Hornsea Project Four: Environmental Statement (ES)

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Volume A5, Annex 8.1: Aviation and Radar Technical Report

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Glossary

Term	Definition
Anomalous Propagation (Anaprop)	Anaprop is an effect to radar which can occur by changes in local atmospheric temperature, air pressure or air water vapor content.
Commitment	A term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or Environmental Statement (ES)). Secondary commitments are incorporated to reduce LSE to acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Controlled Airspace (CAS)	Airspace in which Air Traffic Control exercises authority. In the UK, Class A, C, D and E airspace is controlled.
Cumulative effects	The combined effect of Hornsea Four in combination with the effects from a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Four.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Flight Level	A standard nominal altitude of an aircraft, in hundreds of feet, based upon a standardized air pressure at sea-level.
Helicopter Main Route (HMR)	Helicopter Main Routes are routes typically and routinely flown by helicopters operating to and from offshore destinations and are promulgated for the purpose of signposting concentrations of helicopter traffic to other airspace users. HMR promulgation does not predicate the flow of helicopter traffic. Whilst HMRs have no airspace status and assume the background airspace classification within which they lie (in the case of the Southern North Sea, Class G), they are used by the air navigation service provider and helicopter operators for flight planning and management purposes.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Instrument Flight Rules (IFR)	The rules governing procedures for IFR flights conducted with the crew making reference to aircraft cockpit instruments for situation awareness and navigation.

Term	Definition
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
Minimum Safe Altitude (MSA)	Under aviation flight rules, the altitude below which it is unsafe to fly in Instrument Meteorological Conditions owing to presence of terrain or obstacles within a specified area.
Mitigation	A term used interchangeably with Commitment(s) by the Applicant. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, or PEIR or ES).
Onshore infrastructure	The combined name for all onshore infrastructures associated with the project from landfall to grid connection.
Order Limits	The limits within which Hornsea Four (the 'authorised project') may be carried out.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Uncontrolled Airspace	Airspace in which Air Traffic Control does not exercise any executive authority but may provide basic information services to aircraft in radio contact. In the UK, Class G airspace is uncontrolled.
Visual Flight Rules (VFR)	The rules governing flight conducted visually i.e. with the crew maintaining separation from obstacles, terrain and other aircraft visually.
Visual Meteorological Conditions (VMC)	A flight category which allows flight to be conducted under VFR defined by in flight visibility and clearance from cloud.

Acronyms

Acronym	Definition
ACC	Area Control Centre
ADR	Air Defence Radar
AfL	Agreement for Lease
agl	Above Ground Level
AIP	Aeronautical Information Publication
amsl	above mean sea level
ANSP	Air Navigation Service Provider
AOC	Air Operators Certificate
ASACS	Air Surveillance and Control System
ATC	Air Traffic Control
ATDI	Advanced Topographic Development & Images: ATDI Group (signal propagation software supplier)
ATM	Air Traffic Management
ATS	Air Traffic Service
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAS	Controlled Airspace
DCO	Development Consent Order
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ERCoP	Emergency Response Co-operation Plan

Acronym	Definition
ES	Environmental Statement
FIR	Flight Information Region
FL	Flight Level
GPS	Global Positioning System
HMR	Helicopter Main Route
HVAC	High Voltage Alternating Current
IFR	Instrument Flight Rules
Indra	Indian Doppler Radar
LAT	Lowest Astronomical Tide
LOS	Line of Sight
MCA	Maritime Coastguard Agency
MDA	Managed Danger Areas
MDS	Maximum Design Scenario
Mil AIP	Military Aeronautical Information Publication
MMO	Marine Management Organisation
MOD	Ministry of Defence
MRCC	Maritime Rescue Coordination Centre
MSA	Minimum Safe Altitude
NERL	NATS En Route Limited
OWIC	Offshore Wind Industry Council
PEIR	Preliminary Environmental Information Report
PEXA	Practice and Exercise Area
PSR	Primary Surveillance Radar
RAF	Royal Air Force
RAP	Recognised Air Picture
RCS	Radar Cross Section
RDP	Radar Data Processor
SAR	Search and Rescue
SAT	Site Acceptance Test
SSR	Secondary Surveillance Radar
TOPA	Technical and Operational Assessment
UKIAIP	United Kingdom Integrated Aeronautical Information Package
UKLFS	United Kingdom Low Flying System
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
WTG	Wind Turbine Generator

