NORTH FALLS

Offshore Wind Farm

ENVIRONMENTAL STATEMENT

Appendix 17.1 Airspace Analysis And Radar Modelling

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North Falls Offshore Wind Farm

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1.0	Initial Issue	11/12/23	Initial Issue

Abbreviations

AARA	Air to Air Refuelling Area
AD	Air Defence
AD&OW	Air Defence and Offshore Wind
AIP	Aeronautical Information Publication
amsl	above mean sea level
ATA	Aerial Tactics Area
ATC	Air Traffic Control
ATS	Air Traffic Service
BEIS	Department for Business, Energy and Industrial Strategy
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CTA	Control Area
DA	Danger Area
DASA	Defence and Security Accelerator
DESNZ	Department for Energy Security and Net Zero
DOC	Designated Operational Coverage
DTM	Digital Terrain Model
ES	Environmental Statement
FIR	Flight Information Region
FL	Flight Level
ft	feet
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
HAT	Highest Astronomical Tide
HMRI	Helicopter Main Routing Indicator
km	kilometres
LARS	Lower Airspace Radar Service
LAT	Lowest Astronomical Tide
m	metres
MoD	Ministry of Defence
MRT	Multi Radar Tracking
NAIZ	Non-Auto Initiation Zone
NERL	NATS En Route Limited

nm	nautical miles
Pd	Probability of Detection
PSR	Primary Surveillance Radar
RAF	Royal Air Force
RCS	Radar Cross Section
RLoS	Radar Line of Sight
S&IP	Strategy and Implementation Plan
SAR	Search and Rescue
SSR	Secondary Surveillance Radar
SUA	Special Use Airspace
TMZ	Transponder Mandatory Zone
WTG	Wind Turbine Generator

References

[1] CAA (October 2023), 'CAP032: UK Aeronautical Information Publication'.

[2] CAA (February 2016), 'CAP 764: Policy and Guidelines on Wind Turbines'.

[3] MoD (October 2023), 'UK Military AIP'.

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1. Introduction

1.1. Overview

1.1.1. This document is an appendix to Chapter 17 Aviation and Radar, Volume 1 of the North Falls Offshore Wind Farm Environmental Statement (ES). It provides detailed airspace analysis and radar modelling and outlines potential mitigation options.

1.1.2. The North Falls array area covers an area of approximately 95 square kilometres (km^2) and lies approximately 42km or 23 nautical miles (nm) from shore.

1.2. Effects of wind turbine generators on aviation

1.2.1. Wind turbine generators (WTGs) can be problematic for aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving WTG blade are like an aircraft. The PSR is unable to differentiate between wanted aircraft targets and clutter targets introduced by the presence of WTGs.

1.2.2. Potential impacts on the NATS En Route Limited (NERL) PSR facilities at Cromer and Debden, the Ministry of Defence (MoD) Air Defence (AD) PSR at Neatishead, and the Air Traffic Control (ATC) PSR at Southend Airport were identified at the Scoping stage.

1.2.3. The significance of any radar impacts depends on the airspace usage and the nature of the Air Traffic Service (ATS) provided in that airspace. The classification of the airspace in the vicinity of North Falls and the uses of that airspace (civil and military) are set out in this appendix.

1.2.4. Radar impacts may be mitigated by either operational or technical solutions or a combination of both. In either case, the efficacy and acceptability of any operational and/or technical mitigation options available can only be determined by protracted consultations with the radar operators/ATS providers.

1.3. Technical data

1.3.1. Radar data

1.3.1.1. Radar parameters used in the assessment have been taken from data held on file by Cyrrus, and from the following documents:

- Raytheon ASR-10SS equipment brochure (Raytheon, 2007);
- Raytheon ASR-23SS equipment brochure (Raytheon, 2007); and
- Lockheed Martin AN/TPS-77 Factsheet B013-03 (Lockheed Martin, 2013).

1.3.2. North Falls array boundary

1.3.2.1. The array boundary for North Falls was supplied as a geo-referenced Shapefile and is depicted in Figure 1.

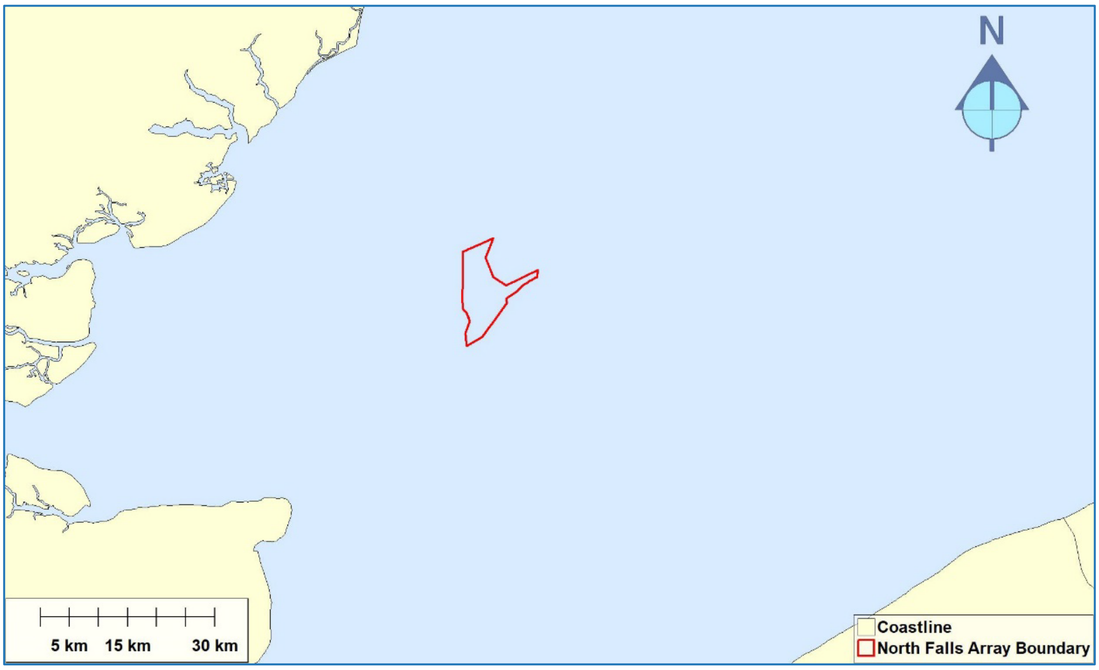

Figure 1: North Falls array area boundary

1.3.3. WTGs

1.3.3.1. Up to 57 WTGs with maximum tip height of 276 metres (m) or up to 34 WTGs with maximum tip height of 377m above Highest Astronomical Tide (HAT) are being considered. The design parameters for these WTGs are shown in Table 1.

Parameter	Smaller WTG	Larger WTG
Maximum blade tip height above HAT	276m	377m
Maximum rotor diameter	236m	337m
Minimum WTG spacing	1,652m downwind, 1,180m cross wind	2,359m downwind, 1,685m cross wind
Maximum number of WTGs	57	34

Table 1: WTG design parameters

1.3.3.2. Note that blade tip heights are above HAT whereas radar assessments are based on tip heights above mean sea level (amsl). Within the North Falls array area HAT is 3.77m above Lowest Astronomical Tide (LAT), while amsl is 1.84m above LAT. This results in HAT being 1.93m amsl.

1.3.3.3. Worst-case blade tip heights of 278m amsl for smaller WTGs and 379m amsl for larger turbines are therefore used for the airspace and radar assessments.

1.3.4. Terrain data

- ATDI UK 25m Digital Terrain Model (DTM).

1.3.5. Analysis tools

- ATDI HTZ communications V2023.10 release 1493 radio planning tool; and
- Blue Marble Global Mapper V21.1.1 Geographic Information System (GIS).

1.3.6. Mapping datum

1.3.6.1. UTM31 (WGS84 datum) is used as a common working datum for all mapping and geodetic references.

1.3.6.2. Where necessary, mapping datum transformations are made using Global Mapper or Grid Inquest II Coordinate Transformation Program.

1.3.6.3. All heights stated in this document are amsl (Newlyn datum) unless otherwise stated.

2. Airspace analysis

2.1. Introduction

2.1.1. This assessment is a review of potential impacts on aviation in the designated area for North Falls Offshore Wind Farm. For the purposes of this assessment a maximum tip height of 1,300 feet (ft) amsl for the WTGs has been assumed, the equivalent to 379m rounded up to the nearest 100ft.

2.1.2. All information has been referenced from the UK Aeronautical Information Publication (AIP) available online from source and is therefore the latest information available. Additional information has been sourced from UK Civil Aviation Authority publications, as appropriate.

2.1.3. The assessment does not draw any conclusions but merely identifies areas of potential impact.

2.2. Scope

2.2.1. The scope of the assessment array area and the surrounding airspace relating to aviation, its use and potential impact. The types of airspace and limitations on its use are identified.

2.3. Airspace classification

2.3.1. In general, airspace can be characterised as either controlled or uncontrolled airspace. Aircraft in controlled airspace are being positively managed by ATC the entire time they are within that designated area. This type of airspace is generally used by airlines and corporate aviation. Aircraft in uncontrolled airspace are operating within a framework of rules but are not being controlled by ATC, although many pilots flying in this environment may choose to report their position, altitude, and intentions to ATC to benefit from the enhanced situational awareness that brings. Users of this airspace tend to be small aircraft engaged in training or private (social) flying.

2.3.2. In addition, Special Use Airspace (SUA) is airspace designated for specific activities such that limitations on airspace access may be imposed on other non-participatory aircraft. An example of such airspace would be a Danger Area (DA) established for military flight training.

2.3.3. There are five classes of airspace in the UK, namely classes A, C, D, E and G. Classes A to E are types of controlled airspace, while class G is uncontrolled airspace. Class A is the most strictly regulated controlled airspace whereby aircraft are positively controlled by ATC, compliance with ATC clearance is mandatory, and aircraft are flown and navigated solely with reference to aircraft instruments. Certain onboard equipment is also a prerequisite. Flight in class G airspace is generally visual, meaning pilots fly and navigate with reference to the natural horizon and terrain features they see outside. Pilots are required to maintain minimum distances from notified obstacles, including WTGs, and may only fly within the minimum weather and visibility criteria.

2.4. Aircraft vertical reference

2.4.1. An aircraft's vertical reference above the ground or sea can either be an altitude amsl or, above a designated altitude, a Flight Level (FL). An aircraft's altitude, expressed in feet, is based on the last known verified local barometric pressure while a FL, expressed in 100ft increments, is based on a common international barometric pressure setting of 1013.2 hectopascals. With aircraft using a common vertical datum safe separation can be achieved by either ATC or between pilots of different aircraft.

2.4.2. The airspace where vertical reference changes from altitude to FL and vice versa is known as the Transition Layer and consists of a (lower) Transition Altitude and (higher) Transition Level. In UK airspace the Transition Altitude is set at 3,000ft amsl except in certain specified airspace where it is higher.

2.4.3. The vertical limits of airspace are defined in terms of either altitudes or FLs, with airspace commonly having a lower limit expressed as an altitude and an upper limit expressed as a FL.

2.5. Current airspace baseline

2.5.1. The North Falls array area lies within the London Flight Information Region (FIR), airspace regulated by the UK Civil Aviation Authority (CAA). The boundary between the London FIR and the adjacent Amsterdam FIR, regulated by the Netherlands Aviation Authority, is approximately 9km south-east of the array area at its closest point. Immediately surrounding the North Falls array area is uncontrolled class G airspace with class A controlled airspace known as the Clacton Control Area (CTA) above that. The array area lies beneath Clacton CTA 7, as shown in Figure 2.

