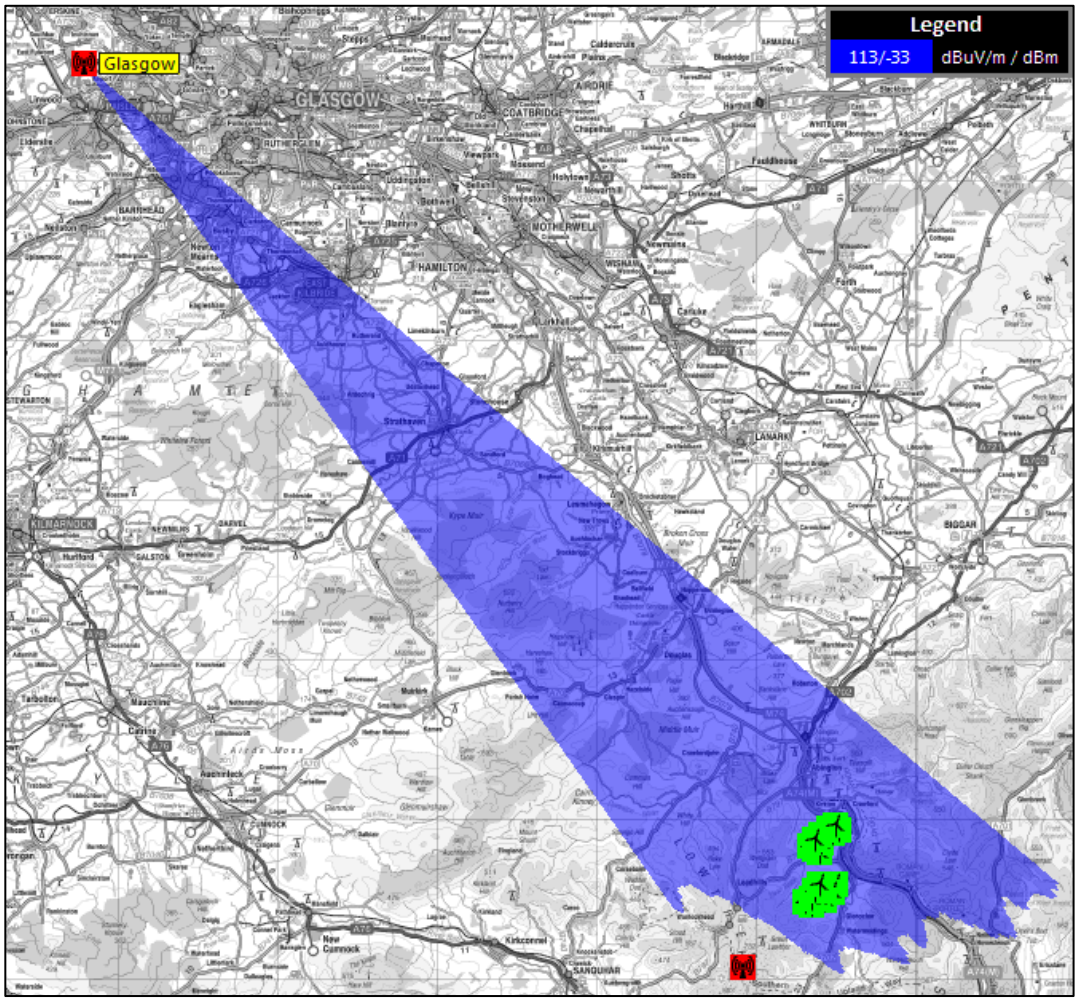


Figure 12 Glasgow Airport PSR - Theoretical Coverage at 2,952 ft amsl

Figure 12 indicates that the Glasgow Airport PSR has a theoretical base of coverage (to detect a 1m^2 target) at the Leadhills Wind Farm site of approximately 2,952 ft (900 m) amsl.

6.8. NATS Multi Radar Tracker

In conjunction with NATS owned/operated PSR systems, a number of regional radars (Edinburgh, Glasgow, Kincardine and Cumbernauld) provide data to the Multi-Radar Tracker (MRT) used for surveillance of aircraft within the NATS Prestwick Air Traffic Control Centre (ATCC).

NATS will require that the radar coverage provided by an alternative source of radar data would be low enough to support the provision of navigation services by NATS to aircraft operating in proximity to the development.

The potential exists that the implementation of an additional supply of data from another PSR in the region that does not detect the Leadhills Wind Farm may be

considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR.

6.9. Conclusions

The Leadhills Wind Farm will theoretically be detectable by the NATS Lowther Hill PSR and the Cumbernauld PSR which supplies radar data to the Prestwick ATCC MRT.

The Glasgow Airport PSR has a base of coverage in the area of the development of approximately 2,952, ft amsl. It is therefore considered that data from this PSR may be suitable to provide appropriate coverage in the NATS MRT to support their operations in mitigation of the effect on the Lowther Hill PSR.

Consultation with NATS will be essential to determining if this option will be acceptable for the Lowther Hill PSR and on the tolerability of any potential impact on the Cumbernauld PSR.

7. MINISTRY OF DEFENCE

7.1. Low Flying Overview

Low flying is an extremely demanding but essential skill for military aircrew gained through progressive training and continuous practice within the United Kingdom Low Flying System (UKLFS). The ability to operate effectively at low-level by day and night is vital to fast jet, transport aircraft and helicopters as they support forces on the ground.

7.2. UKLFS Dimensions and Uses

The UKLFS covers the open airspace of the whole UK and surrounding overseas areas outside of major cities, towns and specific avoidance areas, from surface up to an altitude of 2,000 ft. Additionally, there are three areas, known as Tactical Training Areas (TTA), which are considered suitable for flying lower than the standard training heights due to their challenging terrain and generally sparse population. The capability of Low Flying training in the TTAs allows aircrews to enhance their skills in preparation for deployment onto operations.

Height in the UKLFS can be referred to in terms of minimum separation distance (MSD). This is the distance that must be maintained between any part of an aircraft in flight and the ground, the water or any other ground based object.

Military fixed-wing aircraft are deemed to be low flying if they are less than 2,000 ft MSD and can operate down to 250 ft MSD; light propeller driven aircraft and helicopters are low flying below 500 ft MSD. In the TTAs fast-jets can fly at 100 ft MSD and helicopters can fly down to 100 ft agl or down to ground level. Hercules aircraft can fly at 150 ft MSD in the TTAs.

7.3. Impact on Low Flying Operations

The proposed Leadhills Wind Farm would be located within Low Flying Area (LFA) 16 and when the area is active, within TTA 20T. These areas are located in the south of Scotland, including the Borders Region, Dumfries and Galloway and other counties up to and including those within the central belt of Scotland. The Royal Navy Search and Rescue helicopter base at Prestwick Airport, the QinetiQ range facilities at West Freugh, and the Army training area at Kirkcudbright are located in the area.

LFA 16 and TTA 20T are considered by the MoD to be areas of key importance for military low flying training[7] due to the area having challenging terrain and a generally sparse population. In addition, the area has a high incidence of unrestricted airspace above 2,000 ft, which gives increased flexibility to military aircraft to enter and leave the Low Flying environment, and better than average weather conditions.

