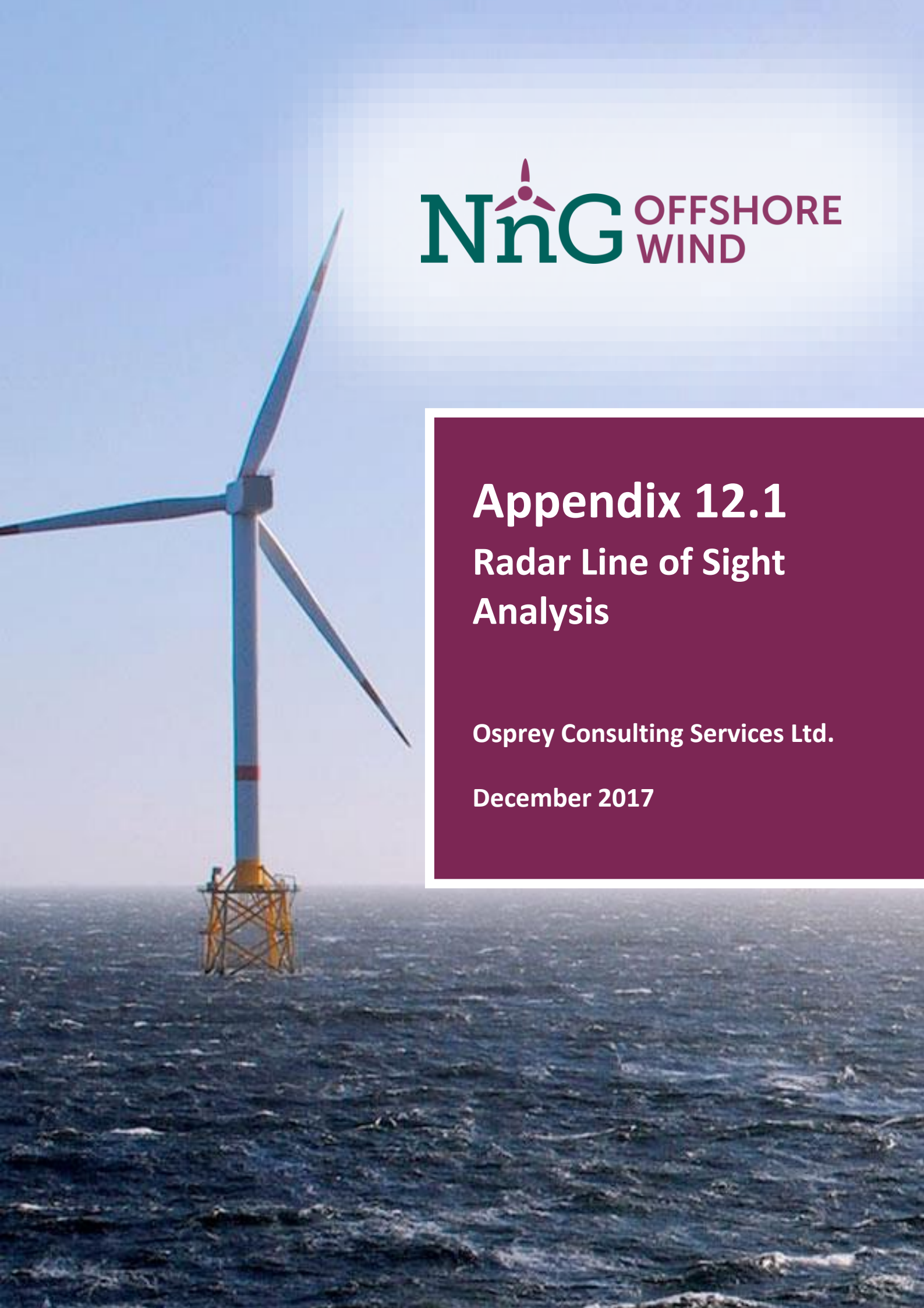

NnG OFFSHORE WIND

Appendix 12.1

Radar Line of Sight Analysis

Osprey Consulting Services Ltd.

December 2017

OSPREY
CONSULTING SERVICES

Neart na Gaoithe Offshore Wind Farm

Radar Systems Line of Sight Analysis

Date: 15 December 2017
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1 Introduction

This Section introduces the report and provides the scope and methodology for the analysis.

1.1 Overview

Neart na Gaoithe Offshore Wind Ltd (NnGOWL) is preparing an application for developing the Neart na Gaoithe (NnG) Offshore Wind Farm (referred to as 'the Project'). NnGOWL are submitting a revised design envelope incorporating larger, but fewer, turbines compared to the Originally Consented Project. The introduction of larger turbines increases the potential for turbines to be detectable by other radar systems in addition to those systems that were assessed as detecting the Originally Consented Project. Consequently, NnGOWL requires understanding of the potential of additional radar systems detecting the Project.

