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Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Annex 11-1: Radar Line of Sight Analysis

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Analysis

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OSPREY
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Thanet Extension Offshore Wind Farm

Radar Line of Sight Analysis

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Executive Summary

Vattenfall Wind Power Limited (VWPL) is developing the Thanet Extension Offshore Wind Farm (TEOWF). Vattenfall has world leading experience in offshore wind, as owner of Kentish Flats, Kentish Flats Extension, Ormonde, and Thanet Offshore Wind Farms, which are currently operational in the UK, as well as a growing portfolio of wind projects across its European markets.

The proposed TEOWF would be located off the southeast coast of Kent in the southeast of England approximately 8 kilometres (km) offshore (at the closest point), surrounding the operational Thanet Offshore Wind Farm. Electricity generated would be transported to the shore by offshore export cables installed within the proposed Thanet Extension Offshore Export Cable Corridor.

Radar Analysis Summary

The development site is within the operational range of the Ministry of Defence (MoD) operated Trimingham Air Defence Radar (ADR) system, the Cromer and Debden Primary Surveillance Radar (PSR) systems operated by NATS and the London Southend Airport PSR. A radar Line Of Sight (LOS) analysis was completed for the maximum proposed turbine height of 250 metres above Highest Astronomical Tide (HAT) to the 34-wind turbine layout iteration, through reference to the array boundary presented as part of the Preliminary Environmental Information (PEI). Since publication of the PEI report the array boundary has been reduced in size with a reduction of the north-west promontory due to a number of sensitivities. For the purpose of the LOS analysis the change in array boundary (termed the Red Line Boundary) has not been applied; this results in a more precautionary assessment.

Analysis concluded that the maximum wind turbine parameters are considered to not be theoretically detectable by the MoD Trimingham ADR or the NATS Cromer PSR; consequently, MoD and NATS utilisation of these radar systems is considered not to be affected. Analysis of the Debden PSR cannot rule out occasional detection at 250 m above HAT of three of the wind turbines; the remaining wind turbines are unlikely to be detectable (apart from Turbine 19). At 215 m above HAT, it is considered unlikely that routine detection the majority of the turbines; however, occasional detection cannot be ruled out. The remaining turbines would not be detected. Finally, theoretical radar detectability by the LSA PSR is highly likely at both 215 and 250 m above HAT blade tip height.

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1 Introduction

This Section defines the requirements and scope for the analysis.

1.1 Assessment Scope

Vattenfall Wind Power Limited (VWPL) has contracted Osprey Consulting Services Ltd (Osprey) to complete a detailed radar Line Of Sight (LOS) analysis to a 34-wind turbine layout iteration of the Thanet Extension Offshore Wind Farm (TEOWF). Osprey will assess LOS across the development area to establish if individual locations would be detectable by selected radar systems at the blade tip height of 250 metres (m) above Highest Astronomical Tide (HAT). A further analysis will also be completed at a blade tip height of 215 m HAT if radar detectability at the higher blade tip height is predicted.

1.2 Document Structure

The report utilises the following structure:

- Section 1 introduces the requirement and the scope of the report;
- Section 2; includes notes on radar system operations and how systems can be affected by wind turbines;
- Section 3 provides the conclusions from the radar line of sight analysis from the identified radar systems; and is followed by the list of references used in the analysis.

2 Radar Background

This Section provides general details of the effects that wind turbines can have on surveillance systems and provides details of the identified aviation stakeholders that might be affected.

2.1 Notes on Radar Operation

In simple terms, radar operates by alternately transmitting a stream of high power radio frequency pulses and 'listening' to echoes received back from targets within its coverage. Generally, air surveillance radars employ a rotating antenna that provides 360° coverage in azimuth; the typical scan rates are between 10 and 15 rotations per minute (rpm) thus illuminating a given target every four to six seconds.