[7] https://restats.decc.gov.uk/cms/assets/SiteFiles/datasets/LowFlyingConsultationZones23Nov2011.pdf

Additionally, the area is close to the Army Field training centre at Otterburn, and it borders on the Electronic Warfare Tactics Range at RAF Spadeadam.

Aircraft completing low flying training in these areas would be considered to be operating in visual meteorological conditions (VMC). This means that aircraft will be operating in weather conditions in which pilots would have sufficient visibility to fly the aircraft maintaining visual separation from terrain, obstacles and other aircraft. Furthermore, such aircraft must also carry appropriate mapping detailing the relevant terrain and any obstacles; this mapping would display the Wind Farm in the event of it being constructed.

Figure 13 below shows an extract of the MoD Low Flying consultation map showing the approximate location of the Leadhills Wind Farm.

Figure 13 Military Low Flying Consultation Areas (not to scale)

Figure 13 illustrates that the Leadhills Wind Farm would be located in an area which is bounded by a high priority low flying area (red) and an area which is less likely to raise MoD concerns (blue).

7.4. UKLFS Conclusions

The issue of the proliferation of wind turbines in both LFA 16 and TTA 20T is of key concern to the MoD. The MoD specification for infrared and low intensity red vertical

obstruction lighting has been detailed in a letter dated 17th December 2010 [Reference 6]. It is considered important that wind developers initiate consultation with the MoD as soon as practicable within the site design process.

The Leadhills Wind Farm would be located in an important and busy area for low flying training, thereby potentially having a detrimental impact on Low Flying training for military aircrews. The MoD may object to the development based on the proliferation of obstacles and the impact to utilisation of the areas to complete essential low flying training; consultation with the MoD is recommended within the site design process.

7.5. Eskdalemuir Seismic Array Overview

The Leadhills Wind Farm would be located approximately 31.5 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area (50 km). The MoD, on behalf of the British Geological Survey, the site operator, is likely to object to the proposal based on effect to the operational functionality of the Eskdalemuir Seismic Array.

The MoD is currently objecting to over 950 Megawatts (MW) of wind farms within a 50 km radius of the Eskdalemuir Seismic Array: the Scottish Government has established a Working Group to review methodologies for calculating the impact of wind turbines on the Eskdalemuir Seismic Array. The first stage of the work ('Stage 0') was completed in July 2013, and initial results appear very encouraging. There is an indication that the station may be able to tolerate more development than the limits identified through earlier studies. Further work is being conducted (Stage 1) to consider: direction and/or site effects; separation of turbine generated Seismic Ground Vibration (SGV) from ambient background noise; turbine blade sizes and rotation speeds; and different propagation models. The Stage 1 work will be necessary to inform future policy and the research and generation of a revised safeguarding model; this work is anticipated to be concluded by the end of January 2014.

7.6. Eskdalemuir Conclusions

The Leadhills Wind Farm would be located approximately 31.5 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area. MoD is likely to object to the development based on its proximity to the station at Eskdalemuir, however first stage work in reviewing the methodologies used for calculating the impact of wind turbines on the Eskdalemuir Seismic Array appears very encouraging; there is an indication that the station may be able to tolerate more development.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Overview

RWE NRL is proposing the Leadhills Wind Farm consisting of nine turbines on land located approximately 7 km northwest of the Daer Reservoir, South Lanarkshire, Scotland. The candidate turbines have a maximum anticipated blade tip height of 130 m.

8.2. Prestwick Airport Conclusions

The location of the Leadhills Wind Farm and the expected radar clutter associated with it may affect the published standard arrival routes via the TRN 1D and the ENOKA waypoint. Aircraft will route aircraft within approximately 5 NM of the Wind Farm on arrival to the Airport via the ENOKA waypoint.

Air traffic controllers are required to maintain 5 NM standard separation between aircraft under their control and unknown aircraft (or clutter that looks like a real aircraft or could be assumed to be masking returns from a real aircraft) and the restriction of manoeuvring airspace to sequence aircraft has the potential to raise an objection to the development by the operators of the Airport.

8.3. NATS Impact Conclusions

No predicted impact is anticipated on NATS En-Route navigational aids or radio communication infrastructure; however, as a consequence of radar detectability to the Lowther Hill and Cumbernauld PSRs, it is considered that NATS may consider the Wind Farm presents an unacceptable impact to NATS en-route operations.

There is a collocated Secondary Surveillance Radar (SSR) located at Lowther Hill and at 8.6 km (estimated measurement from radar antenna) the Wind Farm is inside the 24 km consultation zone for SSR. Consultation will be required with NATS to understand any potential effects the Wind Farm may have on the Lowther Hill SSR.

The Wind Farm is below the Scottish TMA, a complex airways structure heavily utilised by aircraft under the control of NATS; and is an area where normal and regular handover of aircraft between NATS and the Scottish Airports air traffic control will take place. It is considered that the anticipated turbine effects are highly likely to be considered to pose a detrimental effect on routine NATS operations.

Any Project RM upgrade to the Lowther Hill is considered not to be a suitable mitigation strategy due to the close proximity of the development to the location of the Lowther Hill PSR.

The potential exists that the implementation of an additional supply of data from the Glasgow Airport PSR may be considered suitable to support NATS operations to mitigate the effect of the Wind Farm on the Lowther Hill PSR within the NATS MRT system.

All of the turbines are predicted to be detected by the Lowther Hill PSR and the LoS analysis indicates that a significant reduction in turbine blade tip height will be required to remove the turbine from detectability; this option is unlikely to prove

feasible. Consultation with NATS should be undertaken on the tolerability of the impact on the Cumbernauld PSR within the MRT environment.

8.4. MoD Conclusions

The site would be located in an important and busy area for low flying training, thereby potentially having a detrimental impact on Low Flying training for military aircrews. The MoD may object to the Leadhills Wind Farm proposal based on the proliferation of obstacles and the impact to utilisation of the areas to complete essential low flying training.

The Leadhills Wind Farm would be located approximately 31.5 km from the seismological recording station at Eskdalemuir and would fall within its statutory safeguarded area. MoD is likely to object to the development based on its proximity to the station at Eskdalemuir, however first stage work in reviewing the methodologies used for calculating the impact of wind turbines on the Eskdalemuir Seismic Array appears very encouraging; there is an indication that the station may be able to tolerate more development.

It is highly unlikely that the wind industry will see any change in MOD Policy until the second stage research work, validating the first stage work, has been completed The detailed research and generation of a revised safeguarding model (Stage 1) is anticipated to be concluded by the end of January 2014.

Any change in MOD Policy will most likely come after a Scottish Government led consultation and cross-Government department collaboration on working to develop a new Eskdalemuir Safeguarding Policy.

8.5. Recommendations

RWE NRL considers a redesign of the development to eliminate the potential impact to the Prestwick Airport PSR, redesigning the site could remove any requirement for technical mitigation. If redesign is not possible Osprey recommends that RWE NRL consult Prestwick Airport on the findings of this assessment and to discuss any requirement to mitigate the effects that the Leadhills development is anticipated to have on their PSR.