Units

Unit	Definition
ft	feet
m	metre
km	kilometre
NM	nautical mile
rpm	revolutions per minute

1 Introduction

1.1 Introduction

1.1.1 Project background

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter 'the Applicant') is proposing to develop Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 kilometres (km) offshore from the East Riding of Yorkshire coast in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume A1, Chapter 1: Introduction** for further details on the Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network. The location of Hornsea Four is illustrated in **Figure 1**. The Order Limits combines the search areas for the onshore and offshore infrastructure.

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has given due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the array area taken forward at the point of Application, (see **Figure 1**). Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in the **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

1.1.1.4 Osprey Consulting Services Ltd (Osprey) was commissioned by the Applicant to undertake a characterisation of the aviation and radar baseline environment of the Hornsea Four array area and surrounding area to establish the aviation baseline and hence the potential for Hornsea Four to present an impact on aviation and radar interests within the proximity of the Hornsea Four array area.

1.1.1.5 The Hornsea Four aviation and radar study area shown in **Figure 1** encapsulates the Hornsea Four array area, the onshore and offshore Export Cable Corridor (ECC) as well as the airspace between the Hornsea Four array area and the UK mainland from Norwich Airport to the south (helicopter support to the offshore environment) and Royal Air Force (RAF) Brizlee Wood (extent of potential of radar detectability) to the north. For the purposes of the assessment of cumulative effects, the study area also includes other offshore wind farms in the Southern North Sea that could have potential effects on identified military, aviation and radar stakeholders. Specifically, the aviation and radar study area covers:

- Aviation radar systems that could potentially detect 370 metres (m) high (blade tip) Wind Turbine Generators (WTGs) within the Hornsea Four array area;
- Offshore helicopter operations including Helicopter Main Routes (HMRs) that are located within the proximity of the array area;
- Search and Rescue (SAR) flight operations; and
- Military low flying operations.

1.1.1.6 The Civil Aviation Authority (CAA) Civil Aviation Publication (CAP) 764 *Policy and Guidelines on Wind Turbines* (CAA 2016) emphasises the importance of consultation between offshore helideck operators and wind farm developers to ensure the continued safe operation of associated helicopter low visibility approaches in poor weather conditions. In order to help achieve a safe operating environment, a consultation zone of nine nautical mile (NM) radius exists around offshore helicopter destinations. Offshore oil and gas platforms with helidecks within the consultation zone of Hornsea Four have been identified. Consultation has taken place with the operators of these platforms and with the associated offshore helicopter operators in order to determine a solution that maintains safe offshore helicopter operations alongside Hornsea Four. This consultation process, as well as further detail on airborne SAR operations and helicopter operations in relation to oil and gas platforms is presented in Appendix A of **Annex 5.11: Offshore Installation Interfaces**.

1.1.2 Background

1.1.2.1 The effects of WTGs on aviation interests primarily concern the maintenance of safe aviation operations. There are innumerable subtleties in the actual effects but there are three dominant scenarios that can lead to objection from aviation stakeholders:

- Physical: WTGs (and associated infrastructure above sea level) can present a physical obstruction to aircraft in transit at low altitudes;
- Radar/Air Traffic Services (ATS): WTG-derived clutter appearing on radar displays can affect the safe provision of an ATS[1] 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 WTGs can affect the performance of the radar system itself and
- Air Defence Radar: WTG-derived clutter can degrade the Ministry of Defence (MOD) capacity to monitor the airspace in and around the UK in order to launch a response to any potential airborne threat.