1.2 Previous Analysis

Analysis of the Originally Consented Project concluded that the Project would be considered theoretically detectable by the Primary Surveillance Radar (PSR) and Precision Approach Radar (PAR) systems in operation at Leuchars Station in Fife.

1.3 Additional Analysis Requirement

The potential reduction in turbine numbers would incrementally reduce the overall effect of the Project on the PSR and PAR systems at Leuchars; however, the effect of the revised design envelope parameters would still result in an unmanageable effect on Leuchars Station flight operations and would therefore still require the implementation of the agreed mitigation strategies. Additionally, an increase in turbine size would add no further effects on these radar systems; therefore, analysis of the revised design envelope parameters on the two Leuchars radar systems is scoped out of this analysis.

Osprey has completed a radar Line of Sight (LOS) analysis to establish whether larger turbines would be theoretically detectable by other identified aviation radar systems infrastructure operating in the area of the Project. The systems included in the analysis are as follows:

- RAF Brizlee Wood Air Defence Radar (ADR);
- RAF Buchan ADR;
- National Air Traffic Services (NATS) Allanshill PSR; and
- NATS Perwinnes PSR.

LOS analysis was completed at the proposed turbine blade tip heights of 230 metres (m), 220 m, 210 m[1], 205 m and 200 m (all heights Above Mean Sea Level (AMSL)). As stated in Chapter 4: Project Description, the Project design envelope is now for a maximum blade tip height of 208 m above Lowest Astronomical Tide (LAT). The difference between AMSL and LAT is +3 metres; therefore, although the radar LOS modelling was completed with reference to AMSL, it is still appropriate that the effect at a maximum blade tip height of 208 m above LAT can be inferred from the modelling at 205 m AMSL.

In addition, Osprey Consulting Services (Osprey) have completed a review of the updated Ministry of Defence (MOD) PAR Safeguarding criteria in relation to the Project.

[1] NB. Analysis was undertaken at 230 m, 220 m and 210 m as the design envelope at scoping stage included for turbines up to a maximum blade tip height of 230 m above LAT.

2 Radar Line of Sight Analysis

This Section provides the conclusions of the Radar LOS analysis for the proposed development.

2.1 Caveat on Radar Line of Sight Analysis

Osprey used the ATDI ICS LT (Version 4.3.0) tool to model the terrain elevation profile between the identified radar systems and the Project. 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).

The analysis is a limited and theoretical desk based study; in reality there are unpredictable levels of signal diffraction and attenuation within a given radar environment that can influence the probability of turbines within the individual site boundaries being detected. Our analysis is designed to give an indication of the likelihood of the turbines being detected by the system.

2.1.1 LOS Analysis Scope

The figures in the following sub-sections provide conclusions to the theoretical detectability of the prospective turbine parameters, starting at the tallest height, at twenty-five arbitrary locations[2] within the Wind Farm Area (the 105 km^2 area within which the turbines will be located).

The colour-coded qualitative definitions utilised in our LOS assessment are defined in Table 1.

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 1 Qualitative Definitions of LOS results

[2] NB. These 25 points are not intended to show actual locations where turbines will be installed, these locations have been chosen to provide an even spread of turbines across the Wind Farm Area to gauge theoretical detection.