Consideration of investigation with NATS regarding the viability of implementing the suggested mitigation scheme for the Lowther Hill and consultation is completed to understand any potential effect to the Cumbernauld PSR;

PSR −data from the Glasgow Airport PSR; and

Consultation with NATS to investigate any potential effects to the Lowther Hill SSR.

To limit the effect of the Wind Farm on Military Low Flying activities, RWE NRL considers early engagement with the MoD to ascertain the potential for MoD constraints. Additionally, consideration should be given to satisfying any request from the MoD to fit the Wind Farm with a form of aviation obstruction lighting.

REFERENCES

Ref	Title	Origin
1	CAP 764: Policy and Guidelines on Wind Turbines Fifth Edition June 2013	Civil Aviation Authority
2	Guidance on Low Flying Aircraft and Onshore Tall Structures Including Anemometer Masts and Wind Turbines. July 2012	RenewableUK
3	UK Integrated Aeronautical Information Package (UK IAIP) Amended to AIRAC 10/13	National Air Traffic Services
4	SSE Clyde Wind Farm http://www.sse.com/Clyde/ProjectInformation/ Accessed 29 October 2013	SSE
5	NATS Project RM: Wind turbine mitigation Briefing note for developers December 2012 http://www.nats.co.uk/wp-content/uploads/2012/12/ProjectRM.pdf	National Air Traffic Services
6	MoD Specification for IR and Low Intensity Red Vertical Obstruction Lighting WITT/605/LFOPS dated 17th December 2010	Ministry of Defence

ANNEX A: INDIVIDUAL VIABILITY OF THE ELVANFOOT AND LEADHILL WIND FARMS

The following Annex provides information and comparison of the two proposed and adjacent Elvanfoot and Leadhills Wind Farms.

The following table compares the potential impact both wind farms, individually and combined may present to aviation stakeholders in the region.

	Elvanfoot	Leadhills
Detectability to Prestwick Airport PSR	NIL	2 turbines
Potential to affect Prestwick Airport Operations		✓
Detectability to the Lowther Hill PSR	4 turbines	All turbines
Range from Lowther Hill PSR/SSR	8.65 km	5.65 km
Detectability to the Cumbernauld PSR	7 turbines	All turbines
Potential to affect NATS Operations	✓	✓
Potential to create a higher cumulative effect		✓
Possibility of site redesign to reduce detectability	✓	
Within Safeguarded Range of Eskdalemuir	✓	✓
Potential for Low Flying Objection	✓	✓

Although the potential of an objection from an aviation stakeholder exists for developments, the greater line of sight detectability, and the lack of feasible site redesign of the Leadhills development indicates the greater potential of the Elvanfoot Wind Farm.

Consultation should be undertaken to understand the potential impact on the operations of stakeholders identified and the mitigation possibilities available.

Email Only

11th June 2016

Dear Debbie,

With reference to the case below

ELECTRICITY ACT 1989
THE ELECTRICITY WORKS (ENVIRONMENTAL IMPACT ASSESSMENT) (SCOTLAND) REGULATIONS 2000
SCOPING OPINION REQUEST FOR PROPOSED SECTION 36 APPLICATION FOR HARRY BURN WIND FARM LOCATED EAST OF LEADHILLS AND SOUTHWEST OF CRAWFORD, SOUTH LANARKSHIRE.

The Glasgow Prestwick Airport safeguarding team has assessed the turbine location against its safeguarding criteria and can confirm that this development will not cause us any safeguarding issues for the airport.

If there are any changes to the tip height or turbine coordinate we will require to reassess the site.

Yours Sincerely,

Jeanette Graham
Wind Farm Safeguarding Coordinator

Glasgow Prestwick Airport Ltd
Aviation House, Prestwick, Ayrshire, Scotland, KA9 2PL

T: +44 (0)1292 511039 **E:** jgraham@glasgowprestwick.com
www.glasgowprestwick.com

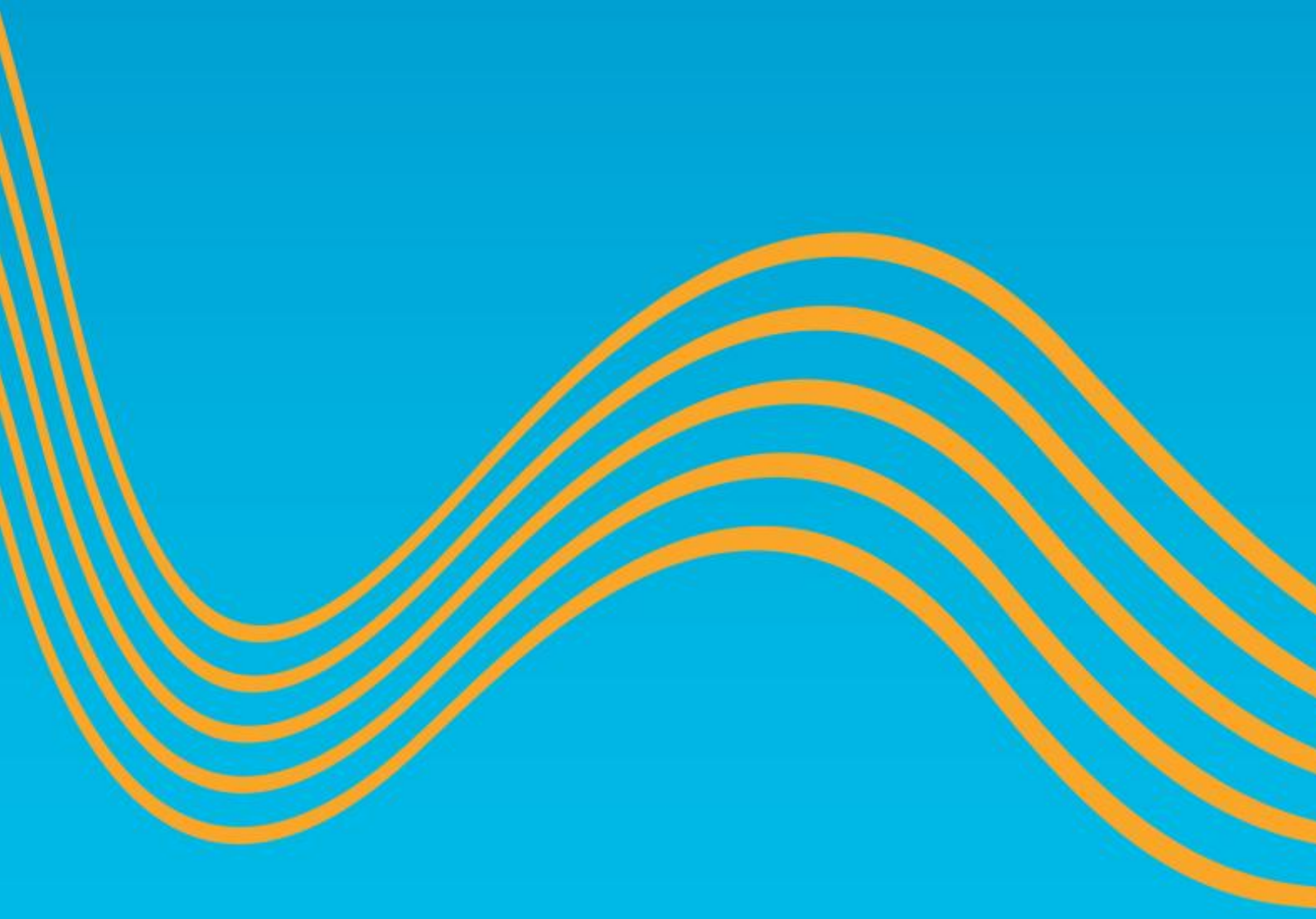
Technical and Operational Assessment (TOPA)