1.1.3 Aims and objectives

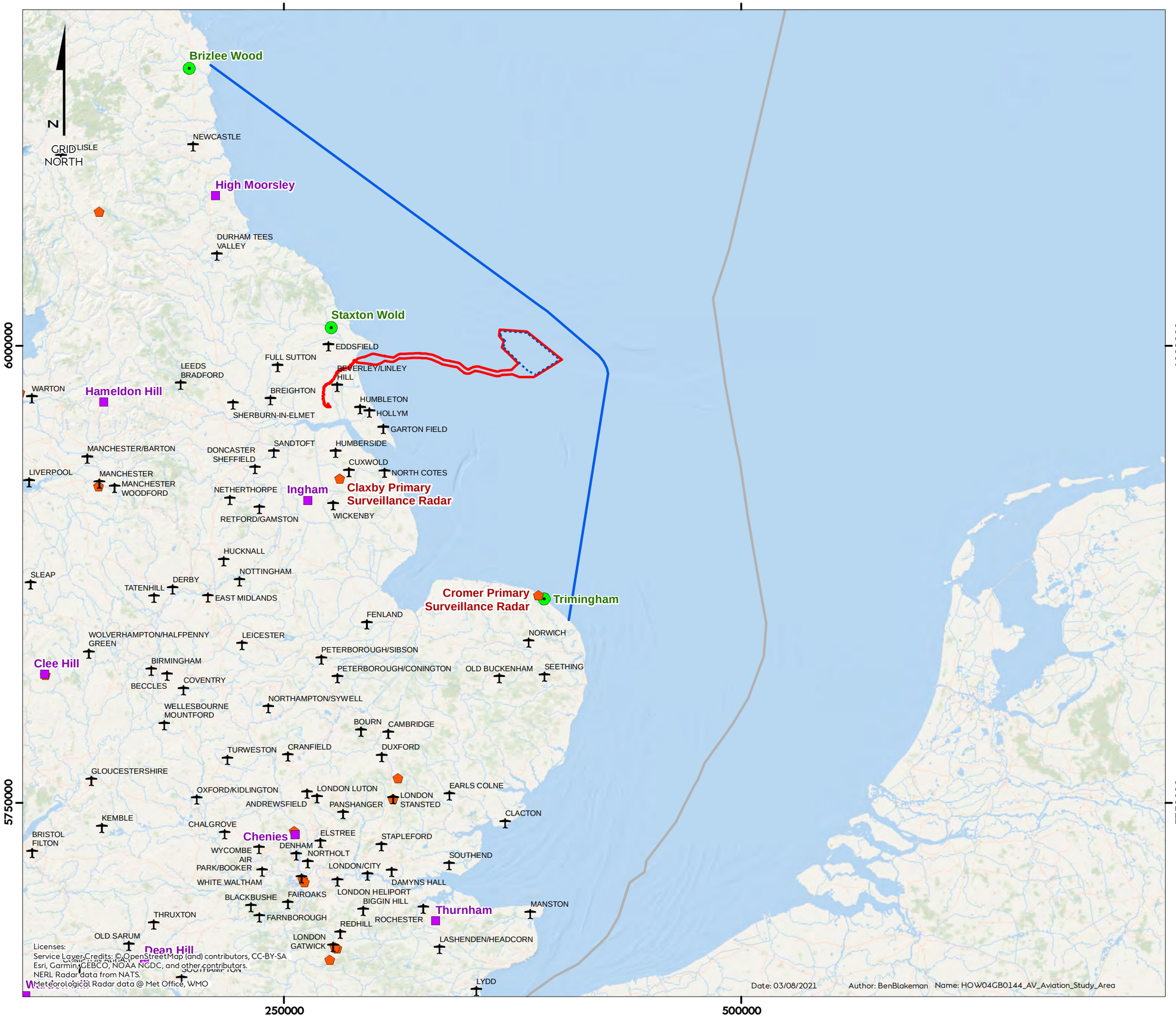
1.1.3.1 The purpose of this document is to establish which aviation stakeholders and receptors have the potential to be affected by the development of Hornsea Four through the establishment of the baseline aviation and radar environment. Having established the baseline, further analysis has been completed on the potential of individual aviation radar systems to detect WTGs together with an analysis of baseline aviation operations conducted at, in, and near the aviation and radar study area as presented in **Figure 1**. This includes the Hornsea Four array area, offshore ECC, High Voltage Alternating Current (HVAC) booster stations, the onshore ECC, and the airspace between the Hornsea Four array area, the UK mainland from Norwich Airport to the south and RAF Brizlee Wood to the north.