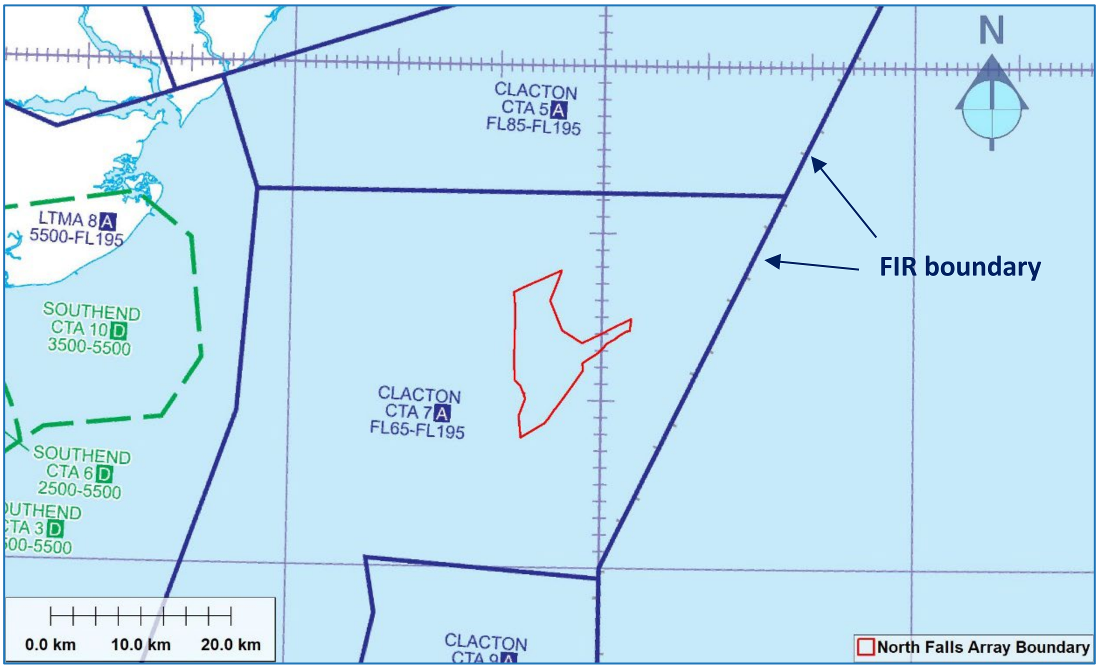

Figure 2: North Falls array area and Clacton CTAs

2.5.2. The Transition Altitude beneath the Clacton CTA is 6,000ft. Clacton CTA 7 has a lower limit of FL65 (approximately 6,500ft amsl). The upper limit of the Clacton CTA is FL195 (approximately 19,500ft amsl). This airspace is extremely busy with airline traffic routing to and from Europe and descending and climbing in and out of London airports.

2.5.3. ATS routes are airways along which aircraft fly, navigating via ground-based electronic aids or, increasingly, Global Navigation Satellite System (GNSS) waypoints. ATS routes are used where high levels of traffic move between areas. They may be standalone sections or embedded, either wholly or in part, within a segment of airspace.

2.5.4. There are several ATS routes within the airspace above the North Falls array area. They are listed below together with their vertical limits:

- L608 FL85 to FL460;
- L980 FL95 to FL460;
- Y4 FL95 to FL460; and
- Y6 FL105/FL165 to FL460.

2.5.5. The airspace and ATS routes mentioned above are all controlled by NATS at their control centre in Swanwick. The ATS route structure in the vicinity of the North Falls array area is shown in Figure 3.

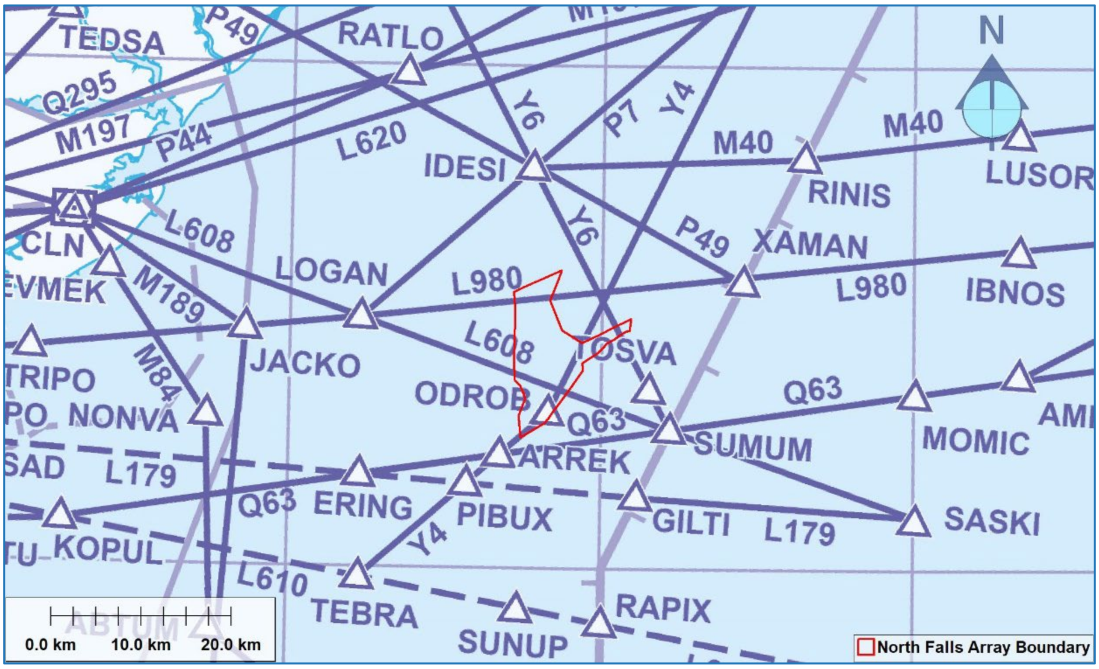

Figure 3: ATS route structure

2.5.6. Given the maximum blade tip height of 1,300ft amsl and the base of the controlled airspace above, the WTG structures will not have an impact on aircraft operations within controlled airspace.

2.6. Helicopter Main Routing Indicators

2.6.1. A network of offshore routes over the Southern North Sea are flown by civilian helicopters to and from offshore destinations and defined as Helicopter Main Routing Indicators (HMRIs). These routes have no lateral dimensions or airspace status, however there should be no obstacles within 2nm of the route centreline. HMRI 20 extends vertically from 500ft amsl to 2,000ft amsl inclusive between Lowestoft and the Greater Gabbard and Galloper offshore wind farms, presumably to allow helicopter traffic to access those sites. HMRI 20 passes within 2nm of the array area, as shown in Figure 4.

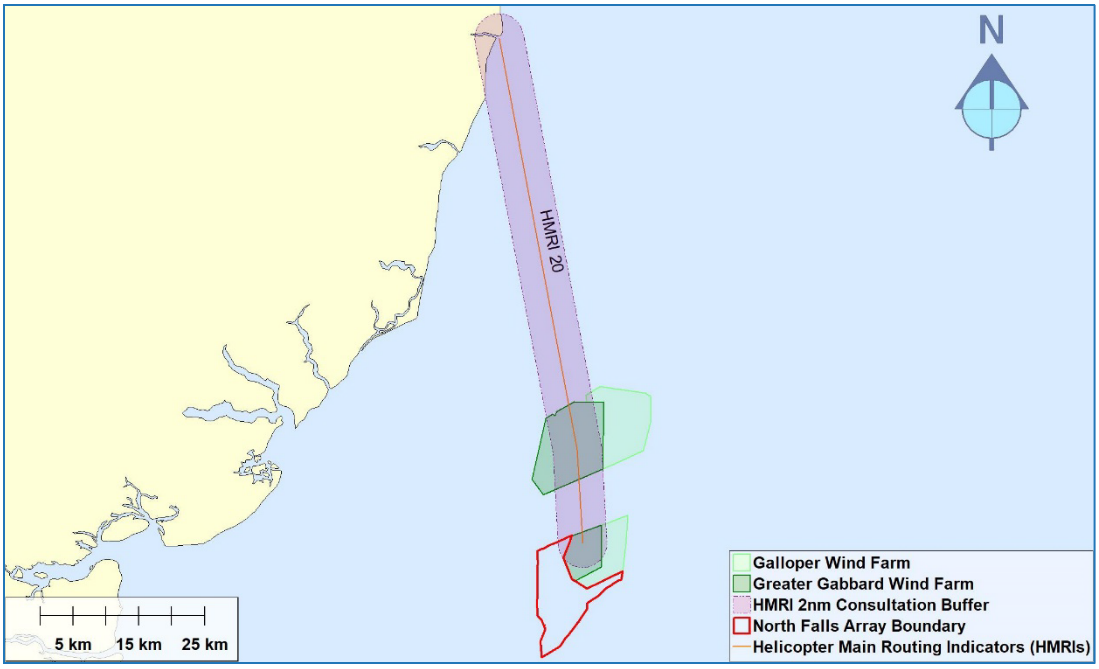

Figure 4: HMRI 20

2.6.2. The CAA publication Civil Aviation Publication (CAP) 764 Policy and Guidelines on Wind Turbines (CAA, 2016) states that planned obstacles within 2nm should be consulted upon with helicopter operators and the Air Navigation Service Provider. However, the AIP advises that there are no Air Traffic Service provision arrangements to support operations on this HMRI.

2.7. Special Use Airspace

2.7.1. SUA in the form of the Shoeburyness Danger Areas D136 and D138A to D138D lies approximately 37km west of the southern array area, as shown in Figure 5. Ordnance, munitions, and explosives are amongst the activities taking place within this airspace.

2.7.2. This airspace is not in operation continuously, but on an ‘as notified’ basis. A pilot will be informed by an Air Traffic Service Unit about the operational status of the airspace at the time of their flight in the vicinity.

2.7.3. Also shown, approximately 62km north of the array area, is Area 9. This is an Air to Air Refuelling Area (AARA) with a lower limit of 2,000ft amsl. The AARA is permanently available, but availability is managed through the MoD section at NATS Swanwick. Due to the levels available in this area, it is assumed that refuelling activities are for military helicopters.

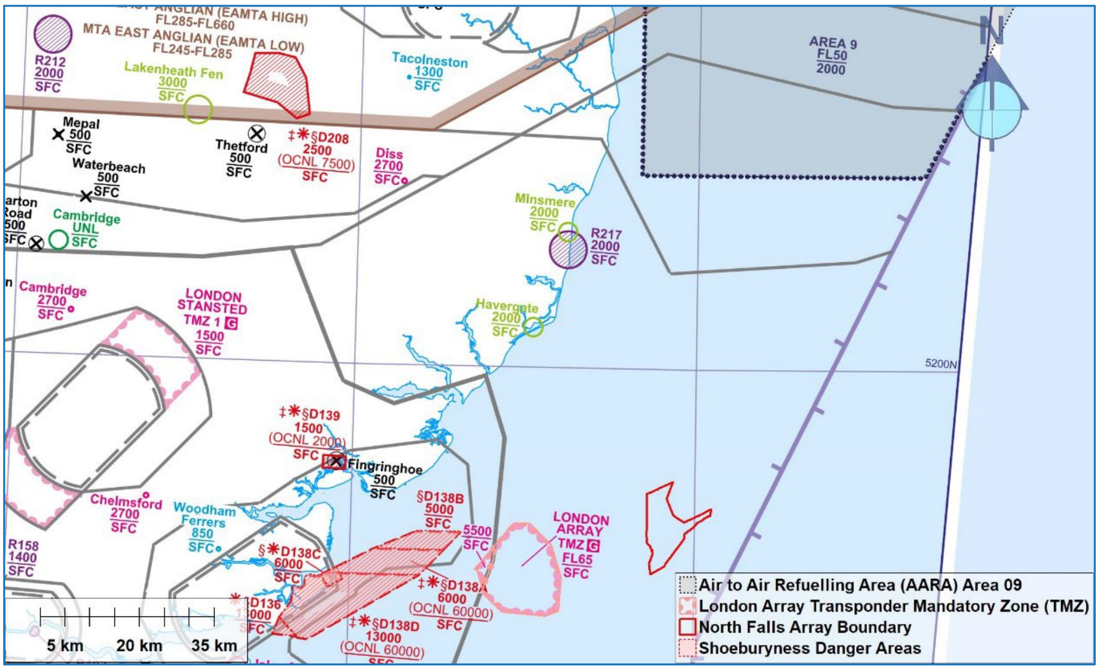

Figure 5: Shoeburyness Danger Areas and Area 9

2.7.4. Approximately 47km north of the array area is the Aerial Tactics Area (ATA) Lakenheath South, as depicted in Figure 6. The ATA has a lower vertical limit of FL60 (approximately 6,000ft amsl). This is airspace designated for air combat training and is an area of intense military activity. The AIP strongly advises pilots to avoid the area.