For Elvanfoot

Windfarm Development

Issue 1

NATS reference: W(F) 18687



Publication history

Issue	Month/Year	Changes in this issue
Issue 1	February 2014	Pre Planning Submission

Contents

1. Background

1.1. En-route Consultation

NATS is responsible for the safe and expeditious movement in the en-route phase of flight for aircraft operating in controlled airspace in the UK. To undertake this responsibility it has a comprehensive infrastructure of radars, communication systems and navigational aids throughout the UK, all of which could be compromised by the establishment of a wind farm.

In this respect NATS is responsible for safeguarding this infrastructure to ensure its integrity to provide the required services to Air Traffic Control (ATC).

In order to discharge this responsibility NATS is a statutory consultee for all wind farm applications, and assesses the potential impact of every proposed development in the UK.

The En-route radar technical assessment section of this document defines the assessments carried out against the development proposed in section 2.

2. Application details

RWE Innogy UK Ltd submitted a request for a NATS technical and operational assessment (TOPA) for the development at Elvanfoot, South Lanarkshire as detailed in the table below.

Turbine	Latitude	Longitude	Easting	Northing	Hub (m)	Tip (m)
1	55.4469	-3.6895	293229	618303	0	130
2	55.4453	-3.6842	293563	618111	0	130
3	55.4431	-3.6794	293858	617867	0	130
4	55.4489	-3.6790	293897	618506	0	130
5	55.4536	-3.6781	293967	619035	0	130
6	55.4031	-3.6687	294426	613394	0	130
7	55.4540	-3.6669	294679	619061	0	130
8	55.4561	-3.6605	295090	619285	0	130
9	55.4586	-3.6848	293557	619593	0	130
10	55.4508	-3.6845	293557	618727	0	130

Table 1 – turbine coordinates and height

3. Assessments Required

The proposed development falls within the assessment area of the following systems:

NERL Radar Sites	Latitude	Longitude	Range(nm)	Range(km)	Azimuth(deg)	Type
Great Dun Fell Radar	54.6841	-2.4509	60.3	111.7	317.8	CMB
Lowther Hill Radar	55.3778	-3.7530	3.3	6.0	33.2	CMB
Perwinnes Radar	57.2123	-2.1309	117.3	217.2	206.6	CMB
Tiree Radar	56.4556	-6.9230	124.6	230.7	117.7	CMB
Glasgow A/P Radar	55.8747	-4.4355	35.7	66.2	134.7	PSR
Kincardine Radar	56.0722	-3.7291	36.9	68.4	177.3	PSR
Cumbernauld Radar	55.9395	-4.0575	31.6	58.4	156.3	PSR
NERL Nav Aid Sites	**Latitude**	**Longitude**	**Range(nm)**	**Range(km)**	**Azimuth(deg)**	**Type**
None						
NERL AGA Comms Sites	**Latitude**	**Longitude**	**Range(nm)**	**Range(km)**	**Azimuth(deg)**	**Type**
Green Lowther	55.3902	-3.7355	2.4	4.5	32.3	Tx
Green Trough	55.3918	-3.7808	3.9	7.2	48.1	Rx

Table 2 – Impacted Infrastructure

3.1.1. En-route radar technical assessment

3.1.2.Predicted impact on Radar

No impact is anticipated on NATS's navigation aids.

3.2. En-route navigational aid assessment

3.2.1.Predicted impact on navigation aids.

No impact is anticipated on NATS's navigation aids.

3.3. En-route radio communication assessment

3.3.1.Predicted impact on the radio communications infrastructure.

No impact is anticipated on NATS's radio communications infrastructure.

4. Conclusions

4.1. En-route consultation

The proposed development has been examined by technical and operational safeguarding teams. A technical impact is anticipated, however this has been deemed to be acceptable.

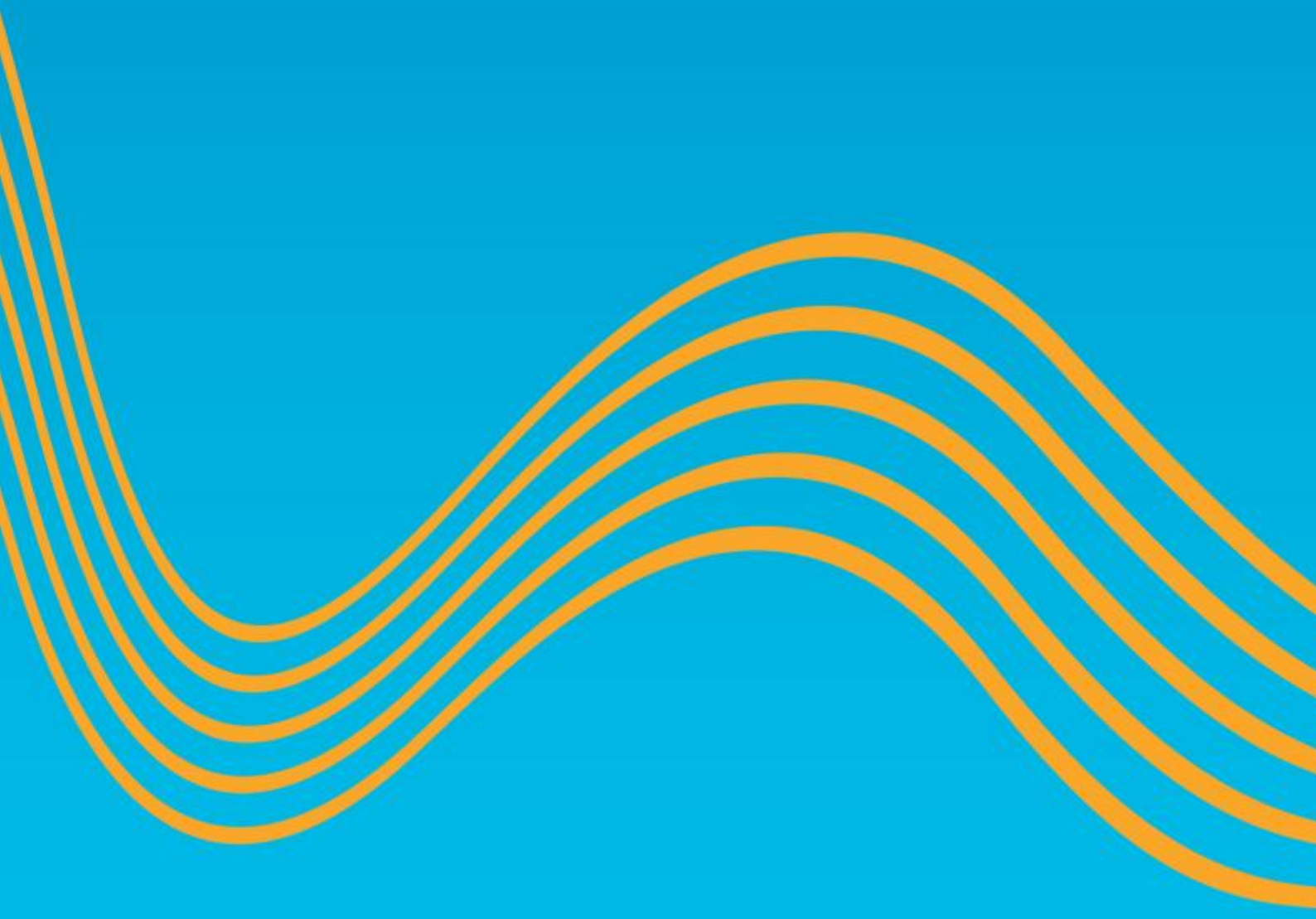
Technical and Operational Assessment (TOPA)