2.2 Brizlee Wood ADR System

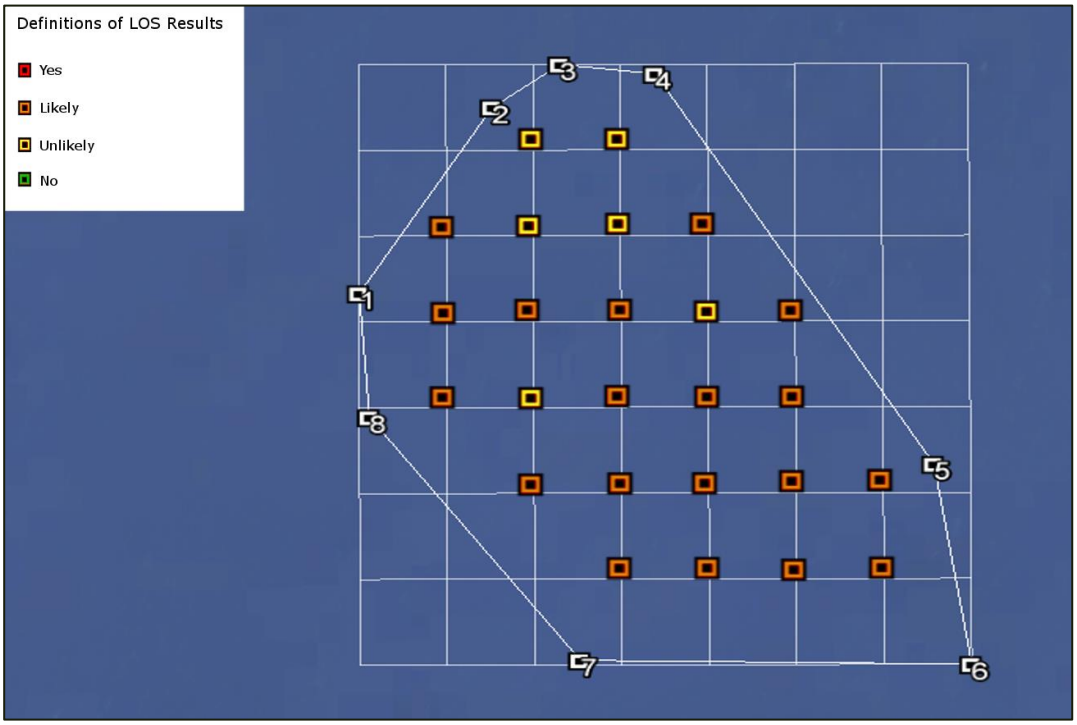

Figure 1 Terrain Elevation Profile – Brizlee Wood ADR to Project turbines at **230 m** amsl

Figure 1 illustrates turbines at 230 m above AMSL within the Wind Farm Area. Results indicate that turbines are theoretically likely to be detected by the ADR at least intermittently, with a lesser amount of area (yellow squares) unlikely to be routinely detected by this system, but occasional detection cannot be ruled out in these areas.

The following figures, Figure 2 through to Figure 5, show the conclusions of the theoretical detectability for the reduced height turbine options by the Brizlee Wood ADR (220 m, 210 m, 205 m, and 200 m above AMSL).

It should be noted that as the turbine height decreases, the area in which turbines are theoretically unlikely to be detected by the system increases.

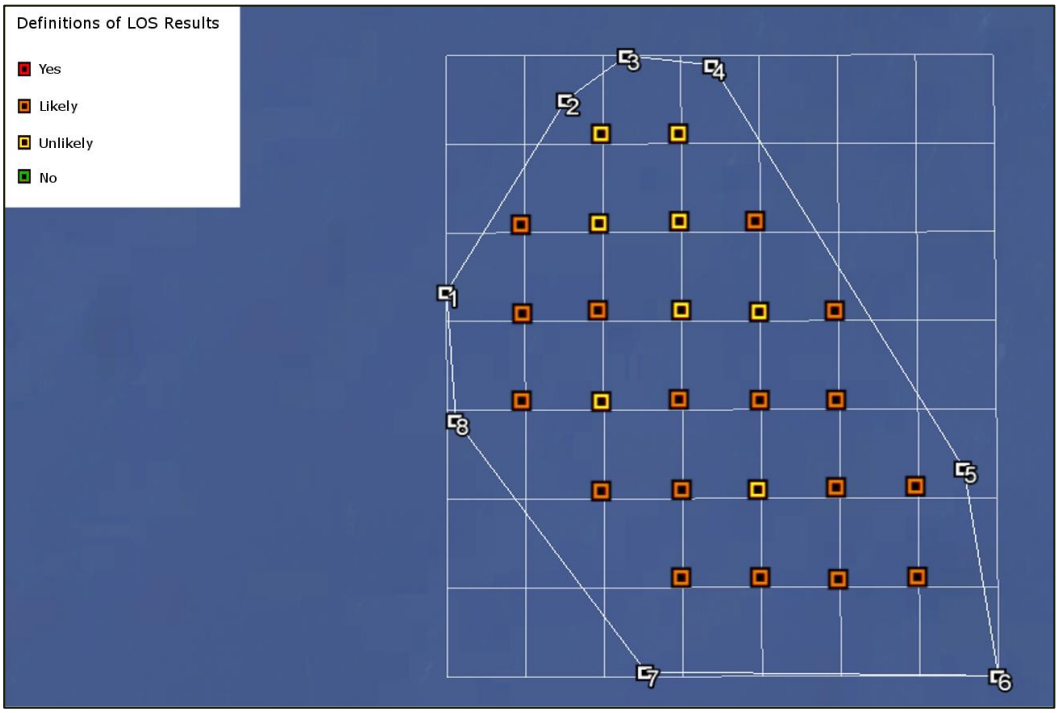

Image © DigitalGlobe

Figure 2 Terrain Elevation Profile – Brizlee Wood ADR to Project turbines at **220 m** amsl