[1] UK Ministry of Defence (MOD) Air Traffic Control (ATC) and Air Defence controllers provide an ATS in accordance with military and civilian regulations.

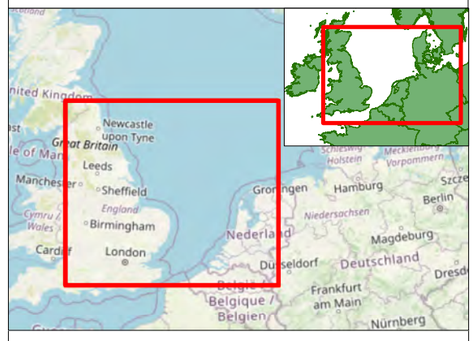
Hornsea Four

Figure 1

Aviation and Radar Study Area



- Order Limits
- Array Area
- Jurisdictional Boundary
- Hornsea Four Aviation & Radar Study Area
- Airports and Airfields
- MoD Air Defence Radar Site
- NERL Radar
- Meteorological Radar Station



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:2,000,000

0 50 100 Kilometres

0 25 50 Nautical Miles

REV	REMARK	DATE
---	First Issue for PEIR	20/06/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Aviation Study Area
Document no: HOW04GB0144
Created by: RM
Checked by: BPHB
Approved by: LK

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2 Methodology

2.1 Establishment of the Baseline

2.1.1.1 The methodology for the establishment of the baseline has been completed by:

- Identifying relevant stakeholders: Osprey has identified a list of potential aviation stakeholders in accordance with CAP 764 (CAA 2016) and has considered the en-route and other aviation radar systems within operational range of the study area. The identification stage has also considered military areas of operation, tactical training and Practice and Exercise Areas (PEXA), and Meteorological Radar systems and airborne SAR operations; and
- Identifying potential impacts on each stakeholder: For each identified stakeholder the impact (including impact to aviation radar systems) has been considered. The operational impact on aviation activities, including the effects of WTG detectability on radar systems has been described.

2.2 Assessment Methodology

2.2.1.1 The operational baseline assessment has included, but not been limited to, consideration of:

- The orientation of approach and departure flight paths; physical safeguarding of flight;
- Types of aircraft flying near to the aviation and radar study area; and
- The characteristics and flight procedures as published in the United Kingdom Integrated Aeronautical Information Package (UKIAIP) (NATS 2021) (for civilian aviation activities) and the Military Aeronautical Information Publication (MOD 2021) (Mil AIP).

2.3 Radar Line of Sight (LOS) analysis

2.3.1 Notes on Radar Operation

2.3.1.1 Radar operates by alternately transmitting a stream of high-power radio frequency pulses and 'listening' to echoes received back from targets within its Line of Sight (LOS). Generally, air surveillance radar employ a rotating antenna that provides 360° coverage in azimuth; the typical scan rate is 15 revolutions per minute (rpm) thus illuminating a given target every four seconds.

2.3.1.2 Primary Surveillance Radar (PSR) 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. A PSR such as the type in use at aerodromes across the UK have no height finding capability and as such the Air Traffic Control (ATC) Officer 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 for useful information such as altitude and heading, which is then passed to the ATC display console. All military aircraft carry transponders which respond to SSR interrogation.

2.3.1.3 A PSR can distinguish between moving and static targets; for targets that are moving towards or away from the radar, the frequency of the reflected signal from a moving target changes between each pulse (transmit and receive) which is known as the Doppler shift. This can be most practically explained by considering the change in frequency of the engine sound heard by a pedestrian when a car passes by on the road – the sound as the car approaches is higher than the sound heard by the pedestrian as it travels away. The Doppler shift has the effect of making the sound waves appear to bunch up in front of the vehicle (giving a higher frequency) and spread out behind it (lower frequency). The true frequency of the engine is only heard when the car is immediately next to the pedestrian. The radar receiver is 'listening' to the radio waves reflected from the moving object and working out whether the returned signal is of a higher/lower frequency (moving object) or if the returned frequency is the same as the transmitted signal (a stationary object).