For Elvanfoot & Leadhills

Windfarm Development

Issue 1

NATS reference: W(F) 18688



Publication history

Issue	Month/Year	Changes in this issue
Issue 1	April 2014	Pre Planning Submission

Contents

1. Background

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In this respect NATS is responsible for safeguarding this infrastructure to ensure its integrity to provide the required services to Air Traffic Control (ATC).

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Turbine	Latitude	Longitude	Easting	Northing	Hub Height (m)	Tip Height (m)
1	55.4469	-3.6895	293229	618303	0	130
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6	55.4031	-3.6687	294426	613394	0	130
7	55.4540	-3.6669	294679	619061	0	130
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9	55.4586	-3.6848	293557	619593	0	130
10	55.4508	-3.6845	293557	618727	0	130
11	55.4256	-3.6632	294836	615897	0	130
12	55.4214	-3.6668	294599	615434	0	130
13	55.4167	-3.6741	294125	614921	0	130
14	55.4172	-3.6804	293724	614984	0	130
15	55.4139	-3.6866	293327	614621	0	130
16	55.4151	-3.7014	292394	614776	0	130
17	55.4176	-3.6868	293322	615042	0	130
18	55.4218	-3.6835	293541	615498	0	130
19	55.4259	-3.6795	293809	615953	0	130

Table 1 – turbine coordinates and height

3. Assessments Required

The proposed development falls within the assessment area of the following systems:

NERL Radar Sites	Latitude	Longitude	Range(nm)	Range(km)	Azimuth(deg)	Type
Great Dun Fell Radar	54.6841	-2.4509	60.3	111.7	317.2	CMB
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None						
NERL AGA Comms Sites	**Latitude**	**Longitude**	**Range(nm)**	**Range(km)**	**Azimuth(deg)**	**Type**
Green Lowther	55.3902	-3.7355	1.9	3.5	39.1	Tx
Green Trough	55.3918	-3.7808	3.1	5.7	55.7	Rx

Table 2 – Impacted Infrastructure

3.1. En-route radar technical assessment

3.1.1. Predicted impact on Lowther Hill Radar

Using the theory as described in Appendix A and development specific propagation profile it has been determined that the terrain screening available will not adequately attenuate the signal, and therefore this development is likely to cause false primary plots to be generated. A reduction in the radar's probability of detection, for real aircraft, is also anticipated.

There is a risk of shadowing affected azimuth accuracy and probability of detection but the turbines are all considerably lower than Lowther Hill, so the affected area is likely to be at very low altitudes.

3.1.2. Predicted impact on Cumbernauld Radar

Using the theory as described in Appendix A and development specific propagation profile it has been determined that the terrain screening available will not adequately attenuate the signal, and therefore this development is likely to cause false primary plots to be generated. A reduction in the radar's probability of detection, for real aircraft, is also anticipated.

There is a risk of shadowing affected azimuth accuracy and probability of detection but the turbines are all considerably lower than Lowther Hill, so the affected area is likely to be at very low altitudes.

3.1.3. En-route operational assessment of radar impact

Where an assessment reveals a technical impact on a specific NATS radar, the users of that radar are consulted to ascertain whether the anticipated impact is acceptable to their operations or not.

Unit or role	Comment
Prestwick Centre ATC	**Unacceptable**
RDP Asset Management	Acceptable
Prestwick Centre Military	Acceptable

Note: The technical impact, as detailed above, has also been passed to non-NATS users of the affected radar, this may have included other planning consultees such as the MOD or other airports. Should these users consider the impact to be unacceptable it is expected that they will contact the planning authority directly to raise their concerns.

3.2. En-route navigational aid assessment

3.2.1. Predicted impact on navigation aids.

No impact is anticipated on NATS's navigation aids.

3.3. En-route radio communication assessment

3.3.1. Predicted impact on the radio communications infrastructure.

No impact is anticipated on NATS's radio communications infrastructure.

4. Conclusions

4.1. En-route consultation

The proposed development has been examined by technical and operational safeguarding teams. A technical impact is anticipated, this has been deemed to be **unacceptable**.

Appendix A – background radar theory

Primary Radar False Plots

When radar transmits a pulse of energy with a power of $\mathbf{P_t}$ the power density, **P**, at a range of **r** is given by the equation:

$$P \quad \frac{G_t P_t}{4 \ r^2}$$

Where $\boldsymbol{G_t}$ is the gain of the radar's antenna in the direction in question.

If an object at this point in space has a radar cross section of **σ**, this can be treated as if the object re-radiates the pulse with a gain of **σ** and therefore the power density of the reflected signal at the radar is given by the equation:

$$P_a \quad \frac{P}{4 \ r^2} \quad \frac{G_t P_t}{(4 \ )^2 r^4}$$

The radar's ability to collect this power and feed it to its receiver is a function of its antenna's effective area, $\mathbf{A_e}$, and is given by the equation:

$$P_r \quad P_a A_e \quad \frac{P_a G_r^{\ 2}}{4} \quad \frac{G_t G_r^{\ 2} P_t}{(4 \ )^3 r^4}$$

*Where $\boldsymbol{G_t}$ is the Radar antenna's receive gain in the direction of the object and **λ** is the radar's wavelength.*

In a real world environment this equation must be augmented to include losses due to a variety of factors both internal to the radar system as well as external losses due to terrain and atmospheric absorption.