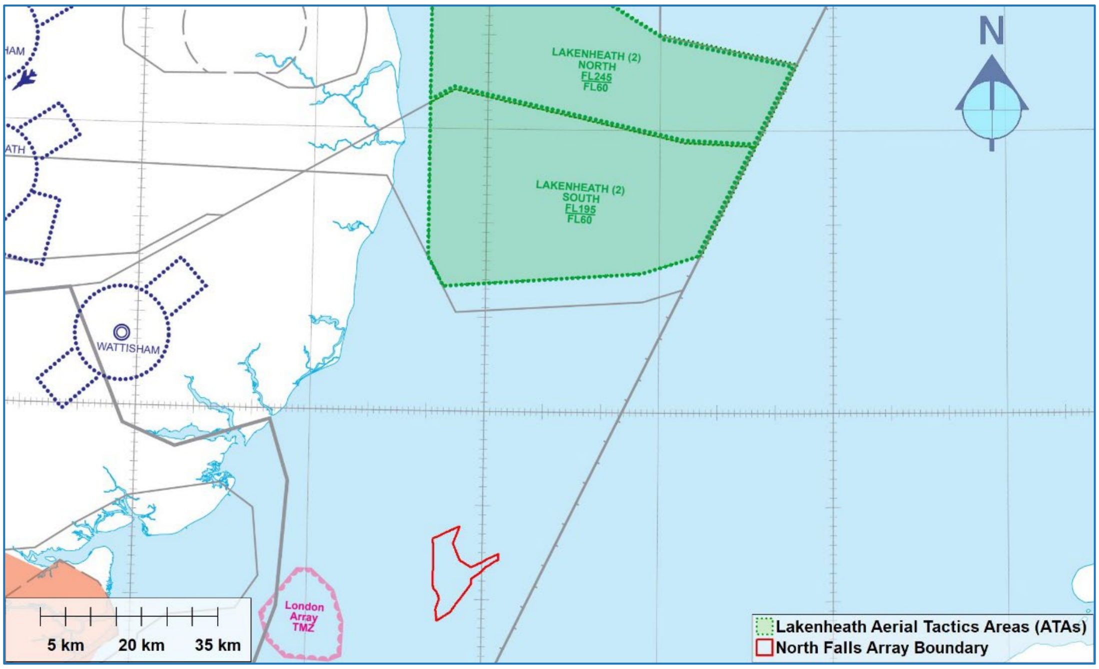

Figure 6: Lakenheath North and South

2.7.5. All of the SUA described above is well removed from the North Falls array area and reference to it is only provided in the context of general awareness of the airspace surrounding the project.

2.8. London Array Transponder Mandatory Zone

2.8.1. Approximately 18km west of the array area is the London Array Transponder Mandatory Zone (TMZ), as shown in Figure 5. Within a TMZ the carriage and operation of aircraft transponder equipment is mandatory. This enables such aircraft to be detected and tracked by Secondary Surveillance Radar (SSR) systems while transiting the Zone. The London Array TMZ is established around the London Array offshore wind farm and is used to mitigate the impact of the associated WTGs on Southend Airport's PSR. The establishment of a TMZ over North Falls is one of the potential mitigation measures to be considered during the design process.

2.9. Southend Airport

2.9.1. Southend Airport is located approximately 81km (44nm) west of the North Falls array area. The airport provides 24 hour ATC services, and a Lower Airspace Radar Service (LARS) is available during the day for aircraft within the airfield's radio and radar coverage flying outside controlled airspace up to FL100 (approximately 10,000ft amsl). The Southend LARS service area is 25nm.

2.9.2. The Standard Instrument Arrival Chart for Sumum 1S and Xaman 1S arrivals to Southend Airport is depicted in Figure 7 and shows paths crossing the array area.

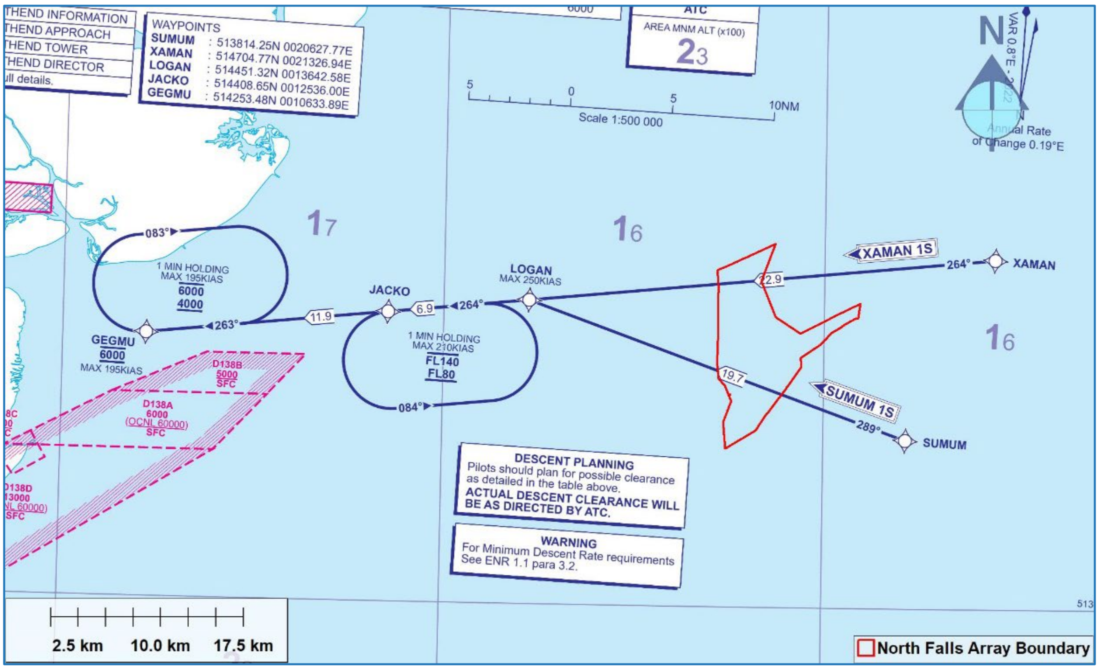

Figure 7: Southend Standard Arrival Chart – Sumum 1S/Xaman 1S

2.9.3. Area minimum altitudes shown on the chart in the vicinity of the WTGs will require revision to maintain the minimum obstacle clearance of 300m or 984ft. The lower limit for the hold pattern at Jacko is FL80 (approximately 8,000ft amsl). Aircraft descending to the hold will be under NATS control and unlikely to be in communication with Southend ATC until considerably west of the North Falls array area.

2.10. Search and Rescue

2.10.1. Search and Rescue (SAR) operations are a highly specialised undertaking involving not only aviation assets, but also small boats, ships and shore-based personnel. SAR operations are generally carried out in extremely challenging conditions and at all times of the day and night. There are 10 helicopter SAR bases, incorporating 22 aircraft, around the UK with Bristow Helicopters providing helicopters and aircrew.

2.10.2. The nearest SAR base is at Lydd Airport, approximately 99km (53nm) south-west of the North Falls array area and its helicopters can provide rescue services up to approximately 460km (250nm) away from base.

2.10.3. The random nature of people, watercraft or aircraft in distress makes it very difficult to determine the routes taken by SAR aircraft. Fixed wing SAR aircraft would tend to stay at higher altitudes in a command-and-control role during major incidents, whilst helicopters would be used in a low-level role, sometimes in support of small rescue boats.

3. Radar line of sight assessment

3.1. Methodology

3.1.1. Radar Line of Sight (RLoS) is determined by use of a radar propagation model (ATDI HTZ communications) using 3D DTM data with 25m horizontal resolution. Radar data is entered into the model and RLoS to the WTGs from the radar is calculated.

3.1.2. Note that by using a DTM no account is taken of possible further shielding of the WTGs due to the presence of structures or vegetation that may lie between the radar and the WTGs. Thus, the RLoS assessment is a worst-case result.

3.1.3. For PSR the principal source of adverse wind farm effects are the WTG blades, so RLoS is calculated for the maximum blade tip heights of the WTGs, i.e. 278m and 379m amsl.

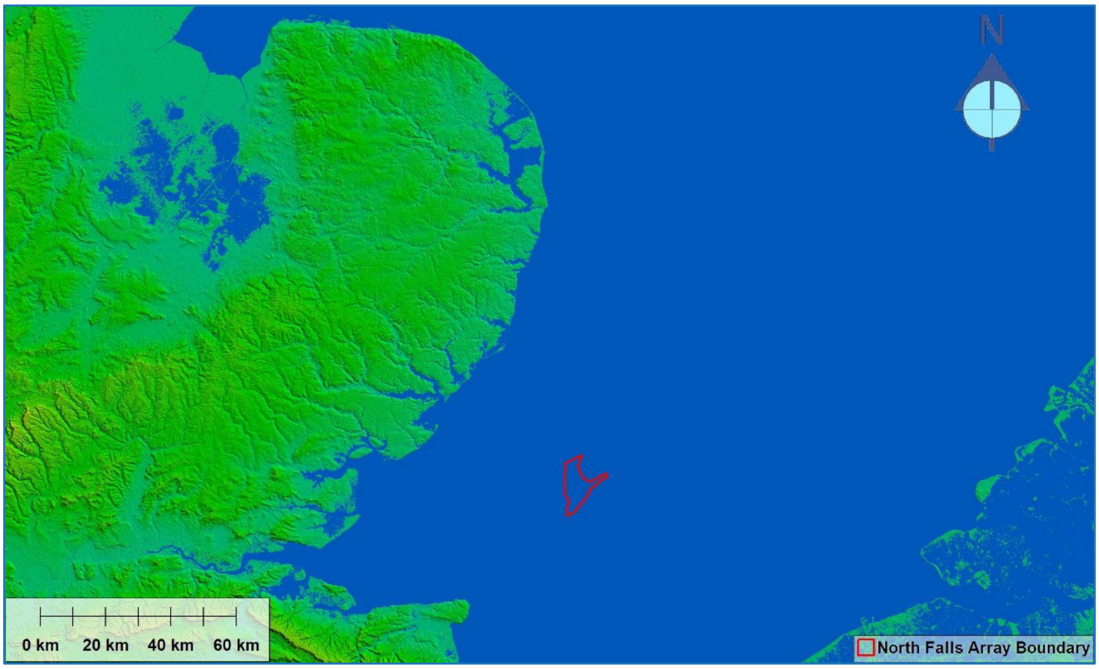

Figure 8: 25m resolution DTM used for RLoS modelling

3.2. Licensed airfields with surveillance radar

3.2.1. The closest radar equipped airfields to North Falls are Norwich, 107km or 58nm to the north, Stansted, 113km or 61nm to the west, and Southend, 81km or 44nm to the west. CAP 764 recommends consultation with any aerodromes with a surveillance radar facility that are within 30km of WTGs, however this distance can be greater depending on the type and coverage of the radar and the particular operation at the aerodrome.