2.1.1 Primary Surveillance Radar

A Primary Surveillance Radar (PSR) system operates in two dimensions: the target range is measured based on the time for the transmitted signal to arrive back at the receiver, and the direction of the beam provides the position of the target in azimuth. The amount of energy that an object reflects back is related to the object's Radar Cross Section (RCS). In terms of wind turbines, generally, the larger a wind turbine is, the larger its RCS will be, which will result in more energy being reflected and an increased chance of it creating unwanted returns (non-aircraft), known as 'clutter' to be produced on Radar Data Display Screens (RDDS). This issue is compounded by increasing numbers of wind turbines that cause a cumulative effect of greater areas and densities of clutter. Generalised effects on PSR systems are as follows:

- Twinkling appearance/blade flash effect;
- Masking of true aircraft targets by increased clutter on an RDDS;
- Increase in unwanted targets or false aircraft tracks;
- Receiver saturation;
- Receiver desensitisation causing loss of targets that are of a small RCS;
- Loss of targets due to Adaptive Moving Target Indication (AMTI) techniques;
- Shadowing behind the wind turbines caused by physical obstruction (blocking of radar transmitted signal);
- Degradation of tracking capabilities; and
- Degradation of target processing capability.

Traditional PSR systems in operation currently cannot distinguish between returns from wind turbines (false returns, or 'clutter') and those from aircraft. Air Traffic Control (ATC) is required to assume that actual aircraft targets could be lost over the location of a wind farm, and identification of aircraft under control could be lost or interrupted. However, progress is being made whereby radar manufacturers are developing new generation systems that will have technical wind turbine mitigation capability.

2.1.2 SSR

PSR systems such as the type in use at aerodromes and at the two Area Control Centres in the UK have no height finding capability. As such, ATC relies on Secondary Surveillance Radar (SSR) for this purpose: SSR is a collaborative radar system, which means that the radar will 'interrogate' a transponder on the aircraft (if fitted and operated) for useful information such as altitude, heading and speed, which is then passed to the ATC RDDS.

Wind turbine effects on SSR are traditionally less than those on PSR systems but can be caused due to the physical blanking and diffracting effects of wind turbine towers, depending on the size of the wind turbines and the windfarm. These effects are typically only a consideration when the wind turbines are located very close to the SSR facility i.e. less than 10 kilometres (km) [Reference 1]; the development site is not within 10 km of any SSR systems, therefore analysis is not required.

2.1.3 Air Defence Radar

Air Defence Radar (ADR) operates differently to traditional ATC radar systems whereby they can detect air targets and determine their position, course, and speed in a relatively large area. 3-D ADR systems do have a height finding capability; however, UK systems are supported by SSR capability. The primary functions of ADR systems are long-range early warning, ballistic missile warning and acquisition in support of ground-control interception. The identified effects relating to PSR systems summarised above also affect ADR systems.

2.2 Notes on Wind Turbine Effects on Radar

Radar detectable wind turbines are a significant cause of PSR false plots, or clutter, as the rotating blades can trigger the Doppler threshold (e.g., minimum shift in signal frequency) of the Radar Data Processor (RDP) and therefore may be interpreted as aircraft targets. Significant effects have been observed on radar sensitivity caused by the substantial RCS of the wind turbines structural components (blades, tower and nacelle) which can exceed that of a large aircraft; the effect 'blinds' the radar (or the operator) to wanted targets in the immediate vicinity of the wind turbine.

False plots and reduced radar sensitivity may reduce the effectiveness of radar to an unacceptable level and compromise the provision of a safe radar service to participating aircraft.

It is mainly for the above reasons that airport operators and other Air Navigation Service Providers (ANSP) object to wind farm developments that are within LOS to their radar systems. However, it is worth noting that detectability of wind turbines does not automatically constitute a valid reason for objection. There are a number of relevant examples where the impact of offshore sites is managed on an operational basis without the need for technical mitigation.

2.3 Identified Aviation Stakeholders

2.3.1 Ministry of Defence (MoD)

The MoD through the Air Surveillance and Control Systems (ASACS) Force is responsible for compiling a Recognised Air Picture (RAP) to monitor the airspace in and around the UK in order to launch a response to any potential airborne threat.