*For simplicity these losses are generally combined in a single variable **L**.*

$$P_r \quad \frac{G_t G_r^{\ 2} P_t}{(4 \ )^3 r^4 L}$$

Secondary Radar Reflections

When modelling the impact on SSR the probability that an indirect signal reflected from a wind turbine has the signal strength to be confused for a real interrogation or reply can determined from a similar equation:

$$P_r \quad \frac{G_t G_r \ ^2 P_t}{(4\ )^3 r_t^2 r_r^2 L}$$

Where $\mathbf{r_t}$ and $\mathbf{r_r}$ are the range from radar-to-turbine and turbine-to-aircraft respectively. This equation can be rearranged to give the radius from the turbine within which an aircraft must be for reflections to become a problem.

$$r_r \quad \sqrt{\frac{^2}{(4\ )^3}} \sqrt{\frac{G_t G_r P_t}{r_t^2 P_r L}}$$

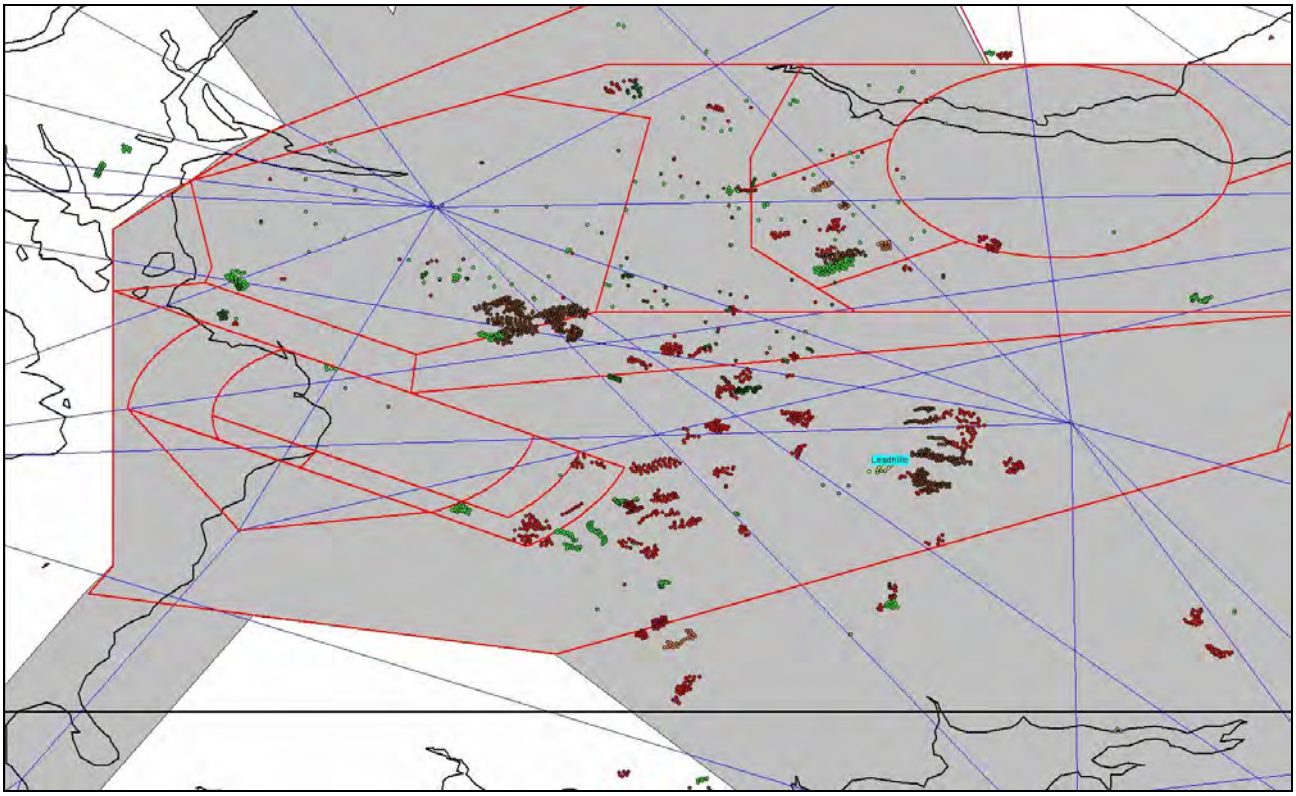
Shadowing

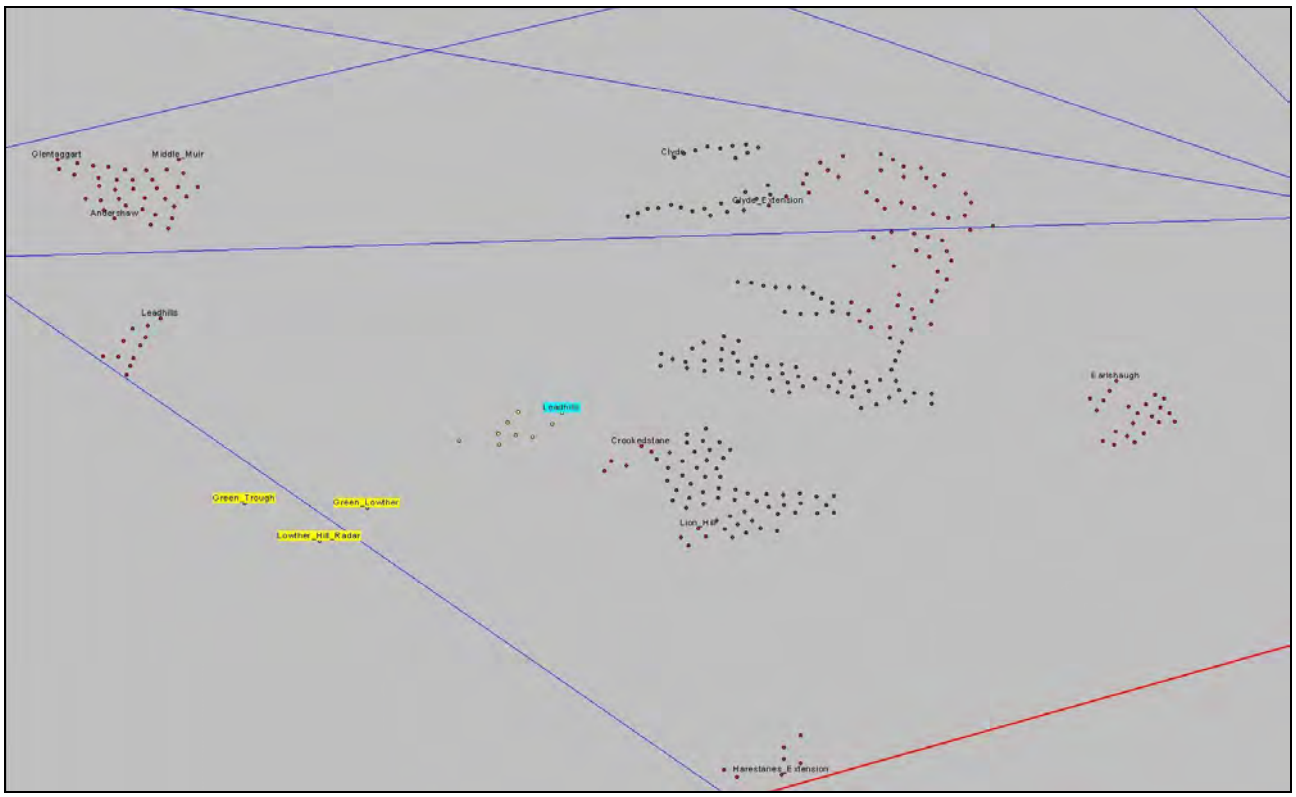
When turbines lie directly between a radar and an aircraft not only do they have the potential to absorb or deflect, enough power such that the signal is of insufficient level to be detected on arrival.
It is also possible that azimuth determination, whether this done via sliding window or monopulse, can be distorted giving rise to inaccurate position reporting.