3.3. Norwich

3.3.1. Norwich RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 9 and Figure 10 respectively.

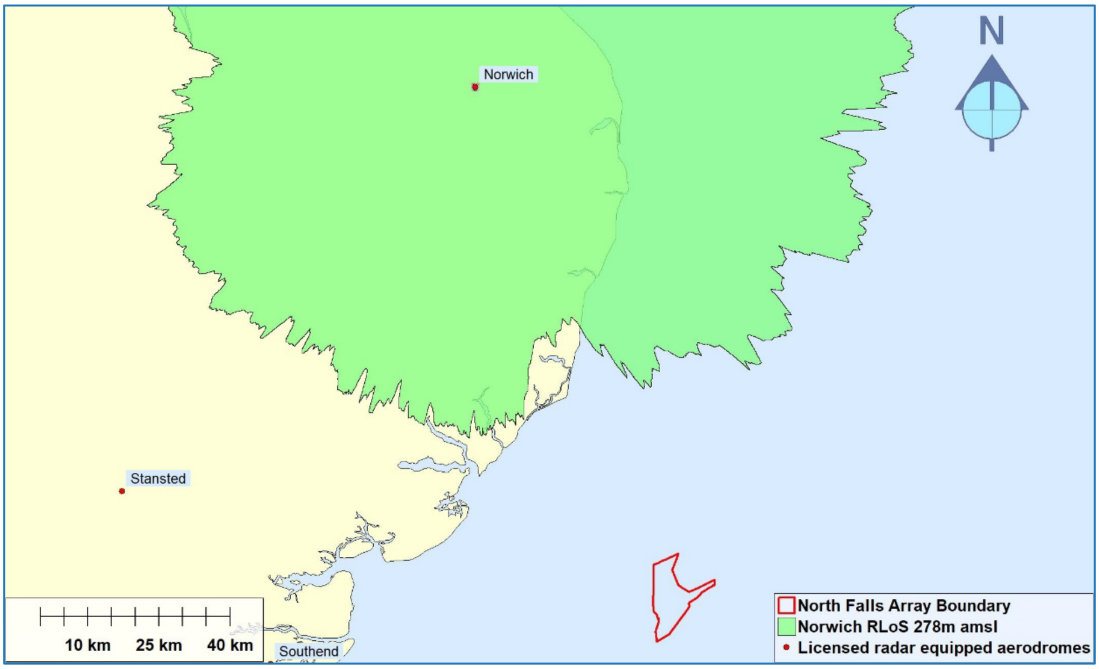

Figure 9: Norwich RLoS 278m amsl

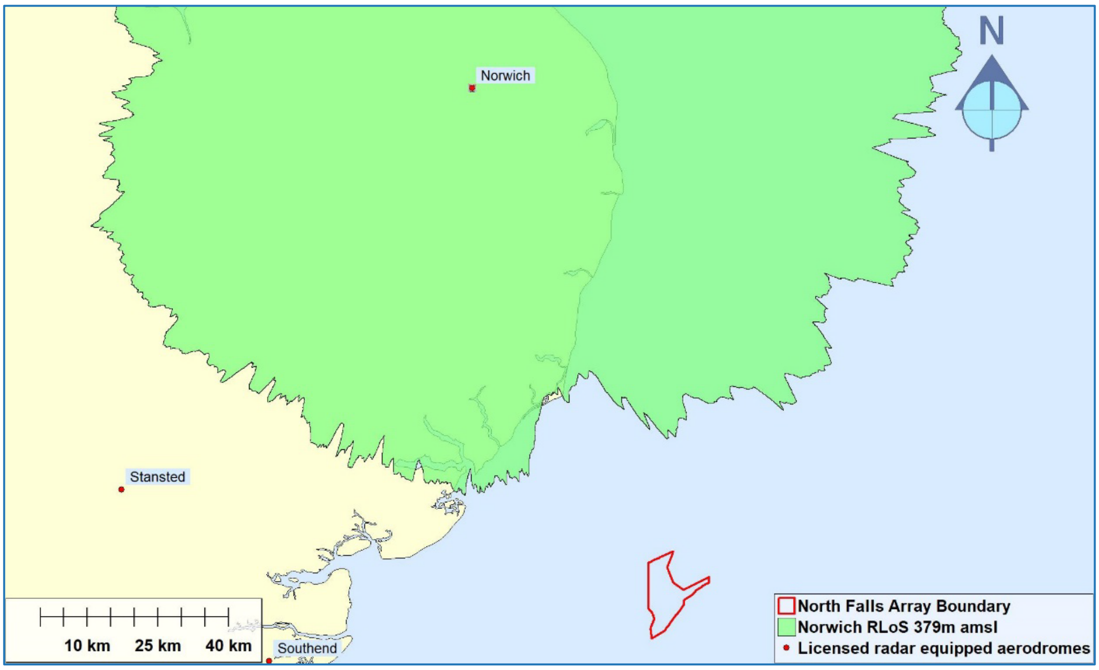

Figure 10**: Norwich RLoS 379m amsl**

3.3.2. At blade tip heights of 278m and 379m amsl, none of the North Falls WTGs will be in RLoS of the Norwich Star 2000 PSR. The Designated Operational Coverage (DOC) for Norwich's ATC radar service is 40nm and, at a minimum range of 58nm, it is considered unlikely that Norwich ATC will be providing a radar control service for aircraft in the vicinity of the North Falls array area

3.4. Stansted

3.4.1. Stansted RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 11 and Figure 12 respectively.

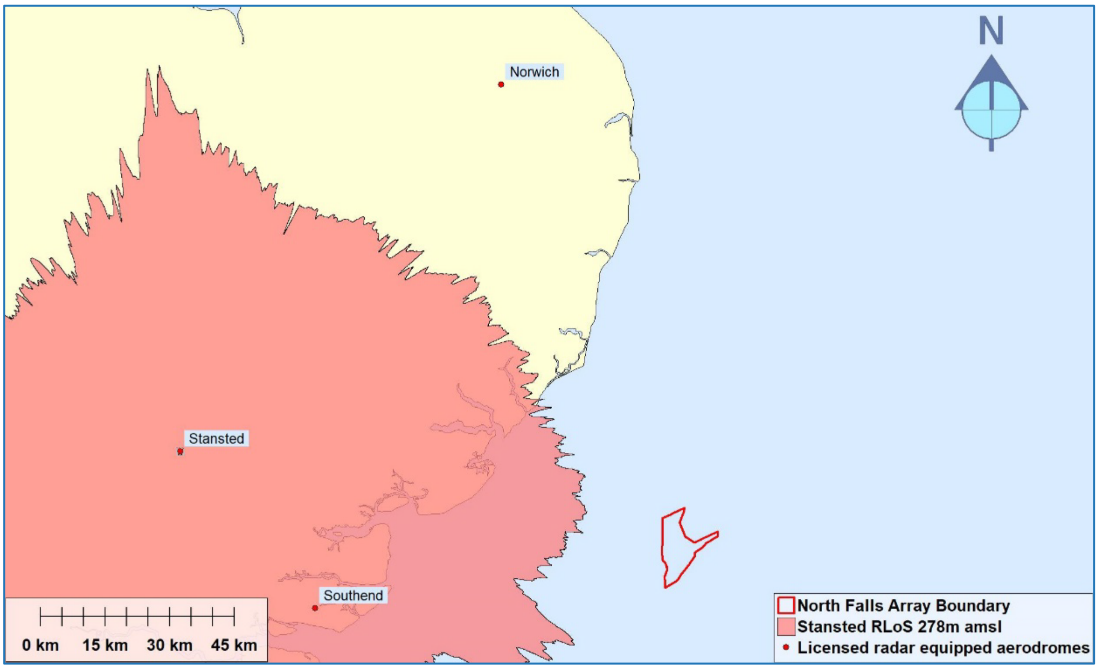

Figure 11: Stansted RLoS 278m amsl

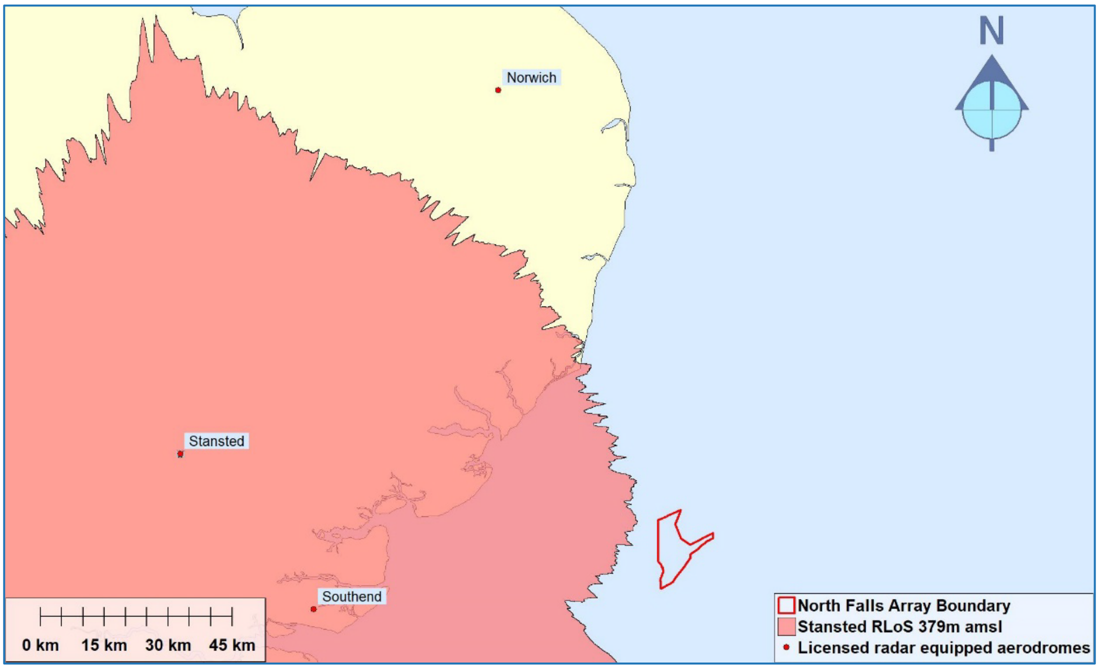

Figure 12**: Stansted RLoS 379m amsl**

3.4.2. At blade tip heights of 278m and 379m amsl, none of the North Falls WTGs will be in RLoS of the Stansted PSR. The Stansted ASR-10SS PSR has a range of 60nm which means that the

North Falls WTGs will be beyond the limit of its detection capability. Stansted ATC will not be providing a radar control service in the airspace above the North Falls array area.

3.5. Southend

3.5.1. Southend RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 13 and Figure 14 respectively.

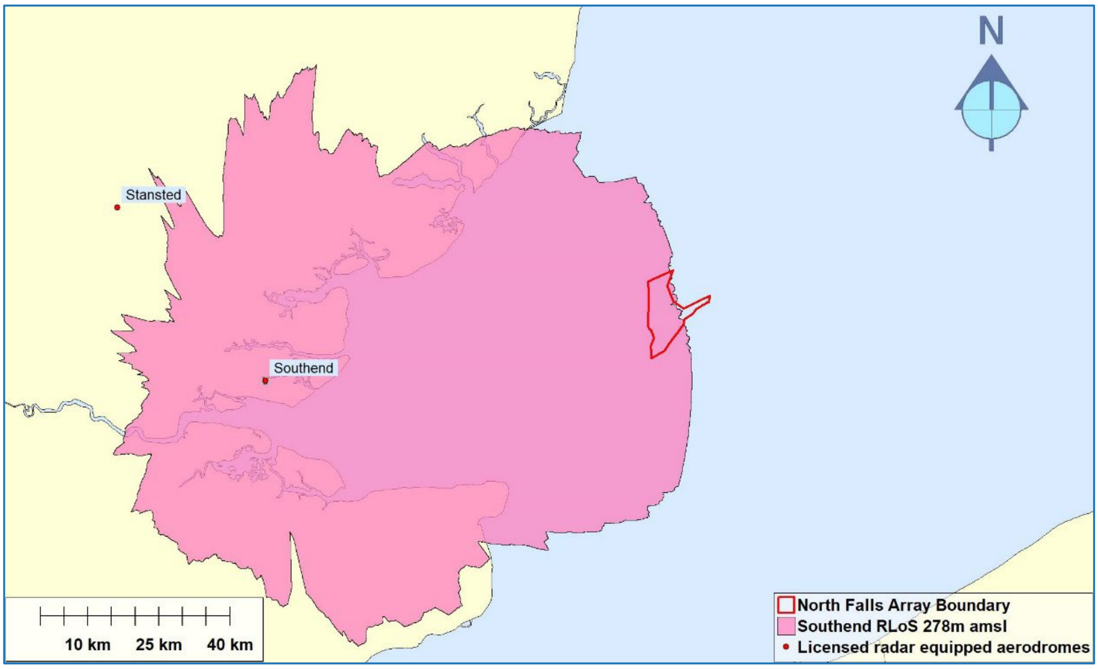

Figure 13: Southend RLoS 278m amsl

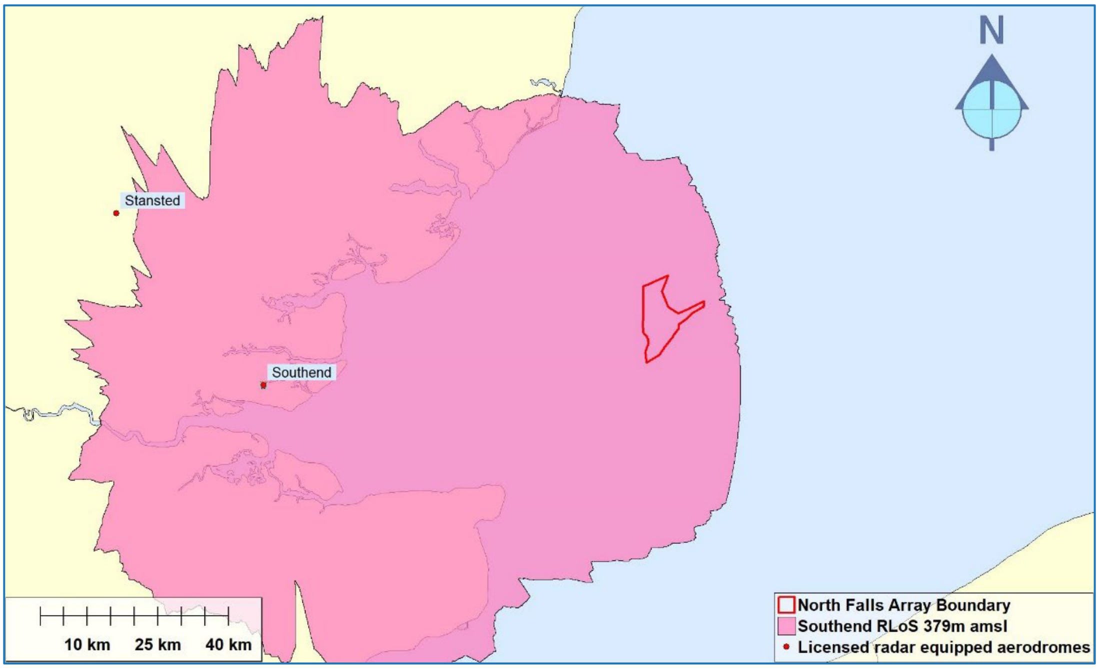

Figure 14**: Southend RLoS 379m amsl**

3.5.2. North Falls WTGs with a blade tip height of 278m amsl will be in RLoS of the Southend ATCR-33SE PSR across most of the array area.