This is achieved through the utilisation of a network of long-range ADR systems, some of which are located along the east coast of the UK. Any identified effect of wind turbines on the ASACS ADR systems that serve the airspace above the TEOWF development would potentially reduce the capability of the ASACS Force. ASACS radar resources are also used in support of air defence training and exercises on an almost daily basis.

2.3.2 NATS

NATS provide air traffic services at some airports in the UK and provide air traffic services to traffic en-route (overflying or flying between airports) in UK airspace. NATS operate a number of long range PSR and SSR systems positioned to provide maximum coverage of UK airspace. Additionally, NATS has a licence obligation to provide radar data to other aviation stakeholders, to a high quality and performance standard for the benefit of UK aviation as a whole. Any effect that the TEOWF might have on NATS radars must be considered both in terms of effect on the civilian en-route services and in the context of its remote users.

2.3.3 London Southend Airport (LSA)

LSA is an international airport, which has seen recent redevelopment with a new passenger terminal, control tower and extended runway. LSA provides radar based air traffic services to pilots operating to and from the airport and on request, a Lower Airspace Radar Service (LARS). LARS is available to all aircraft flying outside of Controlled Airspace (CAS) up to Flight Level (FL) 100, within the limits of radar and radio cover. The service is provided by LSA to a service radius of 25 NM.

3 Radar LOS Conclusions

This section details the Osprey LOS analysis methodology and provides a summary of the results of the Radar LOS analysis for potentially affected radar systems.

3.1 Caveat on Radar LOS 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 wind turbine locations of the TEOWF. Otherwise known as a point-to-point LOS analysis, the result provides a graphical representation of the intervening terrain and the direct signal LOS (taking into account earth curvature and radar signal properties).

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 that can influence the probability of a wind farm being detected. Our analysis is designed to give an indication of the likelihood of the wind turbines being detected by radar.

The 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

3.2 MoD Trimingham ADR System

The Trimingham ADR system is located on the Norfolk coast between Cromer and Mundesley and has an estimated operational range of 400 km (215 Nautical Mile (NM)). The TEOWF development site is located approximately 158 km (85.6 NM) from this system and therefore analysis is required to establish whether the proposed blade tip would be considered theoretically detectable by this system.