Terrain and Propagation Modelling

All terrain and propagation modelling is carried out by a software tool called ICS Telecom (version 11.1.7). All calculations of propagation losses are carried out with ICS Telecom configured to use the ITU-R 526 propagation model.

Appendix B – Diagrams





consented/built impact –accepted impact –objection mitigated

mitigation –proposed no impact refused/withdrawn

RE: Windfarm Contracts- Harryburn (Elvans and Leadfoot)

[redacted]@nats.co.uk>

Wed 08/02/2017 09:15

To:'Coleman Aviation' [redacted]

Cc:NATSwindfarms [redacted]

Good Morning Mike,

Thank you for your E Mail, as I believe you have been informed by Sacha Rossi, our Safeguarding Team have looked at the reduction in Turbine Numbers and assessed the 150m turbines unfortunately the issue remains the same, and the mitigation required is still as Quoted previously on the E Mail below dated 30/7/2015. If you require any additional information or wish to progress the Contract further please do not hesitate to contact me.

Kind Regards

[redacted]

NATS

[redacted]

Data Solutions – Business Co ordinator

D: [redacted]
M: [redacted]
E: [redacted]

4000 Parkway, Whiteley,
Fareham, Hants PO15 7FL
www.nats.co.uk

Defence Infrastructure Organisation

Claire Duddy
Assistant Safeguarding Officer
Ministry of Defence
Safeguarding – Wind Energy
Kingston Road
Sutton Coldfield
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United Kingdom

Telephone [MOD]: +44 (0)121 311 3714
Facsimile [MOD]: +44 (0)121 311 2218
E-mail: DIOODC-IPSSG2a1@mod.uk

Your Reference: Harryburn Wind Farm

Our Reference: DIO/SUT/43/10/1/21986

Mike Coleman
Coleman Aviation

1st April 2015

Dear Mr Coleman

Please quote in any correspondence: DIO21986

Site Name: Harryburn Wind Farm

Proposal: Section 36 Application for the erection of 41 wind turbines

Thank you for consulting the Ministry of Defence (MOD) on the above proposed Section 36 Application in your communication dated 5th March 2015.

I am writing to tell you that at this time the MOD has no objection to the proposal. However, this site is within the consultation zone for the seismological recording station at Eskdalemuir. Following research jointly commissioned by DTI, BWEA and MOD, it has been confirmed that wind turbines of current design generate seismic noise which can interfere with the operational functionality of the array. In order to ensure the UK complies with the Comprehensive Nuclear-Test-Ban Treaty, a noise budget based on the findings of the research has been allocated by the MOD for a 50 km radius surrounding the array. The budget has been set at 0.336 nm rms. The noise budget is allocated to planning applications that fall within the zone on a first come first serve basis. We cannot allocate any of the noise budget to this application until such time as we receive formal consultation on the Section 36 Application from The Scottish Government, and we cannot predict how much of the noise budget will have been allocated at the time that the planning application is submitted. If the budget has been fully allocated at the time that the planning application is submitted, MOD will object to the application.

The allocated noise can alter as new schemes reach planning and others do not obtain consent. Any schemes to which the MOD does not object, which subsequently do not gain planning consent, will have their noise quota added back to the available noise budget.

Calculations are based on current turbine designs. If future technological solutions can be applied to turbines and be scientifically proven to reduce or remove the noise generated, the MOD will reassess its policies.

The application is for 41 turbines at 110 metres to blade tip. This has been assessed using the grid references provided by yourself:

Turbine	100km Square letter	Easting	Northing
1	NS	95090	19285
2	NS	94833	19593
3	NS	94809	15749
4	NS	94679	19061
5	NS	94541	15318
6	NS	94426	19394
7	NS	94051	14882
8	NS	93967	19035
9	NS	93905	16117
10	NS	93897	18506
11	NS	93858	17867
12	NS	93636	14941
13	NS	93606	15650
14	NS	93563	18111
15	NS	93557	18727
16	NS	93355	14466
17	NS	93244	15255
18	NS	93080	18569
19	NS	92930	18940
20	NS	92909	14834
21	NS	92510	18630
22	NS	91924	15757
23	NS	91882	19902
24	NS	91845	15299
25	NS	91741	18034
26	NS	91591	19412
27	NS	91520	17312
28	NS	91410	18187
29	NS	91361	16804
30	NS	91239	19049
31	NS	91239	18590
32	NS	91164	20302
33	NS	91104	19787
34	NS	91037	17079
35	NS	90847	17403
36	NS	90817	18223
37	NS	90627	17746
38	NS	90319	19489
39	NS	90303	17948
40	NS	90257	18998
41	NS	90104	18385

In the interests of air safety the MOD will request that the cardinal turbines are fitted with 25cd *and* IR combination aviation lighting and the perimeter turbines are fitted with 25cd *or* IR lighting with an optimised flash pattern of 60 flashes per minute of 200ms to 500ms duration at the highest practicable point.

The principal safeguarding concern of the MOD with respect to the development of wind turbines relates to their potential to create a physical obstruction to air traffic movements and cause interference to Air Traffic Control and Air Defence radar installations.

Defence Infrastructure Organisation Safeguarding wishes to be consulted and notified of the progression of planning applications and submissions relating to this proposal to verify that it will not adversely affect defence interests.

If planning permission is granted we would like to be advised of the following;

- the date construction starts and ends;
- the maximum height of construction equipment;
- the latitude and longitude of every turbine.

This information is vital as it will be plotted on flying charts to make sure that military aircraft avoid this area.

If the application is altered in any way we must be consulted again as even the slightest change could unacceptably affect us.

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.

Further information about the effects of wind turbines on MOD interests can be obtained from the following websites:

***MOD*:** https://www.gov.uk/government/publications/wind-farms-ministry-of-defence-safeguarding

Yours sincerely

Claire Duddy
Assistant Safeguarding Officer – Wind Energy
Defence Infrastructure Organisation

SAFEGUARDING SOLUTIONS TO DEFENCE NEEDS

RE: Harryburn - DIO Ref 21986

DIO SEE-EPS SG2a1 [redacted]

Wed 07/09/2016 09:32

To:'Coleman Aviation' [redacted]

Hi Mike,

As I think Kalie explained, Safeguarding were consulted formerly by the Scottish Government on the Scoping Request for 27 x 150m turbines at Harry Burn Wind Farm. This is what we based the assessment on.

I will speak to our Low Flying Advisor to ascertain whether our response would be any different if the turbines were 149.5m tbt but before I issue anything formerly I would have to receive a further consultation from the Scottish Govt.

Regarding Eskdalemuir, as the application is a Section 36 consultation, Harry Burn has been added to the list and allocated noise budget.

I will inform you of the low flying response as soon as I receive it.