3.5.3. All North Falls WTGs with a blade tip height of 379m amsl will be in RLoS of the Southend PSR and highly likely to be detected. However, the DOC for Southend's ATC radar service is 40nm and, at a minimum range of 44nm, it is considered unlikely that Southend ATC will be providing a radar control service for aircraft in the vicinity of the North Falls array area. The impact on Southend PSR is therefore not considered to be operationally significant.

3.6. Military airfields with surveillance radar

3.6.1. The closest radar equipped military airfields to North Falls lie to the north-west and are Army Air Corps Wattisham (74km or 40nm), Royal Air Force (RAF) Honington (97km or 52nm), RAF Lakenheath (115km or 62nm), and RAF Marham (131km or 71nm).

3.7. Wattisham

3.7.1. Wattisham RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 15 and Figure 16 respectively.

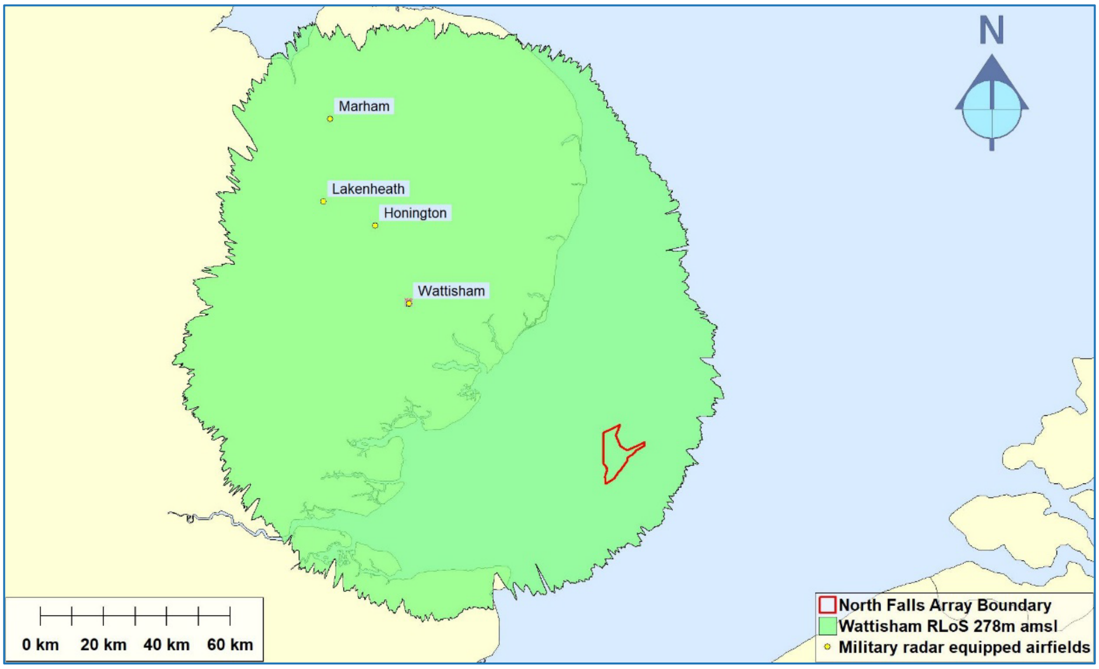

Figure 15: Wattisham RLoS 278m amsl

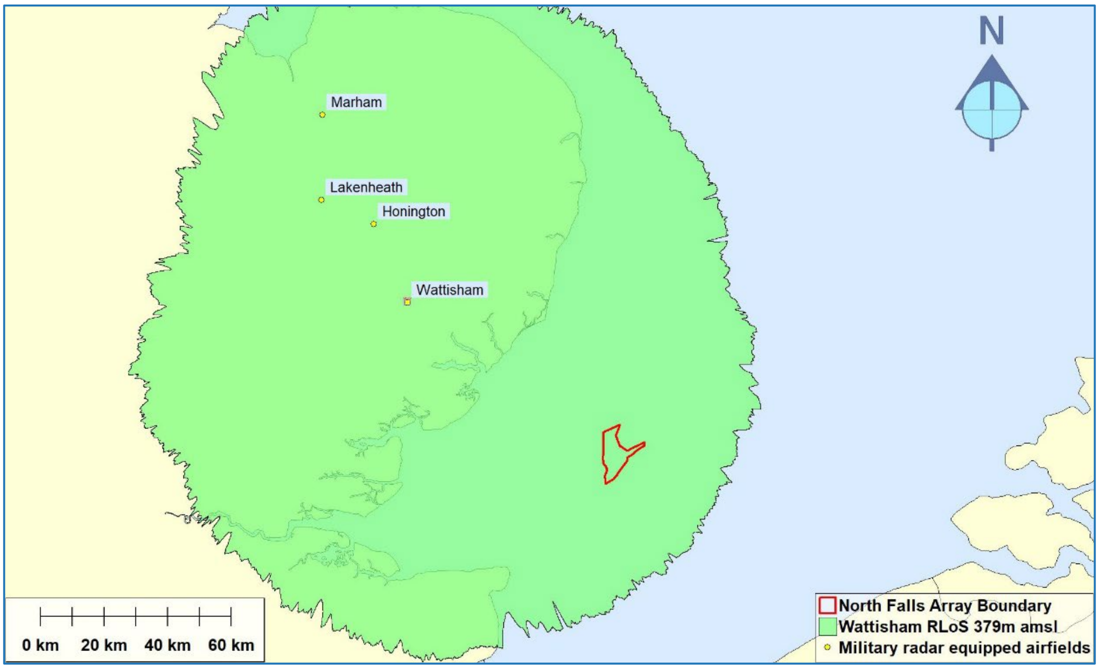

Figure 16: **Wattisham RLoS 379m amsl**

3.7.2. All North Falls WTGs within the array area will be in RLoS of the Wattisham Thales STAR NG PSR, irrespective of blade tip height, and highly likely to be detected.

3.7.3. The Thales STAR NG system is known to have enhanced capability for filtering out clutter from WTGs and can potentially be configured to mitigate the impact of WTGs should this be required to safeguard ATC operations.

3.8. Honington

3.8.1. Honington RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 17 and Figure 18 respectively.

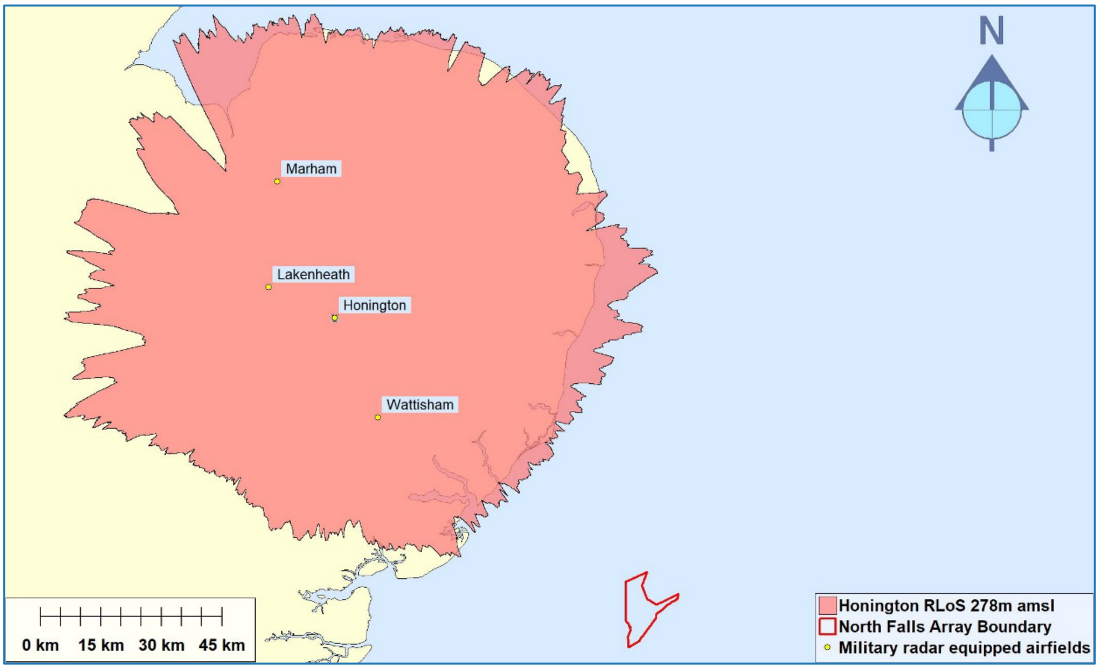

Figure 17: Honington RLoS 278m amsl

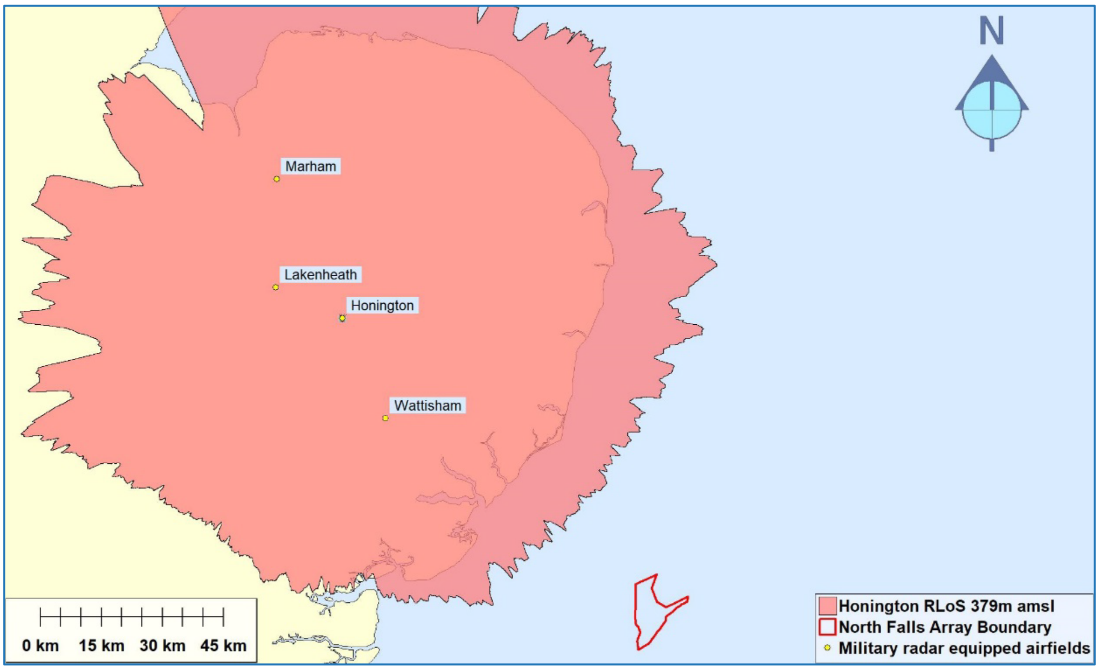

Figure 18: Honington RLoS 379m amsl

3.8.2. No North Falls WTGs with blade tip heights of either 278m or 379m amsl will be in RLoS of the Honington PSR. It is unlikely that WTGs with the maximum blade tip height will be detected by the Honington PSR.