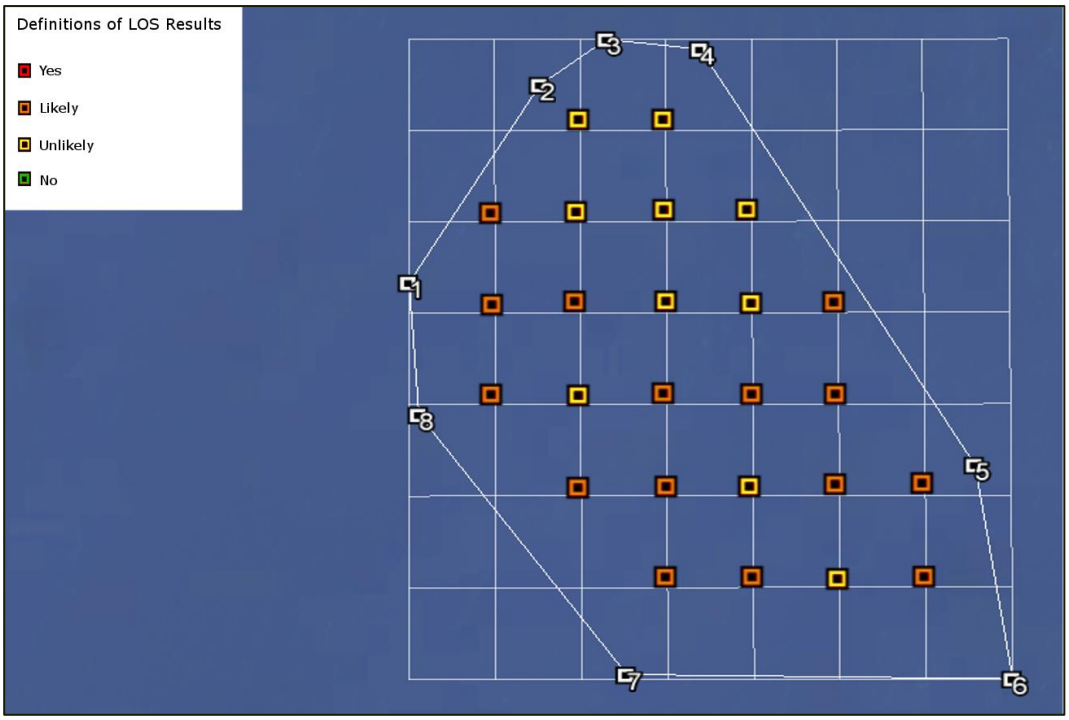

Image © DigitalGlobe

Figure 3 Terrain Elevation Profile – Brizlee Wood ADR to Project turbines at **210 m** amsl

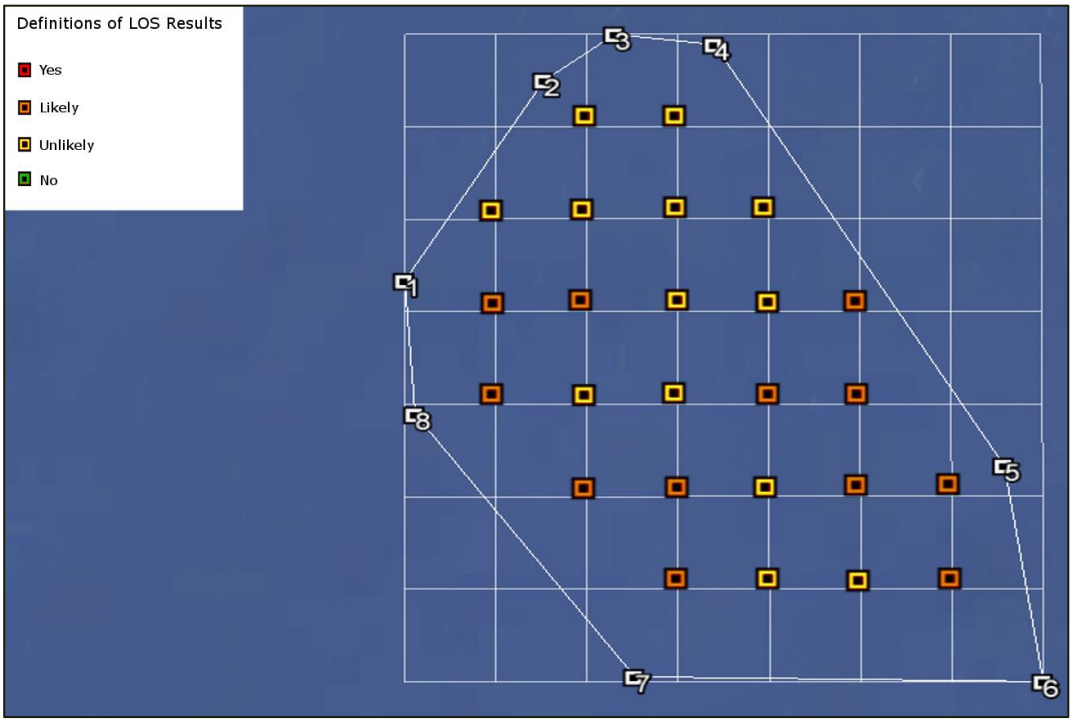

Image © DigitalGlobe

Figure 4 Terrain Elevation Profile – Brizlee Wood ADR to Project turbines at **205 m** amsl