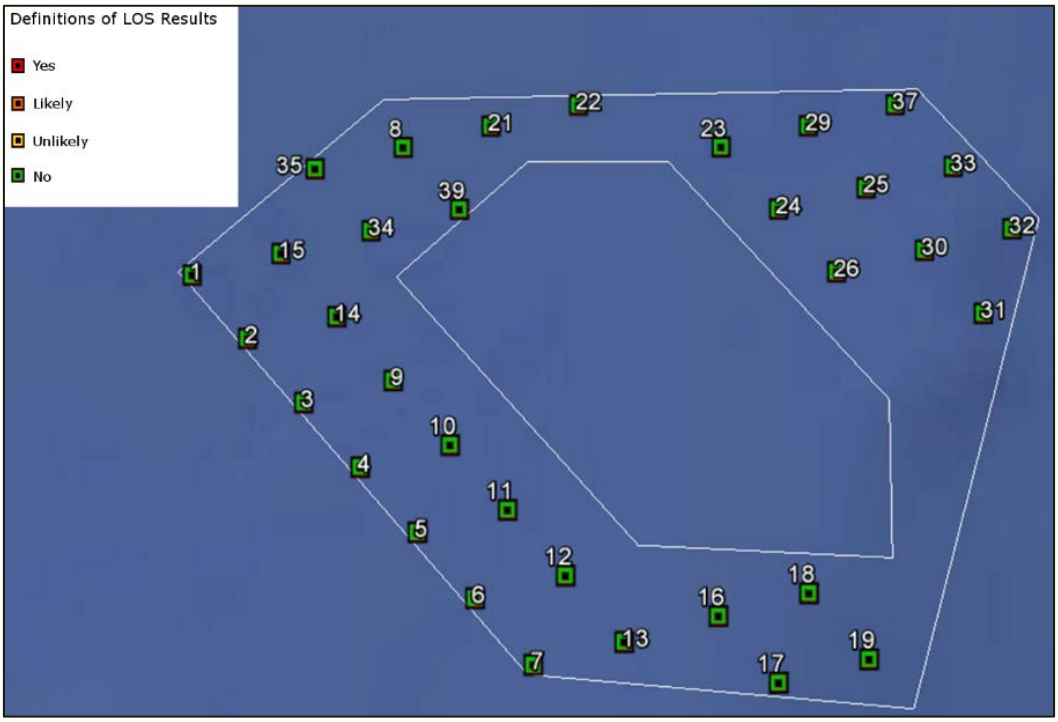

Figure 1 Trimingham ADR Radar LOS Analysis at 250 m above HAT blade tip

Figure 1 illustrates that none of the wind turbines of a blade tip height of 250 m above HAT would be theoretically detectable by the Trimingham ADR system, as no direct radar LOS is evident. Consequently, this system is scoped out from any further analysis.

3.3 NATS Cromer PSR

The Cromer PSR system is located on the Norfolk coast approximately 4 km (2.1 NM) southeast of the town of Cromer. The radar is a Raytheon ASR10-SS used for the provision of en route ATC and has an estimated operational range of 111 km (60 NM). The TEOWF development site is located approximately 160 km (86.8 NM) from this system and therefore analysis would not normally be required as the development is outside of the Documented Operational Range (DOC) of the radar. However, for completeness the results of the radar LOS are included below.

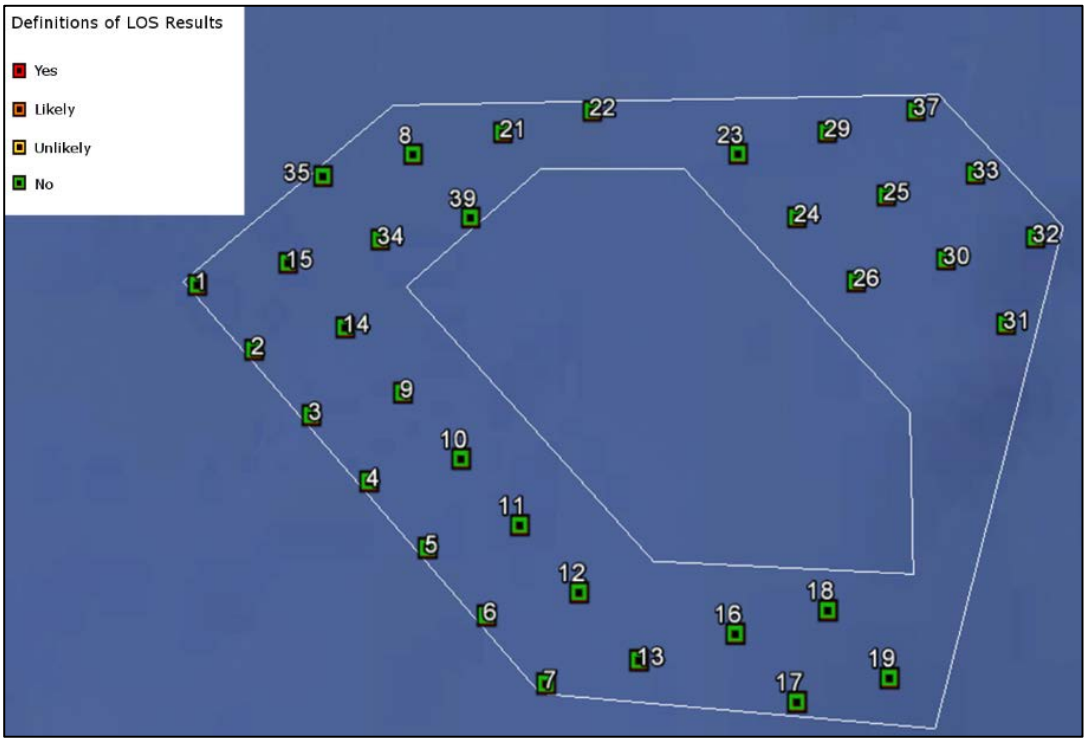

Figure 2 Cromer PSR LOS Analysis at 250 m above HAT blade tip

Figure 2 illustrates that none of the wind turbines of a blade tip height of 250 m above HAT would be theoretically detectable by the Cromer PSR system, as no direct radar LOS is evident. Consequently, this system is also scoped out from any further analysis.