3.9. Lakenheath

3.9.1. Lakenheath RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 19 and Figure 20 respectively.

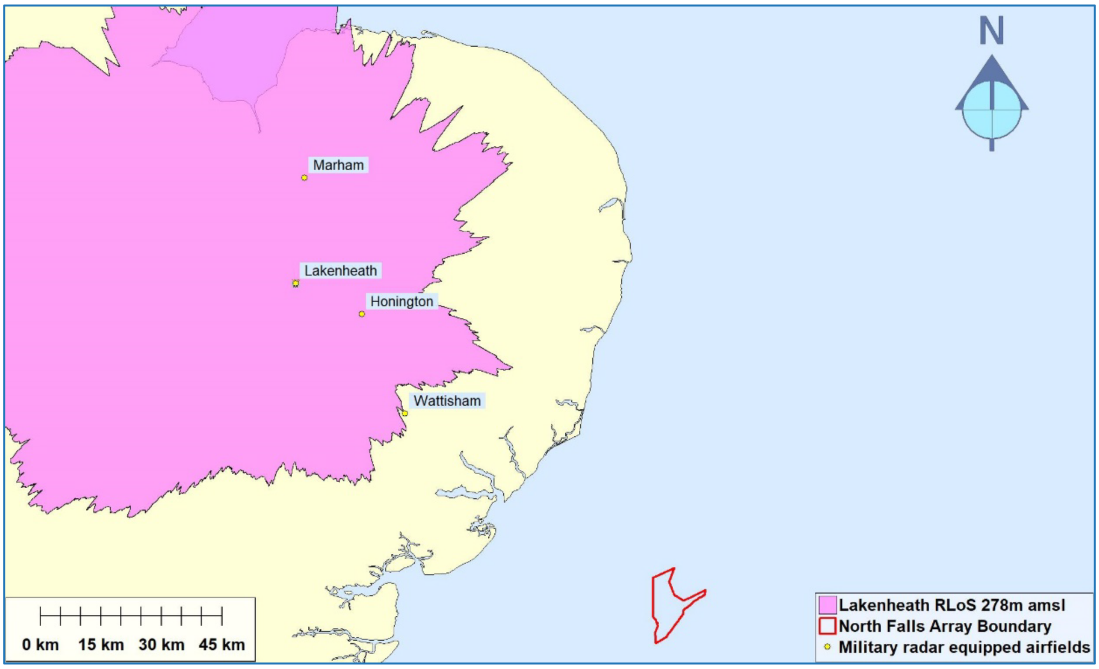

Figure 19: Lakenheath RLoS 278m amsl

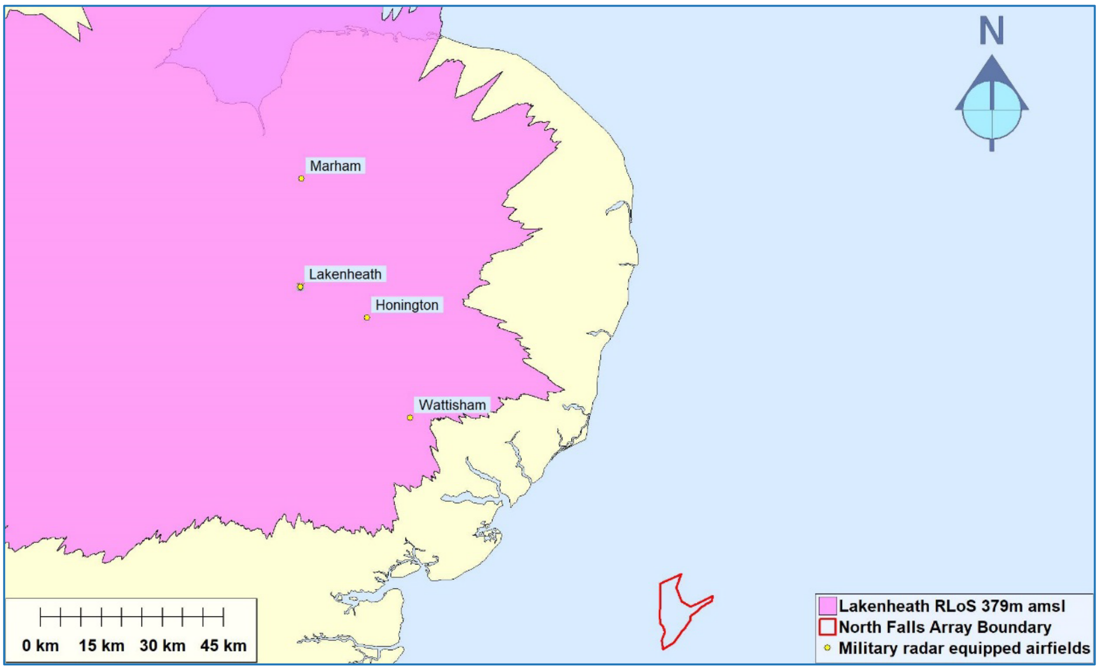

Figure 20: Lakenheath RLoS 379m amsl

3.9.2. No North Falls WTGs with blade tip heights of either 278m or 379m amsl will be in RLoS of the Lakenheath PSR. It is unlikely that WTGs with the maximum blade tip height will be detected by the Lakenheath PSR.

3.10. Marham

3.10.1. Marham RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 21 and Figure 22 respectively.

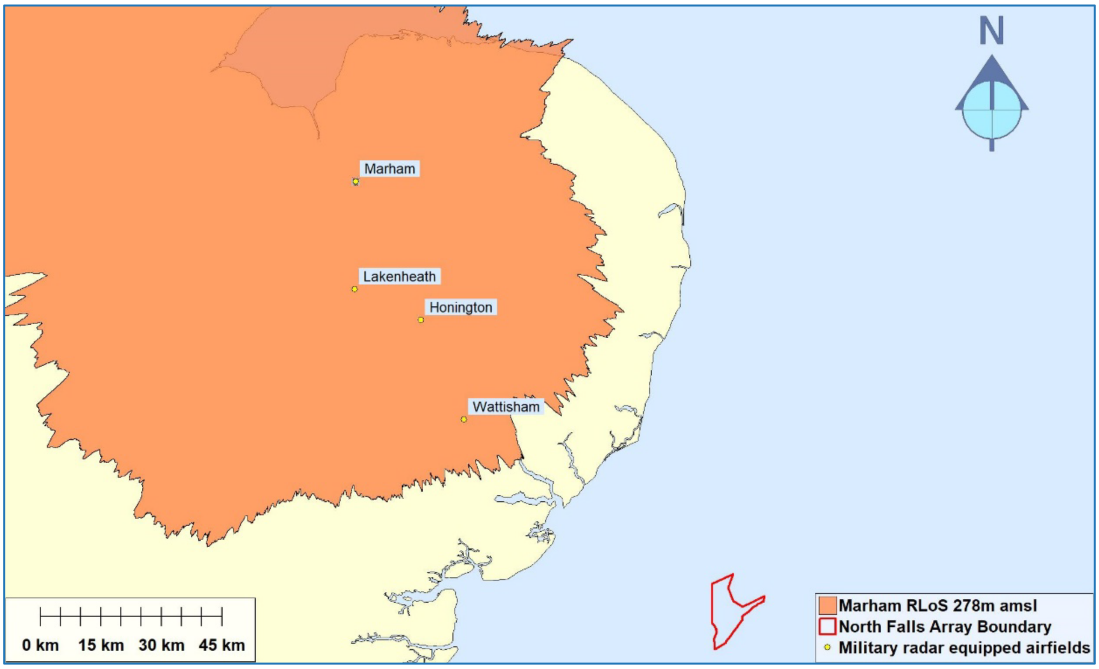

Figure 21: Marham RLoS 278m amsl

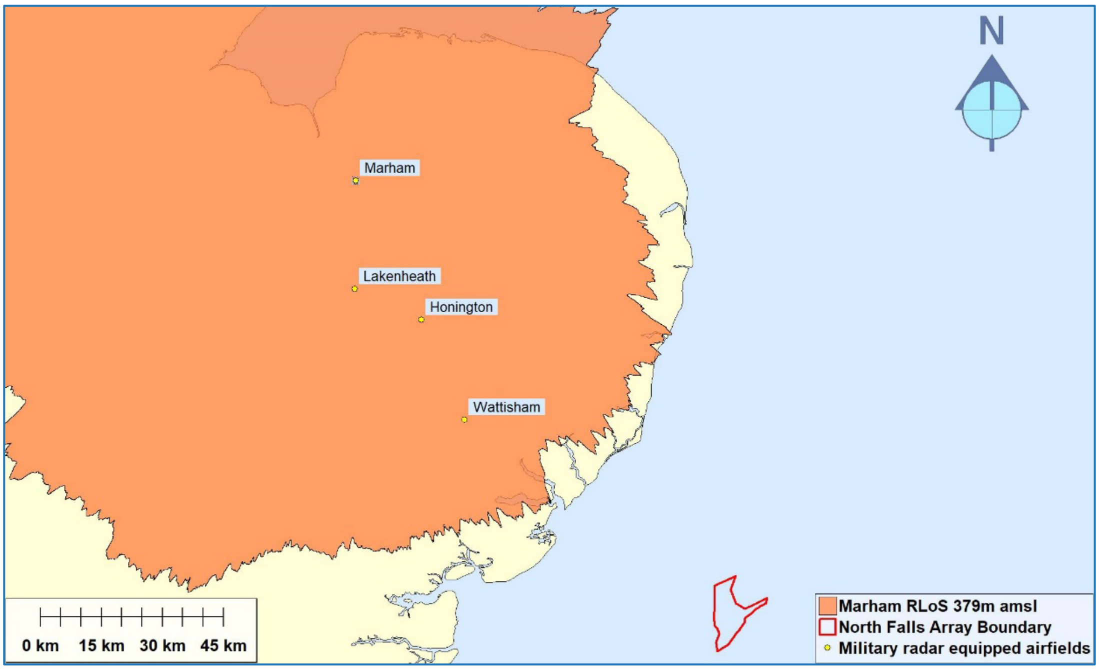

Figure 22: Marham RLoS 379m amsl

3.10.2. No North Falls WTGs with blade tip heights of either 278m or 379m amsl will be in RLoS of the Marham PSR. It is unlikely that WTGs with the maximum blade tip height will be detected by the Marham PSR.

3.11. NERL radars

3.11.1. The closest NERL radars to North Falls are at Cromer, 130km or 70nm to the north, and at Debden, 112km or 61nm to the west.

3.12. Cromer

3.12.1. Cromer RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 23 and Figure 24 respectively.

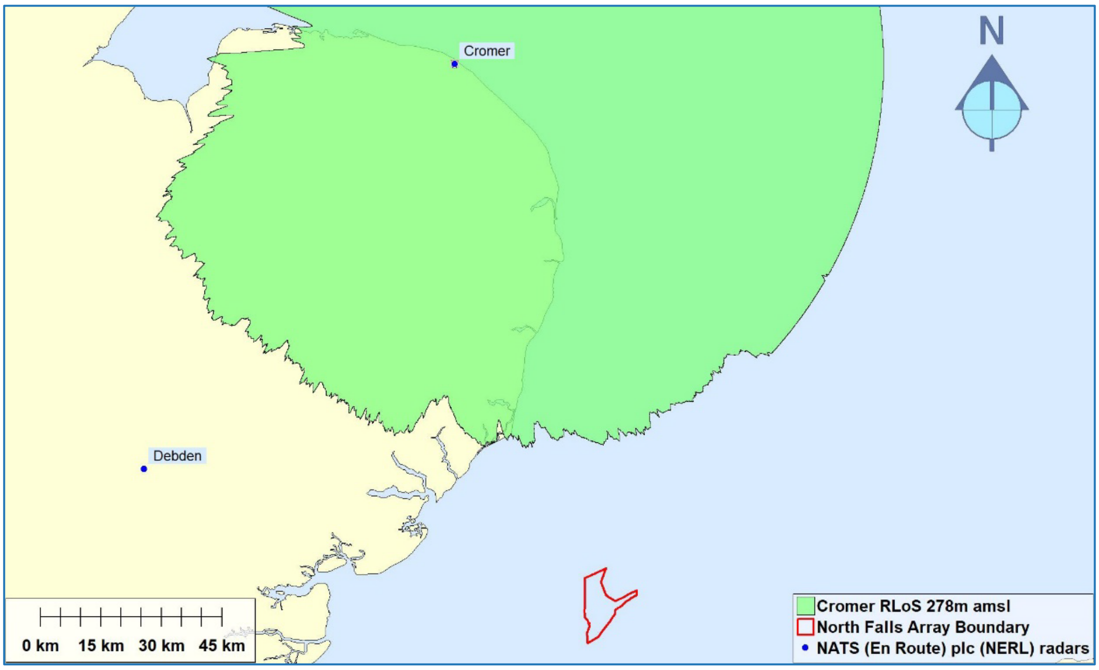

Figure 23: Cromer RLoS 278m amsl

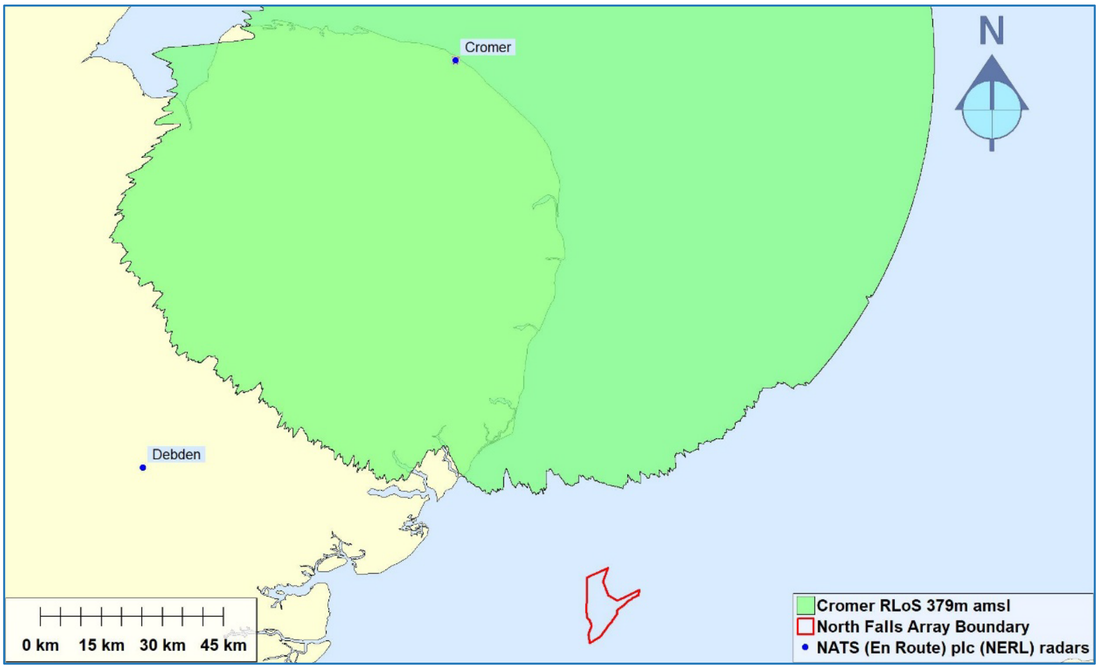

Figure 24: Cromer RLoS 379m amsl

3.12.2. No North Falls WTGs with blade tip heights of either 278m or 379m amsl will be in RLoS of the Cromer PSR. It is unlikely that WTGs with the maximum blade tip height will be detected by the Cromer PSR.