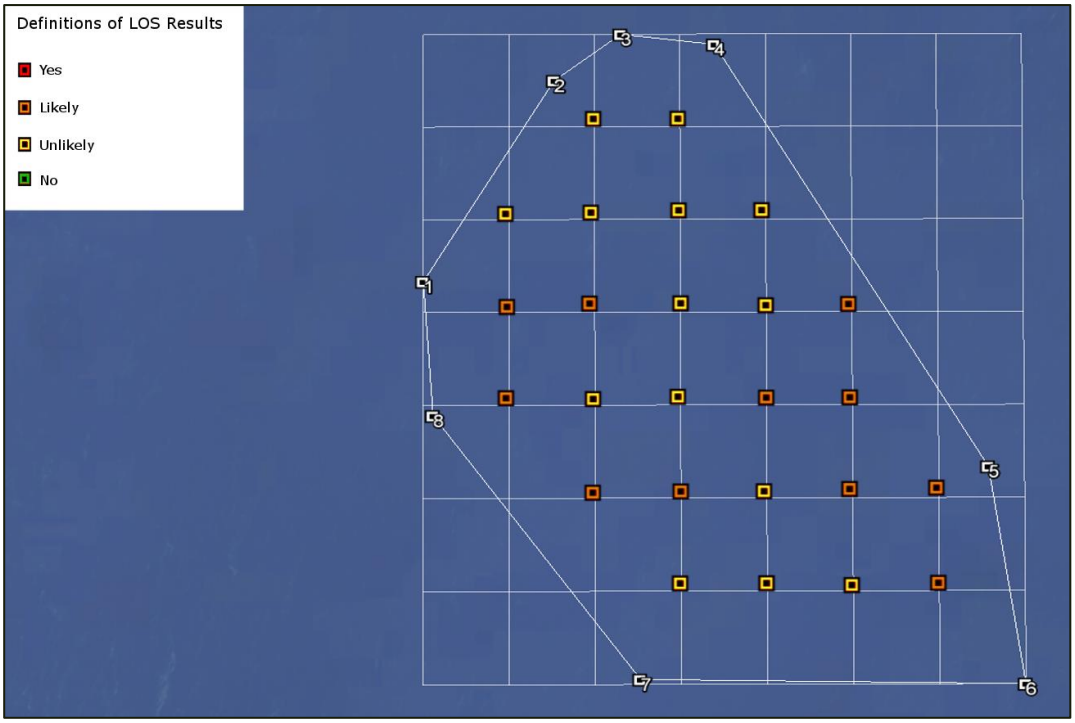

Image © DigitalGlobe

Figure 5 Terrain Elevation Profile – Brizlee Wood ADR to Project turbines at **200 m** amsl