3.4 NATS Debden PSR

The Debden PSR system is located approximately 4 km south southeast of Saffron Walden, Essex. The radar is a Raytheon ASR23-SS used for the provision of en route ATC and has an estimated operational range of 370 km (200 NM). The TEOWF development site is located approximately 105 km (57 NM) from this system and therefore analysis is required to establish whether the proposed blade tip would be considered theoretically detectable by this system.

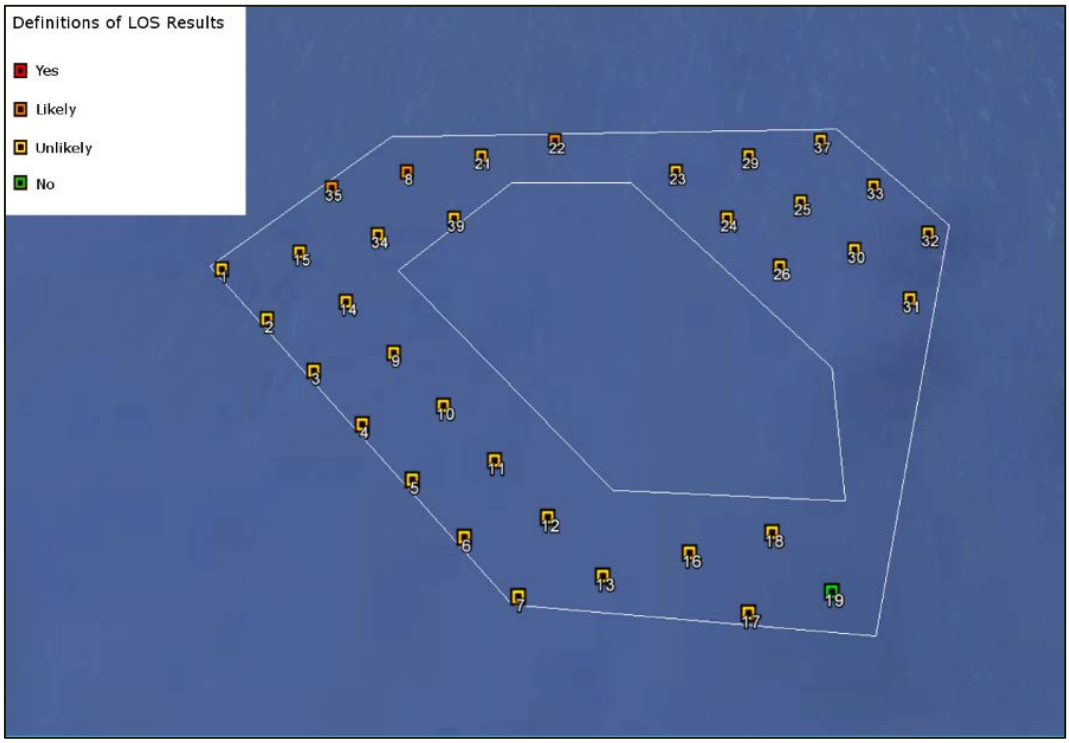

Figure 3 Debden PSR LOS Analysis at 250 m above HAT blade tip

Figure 3 illustrates that Turbines 8, 22 and 35 are likely to be detected intermittently by the Debden PSR at a blade tip height of 250 m above HAT; the rest of the turbines are unlikely to be detectable although analysis cannot rule out occasional detection by this system, the Debden PSR will not detect Turbine 19.

A further radar LOS was completed at 215 m above HAT from the Debden PSR, Figure 4 below provides the results of the analysis.