3.13. Debden

3.13.1. Debden RLoS coverages for blade tip heights of 278m and 379m amsl are shown in Figure 25 and Figure 26 respectively.

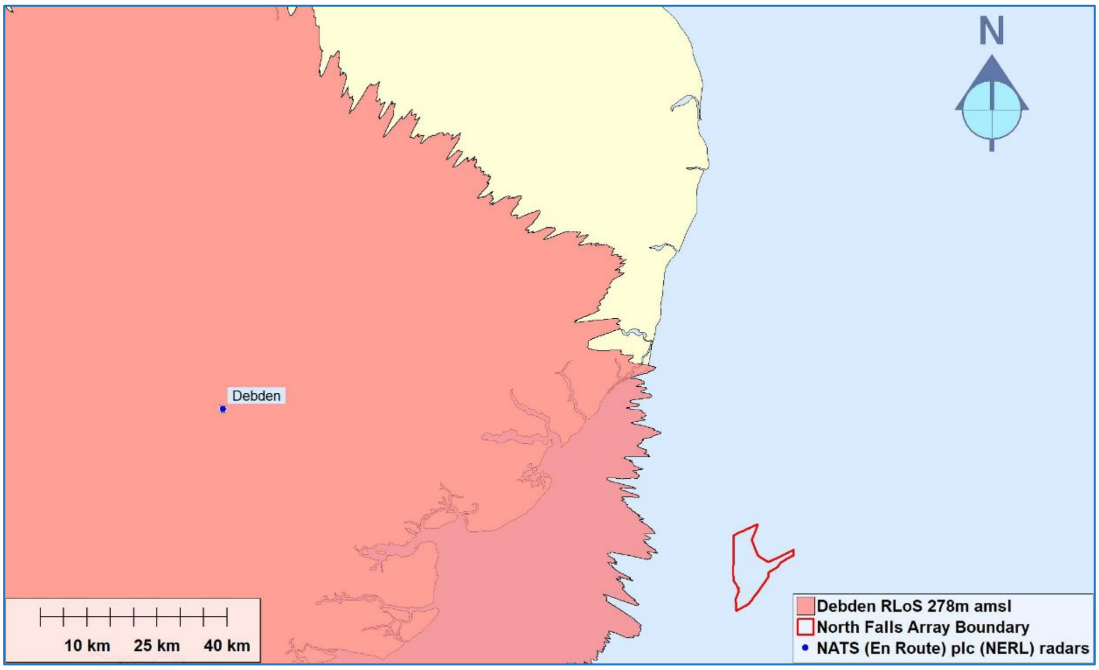

Figure 25: Debden RLoS 278m amsl

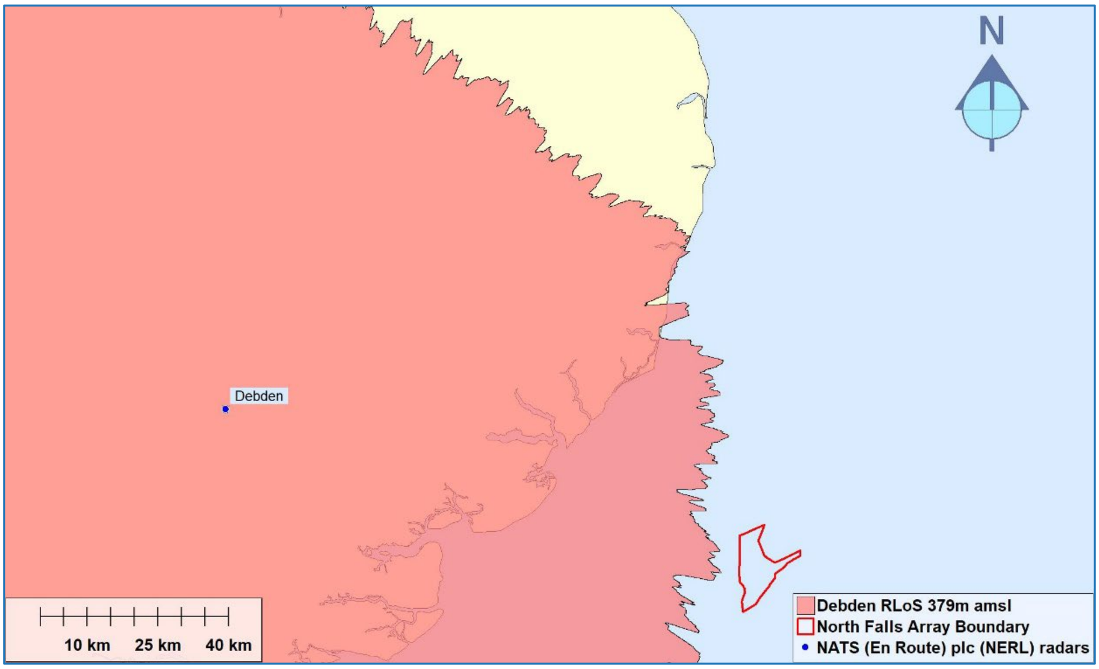

Figure 26: Debden RLoS 379m amsl

3.13.2. North Falls WTGs with a blade tip height of either 278m or 379m amsl will not be in RLoS of Debden PSR.

3.13.3. RLoS is only an indication as to whether the radar will 'see' a WTG. Depending on the radar configuration and the nature of the terrain screening, the Probability of Detection (Pd) may be greater or less than the RLoS distance. Pd may be calculated by using a radio propagation model to determine radar signal path loss between the radar and WTGs, and from the technical characteristics of the radar.

3.13.4. Debden PSR is a Raytheon ASR-23SS system. Parameters are taken from data published by Raytheon for an 8-module radar.

3.13.5. Path loss calculations are made to 379m tip height WTGs across the array area. By knowing the PSR transmitter power, antenna gain, 2-way path loss, receiver sensitivity and the WTG Radar Cross Section (RCS) gain, the Pd can be calculated.

3.13.6. The static parts of each WTG (tower structure) can be ignored in the calculation as these will be rejected by the radar Moving Target filter. Three parts of each 379m WTG are considered for the calculations, with the WTG blade pointing vertically: the blade tip, the blade mid-point and the WTG nacelle. The calculations are made using the ITU526 propagation model.

3.13.7. The amount of radar energy reflected back to the radar from the WTG will depend on the RCS of the WTG blade. For a blade length of 168.5m (half of the 337m diameter) a nominal RCS of 280m^2 is used to determine the energy reflected from each of the three points on the WTG (tip, mid-point and nacelle).

3.13.8. The received signal at the radar from each component part of the WTG is then summed to determine the total signal level. This is then compared with the radar receiver Minimum Detectable Signal level.

3.13.9. The results of Pd calculations for 379m WTGs across the North Falls array area are presented graphically in Figure 27 with the radar received signal level colour coded as follows:

- Green means more than -6dB below the radar receiver threshold. 379m WTGs in these areas are unlikely to be detected;
- Yellow means between -3dB and -6dB and a small possibility of detection for 379m WTGs in these areas;
- Orange means between -3dB and +3dB and a possibility of detection for 379m WTGs in these areas;
- Red means above +3dB. 379m WTGs in these areas have a high probability of detection.

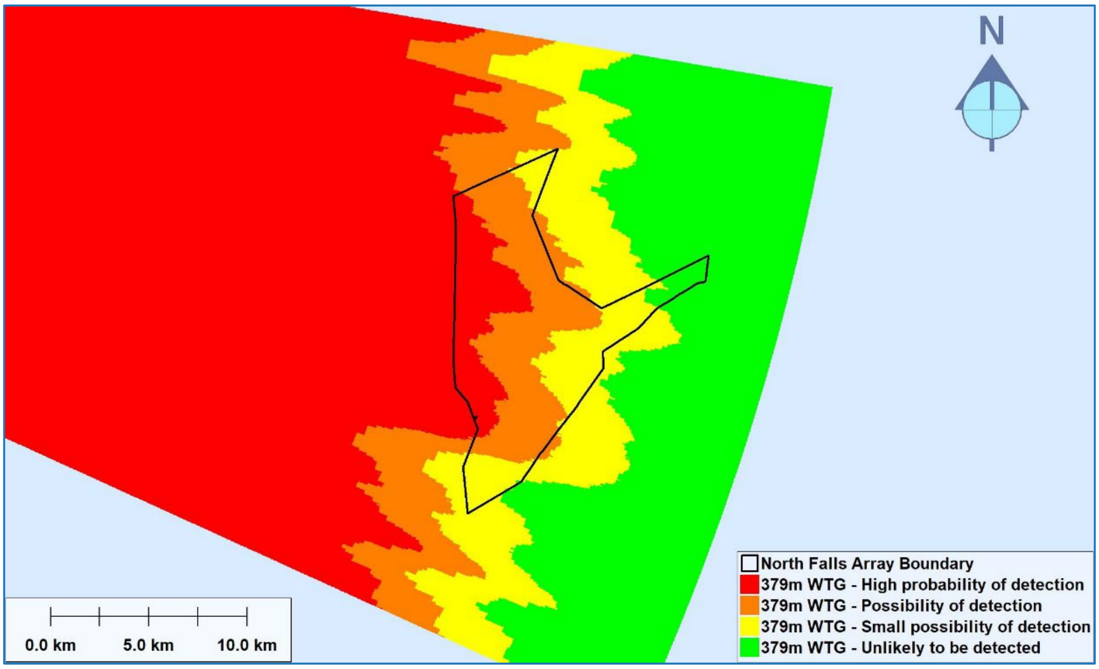

Figure 27: Debden PSR – 379m WTG Pd

3.13.10. The Pd results show that for a blade tip height of 379m, there is a high probability of WTGs being detected within approximately 25% of the array area and a possibility of WTG detection within approximately 46% of the array area.

3.13.11. These results represent the worst-case as they are based on the optimum performance of the radar, however the gain of a radar antenna in the vertical axis is not uniform with elevation angle. Debden PSR uses a modified Cosec^2 vertical antenna pattern which has reduced gain at low elevation angles to moderate the effects of ground clutter but high gain at elevations just a few degrees above the horizon. The actual antenna gain at the WTG elevations (between -0.25° and -0.32°) is expected to be significantly lower than the on-axis gain.

3.13.12. If the antenna gain at the WTG elevations is assumed to be 10dB lower than the on-axis gain, then the Pd results may be revised as shown in Figure 28.