2.3 Buchan ADR System

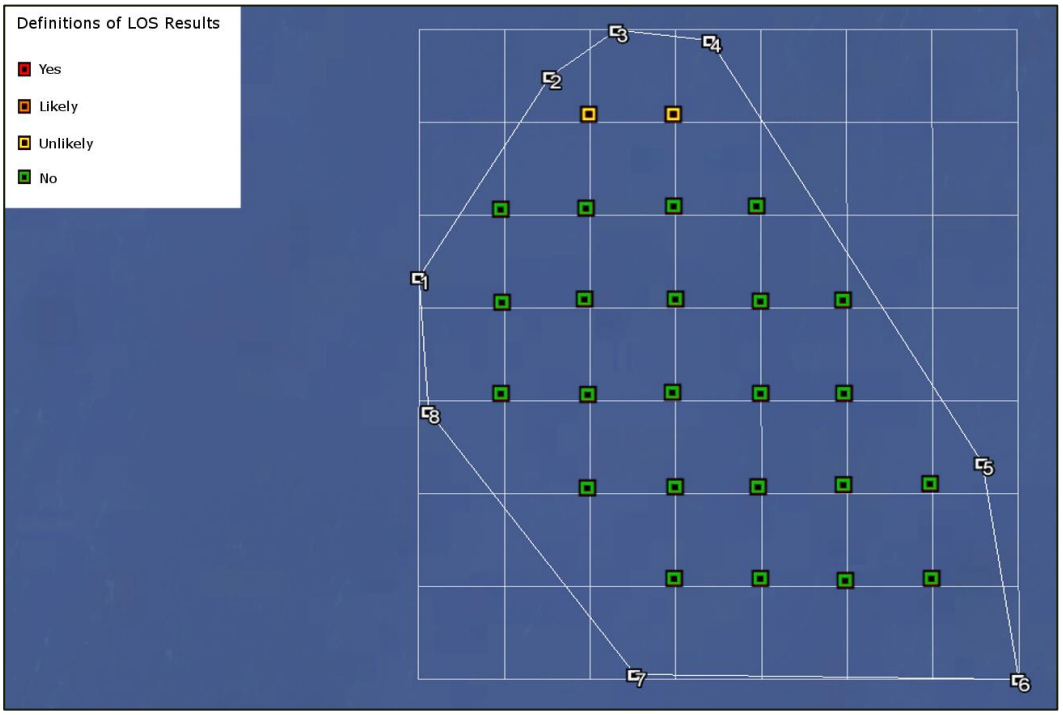

Figure 6 Terrain Elevation Profile – Buchan ADR to Project turbines at **230 m** amsl

Figure 6 show that turbines at 230 m above AMSL would be theoretically unlikely to be routinely detectable by this system in a small portion of the north of the Wind Farm Area; however, occasional detection cannot be ruled out. None of the assessed locations within the southern portion of the development area were considered theoretically detectable by the system at this height.

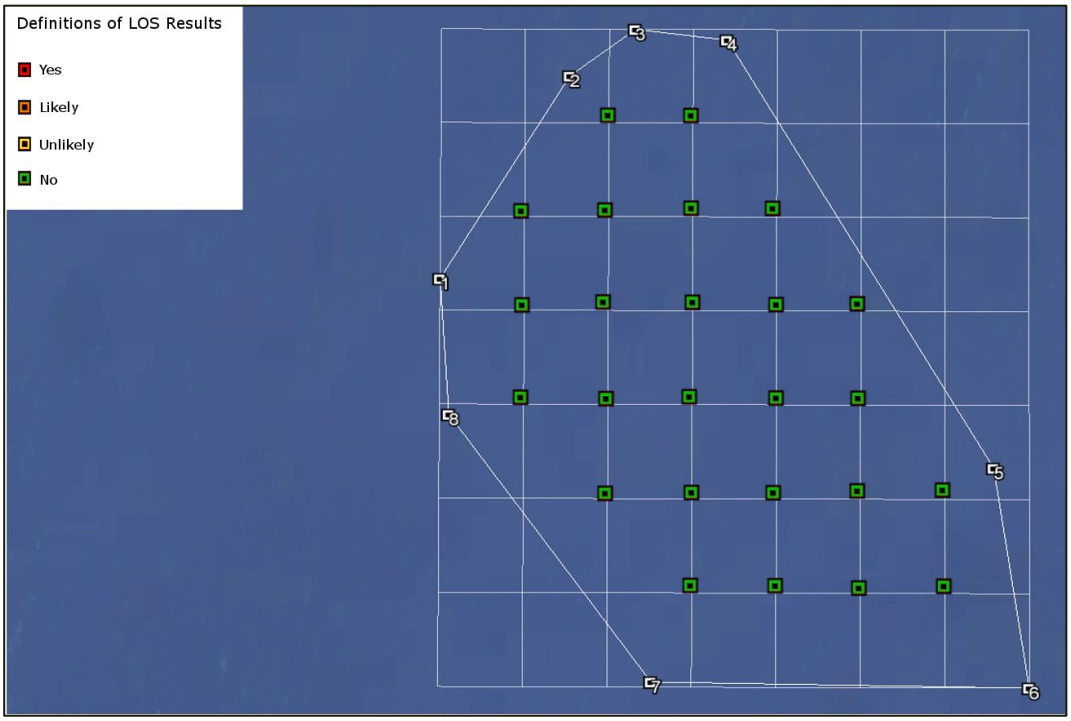

Figure 7 Terrain Elevation Profile – Buchan ADR to Project turbines at **220 m** amsl

Figure 7 above shows that turbines of a maximum of 220 m above AMSL would not be theoretically detectable by this system, concluding that this system would not be affected by the development at 220 m above AMSL. Consequently, analysis of the lower height options is considered unnecessary.