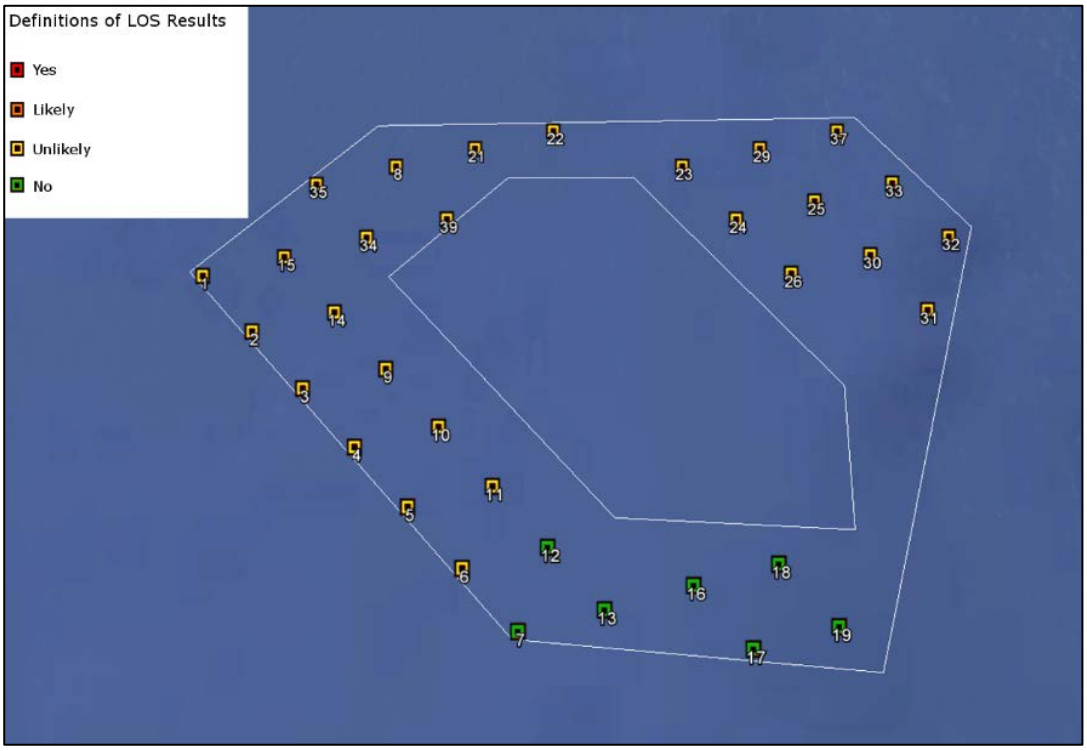

Figure 4 Debden PSR LOS Analysis at 215 m above HAT blade tip

Figure 4 illustrates that the majority of the wind turbines at a blade tip height of 215 m above HAT are unlikely to be detectable by the Debden PSR although analysis cannot rule out occasional detection. The Debden PSR will not theoretically detect Turbines 7, 12, 13, 16, 17, 18 and 19.

3.5 LSA PSR

The proposed development is located 58.7 km, (31.7 NM) at its closest point from LSA on a bearing of 103° and is not likely to impact the provision of LARS; however, the DOC of the LSA PSR is 40 NM in which the Thanet Offshore Wind Farm and the TEOWF are located.