Kind regards

[redacted]
Assistant Safeguarding Officer- Environment & Planning Support – Safeguarding
DIO Safety Environment & Engineering
Defence
Infrastructure
Organisation
Kingston Road, Sutton Coldfield, West Midlands, B75 7RL

MOD telephone: [redacted] **Telephone:** [redacted] **Fax:** [redacted] **Email:** [redacted]

Website: https://www.gov.uk/government/publications/wind-farms-ministry-of-defence-safeguarding

Defence Infrastructure Organisation

Kalie Jagpal
Assistant Safeguarding Officer
Ministry of Defence
Safeguarding – Wind Energy
Kingston Road
Sutton Coldfield
West Midlands B75 7RL
United Kingdom

Telephone [MOD]: +44 (0)121 311 3674
Facsimile [MOD]: +44 (0)121 311 2218
E-mail: DIOSEE-EPSSG2a2@mod.uk

Your Reference: Section 36

Our Reference: DIO/SUT/43/10/1/21986

Ms Debbie Flaherty
Scottish Government

04/07/2016

Dear Ms Flaherty

Please quote in any correspondence: 21986

Site Name: Harry Burn Wind Farm

Proposal: Erection of 27 Wind Turbines

Planning Application Number: Section 36

Site Address: East Of Leadhills & Southwest Of Crawford,South Lanarkshire

Thank you for consulting the Ministry of Defence (MOD) on the above Planning Application in your communication dated 08/06/2016.

I am writing to tell you that the MOD has no objection to the proposal.

The application is for 27 turbines at 150 metres to blade tip. This has been assessed using the grid references below as submitted in the planning application or in the developers' or your pro-forma.

In the interests of air safety the MOD will request that the development should be fitted with aviation lighting in accordance with CAA direction and CAP393 Air Navigation Order Section 1 part 28.

The principal safeguarding concern of the MOD with respect to the development of wind turbines relates to their potential to create a physical obstruction to air traffic movements and cause interference to Air Traffic Control and Air Defence radar installations.

Defence Infrastructure Organisation Safeguarding wishes to be consulted and notified of the progression of planning applications and submissions relating to this proposal to verify that it will not adversely affect defence interests.

If planning permission is granted we would like to be advised of the following prior to commencement of construction;

- the date construction starts and ends;
- the maximum height of construction equipment;
- the latitude and longitude of every turbine.

This information is vital as it will be plotted on flying charts to make sure that military aircraft avoid this area.

If the application is altered in any way we must be consulted again as even the slightest change could unacceptably affect us.

Please note that the Met Office is now a statutory consultee for planning relating to their technical infrastructure. As such, the MOD has not informed the Met Office of this planning application. If the wind turbine application falls within any of the Met Office safeguarded zones you will need to contact the Met Office directly. More information can be found on the Met Office website at:

http://www.metoffice.gov.uk/learning/library/publications/safeguarding.

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.

Further information about the effects of wind turbines on MOD interests can be obtained from the following websites:

MOD: https://www.gov.uk/government/publications/wind-farms-ministry-of-defence-safeguarding

Yours sincerely

Mrs Kalie Jagpal
Assistant Safeguarding Officer – Wind Energy
Defence Infrastructure Organisation

SAFEGUARDING SOLUTIONS TO DEFENCE NEEDS

RE: Harryburn - DIO Ref 21986

DIO SEE-EPS SG2a1 [redacted]

Fri 16/09/2016 09:41

To:'Coleman Aviation' [redacted]

Good morning Mike,

I can confirm that if the proposed turbines at Harryburn are less than 150m to tip, the MOD would request that the cardinal turbines are fitted with 25cd and IR combination lighting and the perimeter turbines are fitted with IR lighting.

[redacted]

Kind regards

[redacted]
Assistant Safeguarding Officer- Environment & Planning Support – Safeguarding
DIO Safety Environment & Engineering
Defence
Infrastructure
Organisation
Kingston Road, Sutton Coldfield, West Midlands, B75 7RL

MOD telephone: [redacted] **Telephone:** [redacted] **Fax** [redacted] **Email:** [redacted]

Website: https://www.gov.uk/government/publications/wind-farms-ministry-of-defence-safeguarding

Flaherty D (Debbie)

From: Windfarms <Windfarms.Windfarms@caa.co.uk>
Sent: 13 June 2016 13:09
To: Econsents Admin
Cc: Flaherty D (Debbie); Alison Sidgwick
Subject: 20160613REScopingHarryBurnWindfarmNearLeadhillsSouthLanarkshire

Dear Sir or Madam,

ELECTRICITY ACT 1989 THE ELECTRICITY WORKS (ENVIRONMENTAL IMPACT ASSESSMENT) (SCOTLAND) REGULATIONS 2000
SCOPING OPINION REQUEST FOR PROPOSED SECTION 36 APPLICATION FOR HARRY BURN WIND FARM LOCATED EAST OF LEADHILLS AND SOUTHWEST OF CRAWFORD, SOUTH LANARKSHIRE.

Having reviewed the Scoping Report provided, the appropriate aviation consultees (NATS, the MoD and Prestwick Airport) have been identified although the positions of each consultee regarding the proposed development should be established by consultation.

It is also recommended that Emergency Service Helicopter Support Units are consulted as they may operate in the area of concern and be affected by the introduction of tall obstacles. We note that Table 3-1 in the Report shows the intention to consult such units.

We note that the Scoping Report states that the turbines will have a maximum tip height of 150m above ground level. Any structure of **150 metres or more** must be lit in accordance with the Air Navigation Order and should be appropriately marked. If the maximum tip height fell below 150m above ground level, there would be no CAA requirement for the turbines to be lit, although if an aviation stakeholder (including the MoD) made a request for lighting it is highly likely that the CAA would support such a request. If during the planning process the proposed maximum turbine heights increase, or turbine locations change, then previously consulted aviation stakeholders will need to be re-consulted to ensure that any impact assessments reflect such changes.

In terms of charting, there is an international civil aviation requirement for all structures of 300 feet (91.4 metres) or more to be charted on aeronautical charts. Accordingly such structures should be reported to the Defence Geographic Centre (DGC) which maintains the UK's database of tall structures (the Digital Vertical Obstruction File) at least 10 weeks prior to the start of construction. The point of contact is Nigel Whittle (0208 818 2702, mail to dvof@mod.uk). The DGC will require the accurate location of the turbines/meteorological masts, accurate maximum heights, the lighting status of the turbines and / or meteorological masts and the estimated start / end dates for construction together with the estimate of when the turbines are scheduled to be removed. In addition, the developer should also provide the maximum height of any construction equipment required to build the turbines.

In order to ensure that aviation stakeholders are aware of the turbines and / or meteorological masts while aviation charts are in the process of being updated, developments should be notified through the means of a **Not**ice to **A**ir**m**en (NOTAM). To arrange an associated NOTAM, a developer should contact CAA Airspace Regulation (AROps@caa.co.uk / 0207 453 6599); providing the same information as required by the DGC at least 14 days prior to the start of construction.

It should be noted that the CAA considers the maximum height of a wind turbine to be measured to the maximum blade tip height.

Should you have any further questions please feel free to contact me, details below.

Yours Faithfully,

Mark Deakin
Surveillance Policy
Airspace, ATM & Aerodromes
Civil Aviation Authority

Tel: 020 7453 6534

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