2.4 Allanshill PSR System

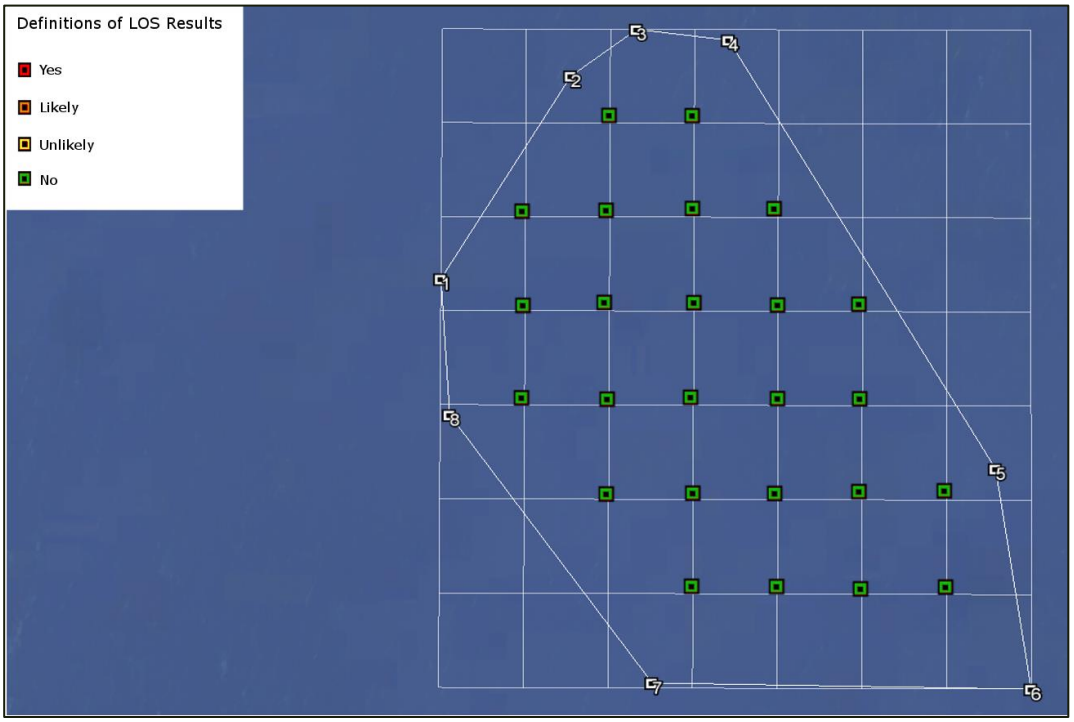

Figure 8 Terrain Elevation Profile – Allanshill PSR to Project turbines at **230 m** amsl

Figure 8 shows that at a prospective blade tip height of 230 m above AMSL, none of the assessed locations within the project boundary were considered theoretically detectable by the NATS Allanshill PSR system, concluding that this system would not be impacted by the Project at the maximum turbine height. Consequently, analysis of the lower height options is considered unnecessary.

2.5 Perwinnes PSR System

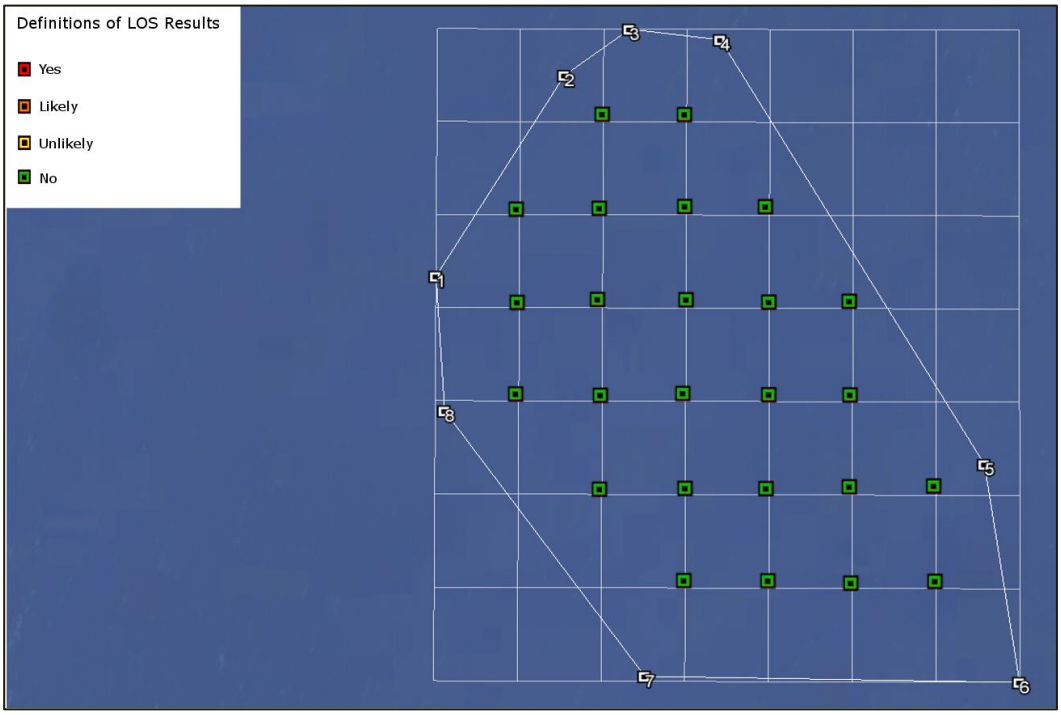

Figure 9 Terrain Elevation Profile – Perwinnes PSR to Project turbines at **230 m** amsl