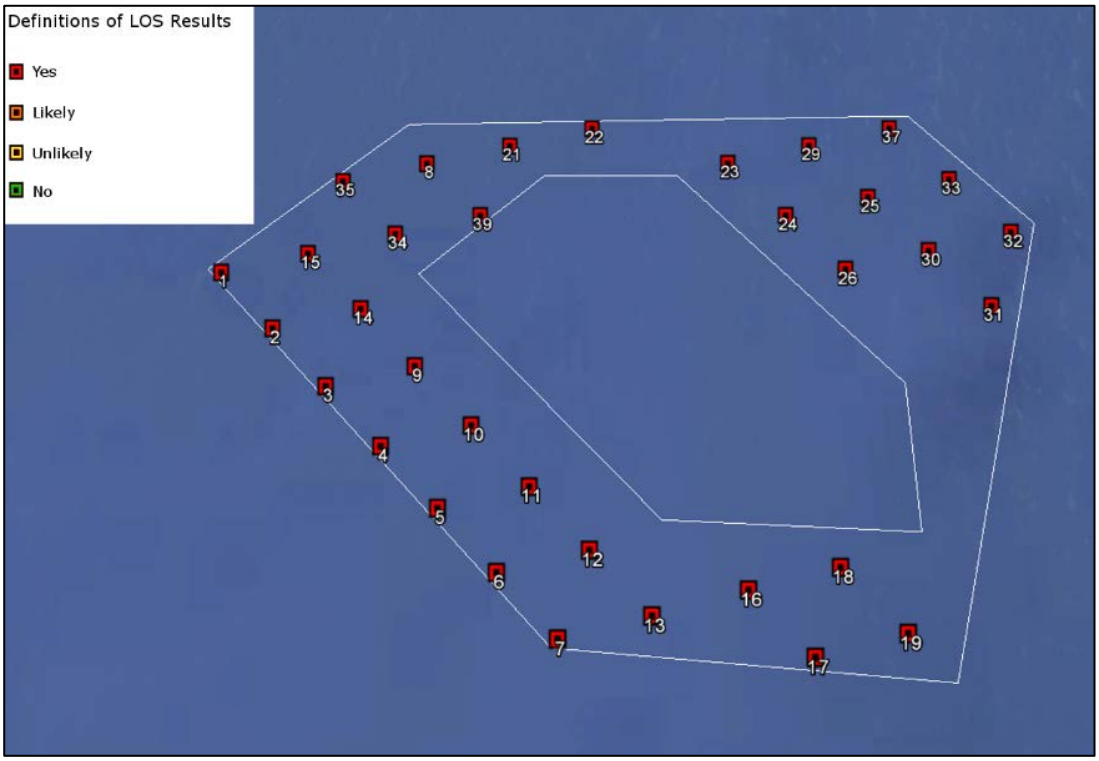

Figure 5 Cromer PSR LOS Analysis at 250 m above HAT blade tip

Figure 5 illustrates that the LSA PSR system will theoretically detect all the wind turbines in the proposed 34-wind turbine layout of TEOWF at 250 m the result is indicative for the LOS analysis at 215 m above HAT. The results indicate that at both heights, all wind turbines will be theoretically detectable by this system.

3.6 Summary

The development site is within the operational range of the MoD Trimingham ADR system; however, wind turbines of 250 m above HAT within the layout iteration will not be theoretically detectable by the ADR. Consequently, the MoD utilisation of the Trimingham ADR is considered not to be impacted by the TEOWF. Due to its theoretical non-detectability, the TEOWF will not contribute any cumulative effects to this system.

The development site is within the operational range of the NATS Debden PSR system. Analysis cannot rule out intermittent detection by the Debden PSR to three of the wind turbines at 250 m above HAT blade tip; the remaining wind turbines are unlikely to be detectable (apart from Turbine 19) at a blade tip height of 250 m above HAT although analysis cannot rule out occasional detectability.

Decreasing wind turbines heights to 215 m above HAT reduces theoretical radar LOS as the majority of the wind turbines are unlikely to be detectable by the Debden PSR although analysis cannot rule out occasional detection. The Debden PSR will not theoretically detect Turbines 7, 12, 13, 16, 17, 18 and 19 at a blade tip height of 215 m above HAT.

The LSA PSR will theoretically detect all turbines in the 34-layout iteration at both 250 m and 215 m above HAT.

3.7 Recommendations

NATS were consulted at the Scoping stage of the TEOWF, which presented a blade tip height of 210 m above HAT. NATS responded stating that they have no safeguarding concerns but should be kept informed if the application is revised or amended [Reference 2]. With the considered worst case of increased blade height to 250 m above HAT, additional consultation with the NATS Safeguarding Team has been completed and NATS have confirmed that they have no safeguarding objections at the worst-case scenario of a blade tip height of 250 m above HAT [Reference 3].

4 References

Reference	Name	Origin
1	CAP 764 - Policy and Guidelines on Wind Turbines Issue 6	CAA
2	NATS Response to Scoping 9 January 2017 10;28;16	NATS Safeguarding Environmental Services
3	Email from NATS to VWPL 3 May 2018	NATS

Table 2 Table of References