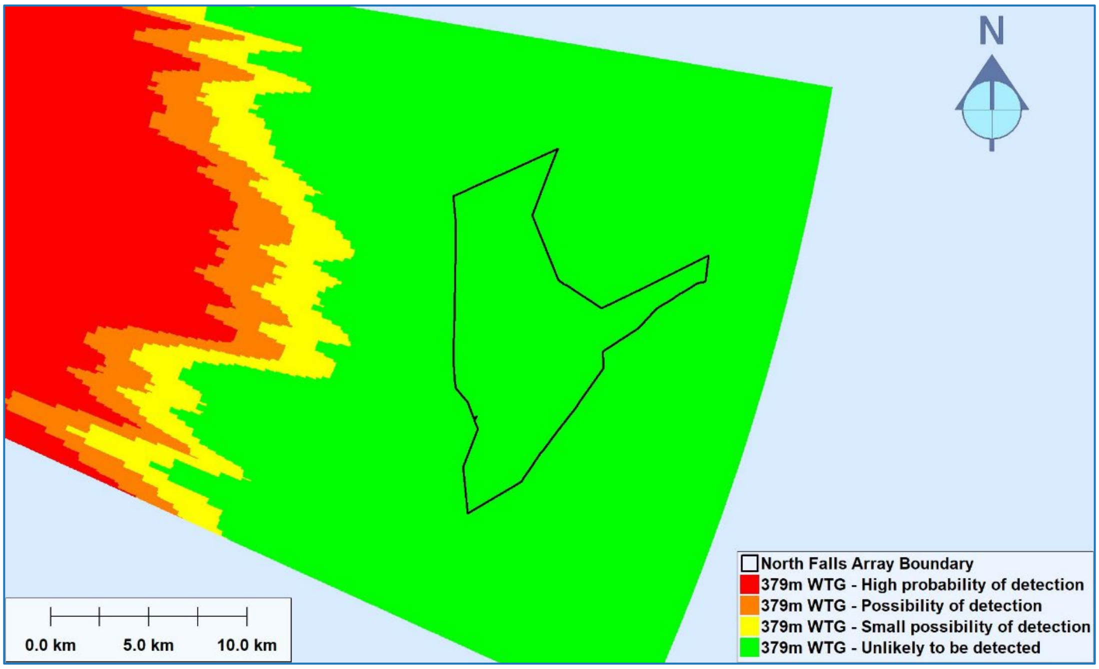

Figure 28: Debden PSR – 379m WTG Pd with reduced antenna gain

3.13.13. With a 10dB reduction in antenna gain, Debden PSR is now unlikely to detect any WTGs in the array area.

3.13.14. NERL will be able to confirm the actual antenna gain at an elevation of 0°.

3.14. MoD Air Defence radars

3.14.1. The closest AD radar to North Falls is at Neatishead, 107km or 58nm to the north. The Neatishead site is the new location for the TPS-77 radar that was formerly at Trimingham.

3.15. Neatishead

3.15.1. Neatishead RLoS coverage for blade tip heights of 278m and 379m amsl are shown in Figure 35 and Figure 36 respectively.

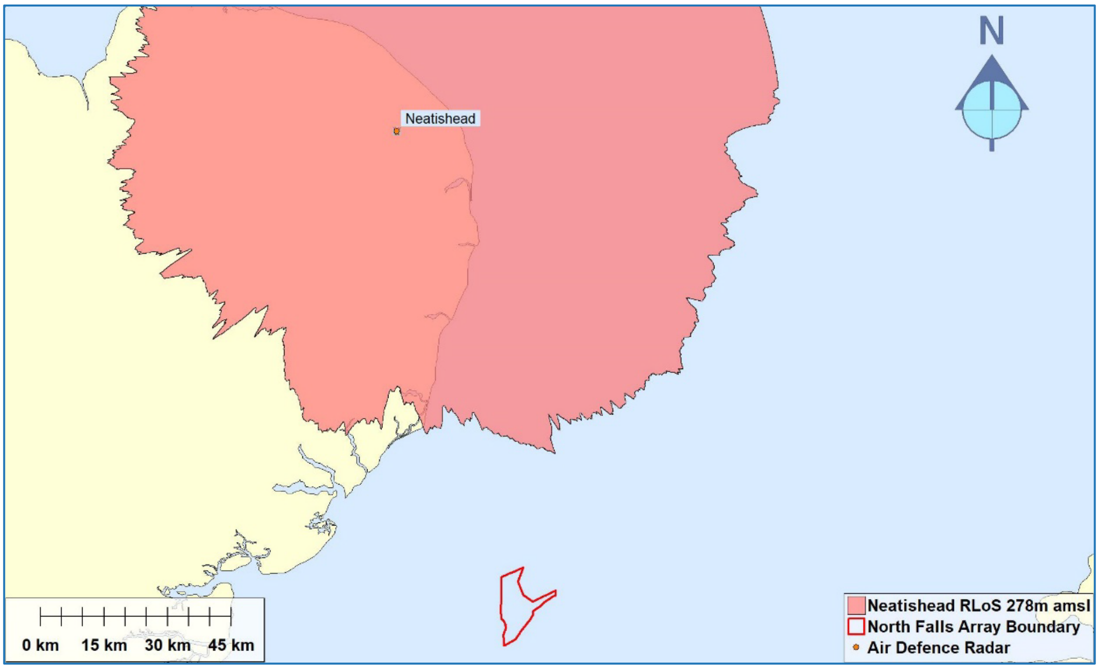

Figure 29: Neatishead RLoS 278m amsl

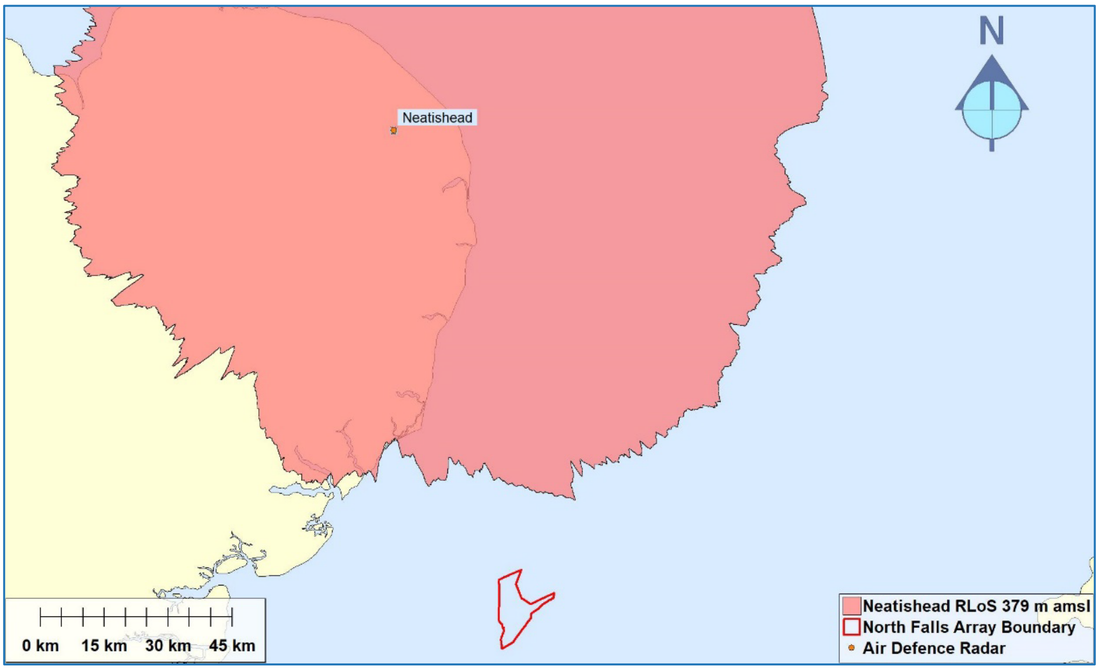

Figure 30: Neatishead RLoS 379m amsl

3.15.2. No North Falls WTGs with blade tip heights of either 278m or 379m amsl will be in RLoS of the Neatishead PSR.

3.15.3. RLoS is only an indication as to whether the radar will 'see' a WTG. Depending on the radar configuration and the nature of the terrain screening, the Pd may be greater or less than the RLoS distance. Pd may be calculated by using a radio propagation model to determine radar signal path loss between the radar and WTGs, and from the technical characteristics of the radar.

3.15.4. The Neatishead PSR is a Lockheed Martin TPS-77 system. The MoD is unable to provide detailed technical information or specifications for this system as these are protected by the International Traffic in Arms Regulations, however previous assessments carried out by Cyrrus, using limited information from a publicly available factsheet, have determined that WTGs that are not in RLoS of Neatishead PSR are unlikely to be detected under standard atmospheric conditions.

3.16. Radar mitigation

3.16.1. Southend

3.16.1.1. Should Southend Airport be able to substantiate the significance of the impact of WTGs on their PSR then mitigation in the form of blanking combined with a TMZ should be available. It is noted that the existing TMZ established around the London Array Offshore Wind Farm provides similar mitigation for WTG impacts on Southend PSR.

3.16.2. Wattisham

3.16.2.1. The Wattisham PSR has recently been upgraded to a Thales STAR NG system as part pf the Project Marshall ATC radar upgrade project. The new radar is known to have enhanced capability for filtering out WTG clutter, and, if necessary can potentially be configured to mitigate the impact of the North Falls WTGs.

3.16.3. Neatishead

3.16.3.1. The MoD may have concerns regarding radar detection of WTGs under anomalous propagation conditions, when ducting propagation enables radars to 'see' targets that would normally be beyond the RLoS horizon.

3.16.3.2. In respect of the TPS-77 PSR at Neatishead, the most common WTG mitigation technique applied for previous wind farm developments was the application of a Non-Auto Initiation Zone (NAIZ) in the TPS 77's lowest beam over the footprint of any detectable WTGs. A NAIZ is a pre-defined geographical area where spurious radar returns from turbines will not initiate a track that could be interpreted as an aircraft. However, on 24 August 2018 the MoD issued a statement indicating that the TPS 77 NAIZ mitigation had not performed to expectations at flight trials over two offshore wind farms and as a result immediately paused the receipt and assessment of any technical mitigation reports or submissions relating to TPS-77 radars and multi-turbine wind farms.

3.16.3.3. An Air Defence and Offshore Wind (AD&OW) Windfarm Mitigation Task Force was formed as a collaborative initiative between the MoD, what was the Department for Business, Energy and Industrial Strategy (BEIS) now the Department for Energy Security and Net Zero (DESNZ), the Offshore Wind Industry Council and The Crown Estate in August 2019. The aim of the Task Force is to enable the co-existence of UK Air Defence and offshore wind by identifying potential mitigations and supporting processes, allowing offshore wind to contribute towards meeting the UK Government's Net Zero target without degrading the nation's AD surveillance capability.

3.16.3.4. The AD&OW Strategy and Implementation Plan (S&IP) sets the direction for this collaboration by identifying, assessing and deploying solutions that will enable the co-existence of AD&OW operations such that neither is unduly nor excessively compromised. The S&IP may lead to significant changes to current AD PSR characteristics and capabilities that in turn affect the potential impact that North Falls may have.

3.16.3.5. In support of the S&IP, in March 2020 the MoD Defence and Security Accelerator (DASA) and BEIS launched an Innovation Challenge to reduce and remove the impact of wind farms on the UK's AD surveillance systems by seeking technological proposals in four areas:

- Alternatives to radar;
- Technologies applied to the WTG or installation;
- Technologies applied to the radar, its transmission or return; and
- Technological mitigations not covered by the above.

3.16.3.6. Phase 1 identified mitigations such as new radar signal processing methods or radar absorbing treatments applied to WTGs, and recommended a hybrid approach involving changes to both radar and WTG design to solve the problem in the long term.

3.16.3.7. Phase 2 of the competition was launched in April 2021 seeking proposals to address four main subject areas:

- Reduction of clutter or the impact of clutter;
- Ensuring efficient detection and tracking time;
- Technologies to mitigate against larger turbine blades and wider turbine spacing development; and
- Alternate methods of surveillance.

3.16.3.8. Of twenty submitted proposals, contracts for seven proposals were awarded in September 2021 and completed by March 2023.

3.16.3.9. DASA and DESNZ launched Stream 1 of Windfarm Mitigation for UK Air Defence: Phase 3 in February 2023, building upon Phases 1 and 2 to advance innovative technologies in radar signal processing, WTG materials and alternative tracking approaches.

3.16.3.10. In August 2023 funding was awarded for two projects: a project developing passive air defence sensors to address clutter from WTG blades, and another project developing stealth materials for next-generation WTG blades. At the same time, Phase 3 Stream 2 was launched to find solutions for the modelling and testing of different mitigation technologies.

3.16.3.11. The ultimate aim of the S&IP is to have mitigations in place to support offshore wind developments by Q2 2025, and therefore it is expected that such mitigation will be available before the construction of North Falls.

3.17. Consultation on mitigation

3.17.1. Potential mitigation measures will be consulted upon with stakeholders as part of the Environmental Impact Assessment process and will also reflect appropriate measures that are being discussed at an industry level.

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