Figure 9 shows that at a prospective blade tip height of 230 m above AMSL, none of the locations within the project boundary were considered theoretically detectable by the NATS Perwinnes PSR system, also concluding that this system would not be affected by the development at the maximum turbine height. Consequently, analysis of the lower height options is also considered unnecessary.

3 Precision Approach Radar

This Section summarises how the PAR system is utilised by operators and provides detail on how turbines may affect the system.

3.1 System Overview

The Exelis (formerly ITT Gilfillan) PAR system employed by the MOD is a radar guidance system designed to provide lateral and vertical guidance to an aircraft pilot for landing, or until the landing threshold is reached. In general terms, the radars coverage extends out to 20 nautical miles (NM) (37 kilometres (km)) from the runway touchdown point and 20° either side of the extended runway centreline. However, the initial MOD safeguarding criteria for the system was 15° either side of the runway centreline out to 20 NM.

3.2 Trials and Evidence

Very limited information on the PAR systems is publically available, as the technology is developed in the United States and is subject to International Traffic in Arms Regulations (ITAR), a set of US government regulations that control the export and import of defence-related services and equipment.

Turbines when constructed within the arc of coverage of PAR installation (mentioned above) have the capacity to affect PAR in a variety of ways. In particular, the MOD has previously objected to proposals based on track loss, track seduction, and processor overload. Issues of track loss and seduction are well documented in footage from the 2008 PAR Investigation at Royal Air Force (RAF) Lossiemouth [Reference 1], occurring in excess of 80% of aircraft runs. In support of this evidence, the suppliers of the PAR system have confirmed that track seduction is a serious issue.

The evidence from the Lossiemouth trial indicated that track seduction occurs over a relatively limited area, as the aircraft is passing over or near the turbines. Therefore, the MOD is most likely to be concerned where the proposed turbines are located within the normal arc of coverage. Processor overload occurs because, as the manufacturer have expressly confirmed, the PAR is only capable of processing a certain number of targets. Once these thresholds are exceeded, the PAR would 'drop' the weakest signal, which is likely to be the aircraft target. The system manufacturer has confirmed that the PAR is likely to detect turbines (and potentially the individual blades of a turbine) as separate targets, each of which will reduce the number of residual targets that the PAR system can accommodate.

3.3 Manufacturer Conclusions

In 2012, the manufacturer informed the MOD that safeguarding parameters for the system should be increased to include a 40° arc. It is understood that this increase

was based on turbines outside the limit of the initial arc parameters affecting the system. Consequently, the MOD position is that turbines have the potential to affect PAR within its full range of 20 NM and an arc of 40° (20° either side of the approach centreline), and that where this is the case, the effects of a turbine proposal will need to be mitigated by the developer.

4 Conclusions

This section provides the conclusions from the LOS analysis.

4.1 Air Defence Radar

4.1.1 Brizlee Wood ADR

The Brizlee Wood ADR is theoretically likely to detect turbines within the Wind Farm Area at the lowest assessed height of 200 m AMSL. Chapter 13: Aviation (Section 13.8) discusses the results of the LOS analysis further; Section 13.9 provides information on a potential mitigation solution.

4.1.2 Buchan ADR

Results of the radar LOS analysis to Buchan ADR indicate that theoretically the radar system will not detect turbines in the Wind Farm Area at 220 m AMSL however; due to their role in UK strategic defence the exact operating parameters of ADR systems are unknown. The Defence Infrastructure Organisation (DIO), which is the Safeguarding arm of the MOD have been provided with the revised turbine blade tip height; the results of the DIO analysis are awaited.

4.2 Primary Surveillance Radar

4.2.1 Allanshill and Perwinnes PSR

Results of the radar LOS analysis to the NATS Allanshill and Perwinnes PSRs indicate that theoretically the two radar systems will not detect turbines at 230 m AMSL within the Wind Farm Area, consequently, analysis of the lower height options was considered unnecessary.

5 References

Reference	Name	Origin
1	MOD PAR Wind Farm Trial Report Issue 3 June 2009	MOD

Table 2 Table of References