2.3.1.4 Dependent on radar detectability, WTGs are potentially a cause of PSR false plots, or clutter, as the rotating blades can trigger the Doppler threshold (minimum shift in signal frequency) of the Radar Data Processor (RDP) and therefore may be interpreted as legitimate target echo (aircraft) movement. Significant effects have been observed on radar sensitivity caused by the substantial Radar Cross Section (RCS) of the WTG 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 WTG. Radar anomalous propagation (Anaprop) can occur during calm, stable atmospheric conditions associated with radar beam refraction in which false radar returns (not moving but varying greatly in intensity with time) are created as the radar beam is distorted and unexpectedly directed to the surface. False plots and reduced radar sensitivity may impair the effectiveness of radar to an unacceptable level and compromise the provision of a safe radar service to participating aircraft.

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

2.3.2 Method

2.3.2.1 Osprey used the Advanced Topographic Development & Images (ATDI) ICS LT (Version 4.3.3) tool to model the terrain elevation profile between the identified radar systems and the Hornsea Four array area. This is otherwise known as a point-to-point LOS analysis. WTG analysis points of reference, in the form of a grid pattern at a blade tip height of 370 m above mean sea level (amsl) across the offshore array area, were utilised to complete the analysis. It is important to note that 370 m amsl represents a higher elevation than the Maximum Design Scenario (MDS) for Hornsea Four blade tip height which is 370 m Lowest Astronomical Tide (LAT). As such, the LOS analysis is considered suitably precautionary. The result is a graphical representation of the intervening terrain and the direct signal LOS (considering earth curvature and radar signal properties).

2.3.2.2 The analysis undertaken gives an indication of the likelihood of WTGs being theoretically detected such that the operational significance of the WTG relative to nearby radar assets can be assessed.

2.3.2.3 It is important to note that the analysis of radar detectability of WTGs 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 each influence the probability of a WTG being detected. However, radar LOS analysis provides an indication of the potential of radar detectability to assess potential impacts on aviation surveillance equipment. The radar LOS analysis was undertaken on a slightly larger array area than the array area within the Hornsea Four Order Limits at DCO application; the reduction in size of the northern part of the array area does not influence the results of the radar LOS analysis.

2.3.2.4 The qualitative definitions used in the LOS assessment are defined in **Table 1**.

Table 1: Radar LOS Qualitative Definitions.

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

3 Aviation Baseline Environment

3.1.1.1 The Hornsea Four array area is situated in an area of Class G uncontrolled airspace, which is established from the surface up to Flight Level[2] (FL) 195 (approximately 19,500 feet (ft)). Several established airways are located above FL 195 in Class C Controlled Airspace (CAS) which are illustrated within **Figure 2**.

3.1.1.2 Under these classifications of airspace, the following applies:

- Class G uncontrolled airspace: any aircraft can operate in this area of uncontrolled airspace without any mandatory requirement to be in communication with an ATC unit. Pilots of aircraft operating under Visual Flight Rules (VFR) in Class G airspace are ultimately responsible for seeing and avoiding other aircraft and obstructions; and
- Class C CAS: all aircraft operating in this airspace must be in receipt of an ATS.

3.1.1.3 Overhead and surrounding the array area, uncontrolled airspace below FL 195 is sub-divided into areas with the following aviation stakeholder responsibility:

- NATS: provide an ATS at some airports in the UK and additionally provide an ATS to traffic en-route (overflying or flying between airports) in UK airspace. NATS operate a

[2] Flight Level – used to ensure safe vertical separation between aircraft which are operating above the transition altitude. Above the transition attitude the aircraft altimeter pressure setting is normally set to a standard pressure setting and altitudes expressed as a Flight Level.

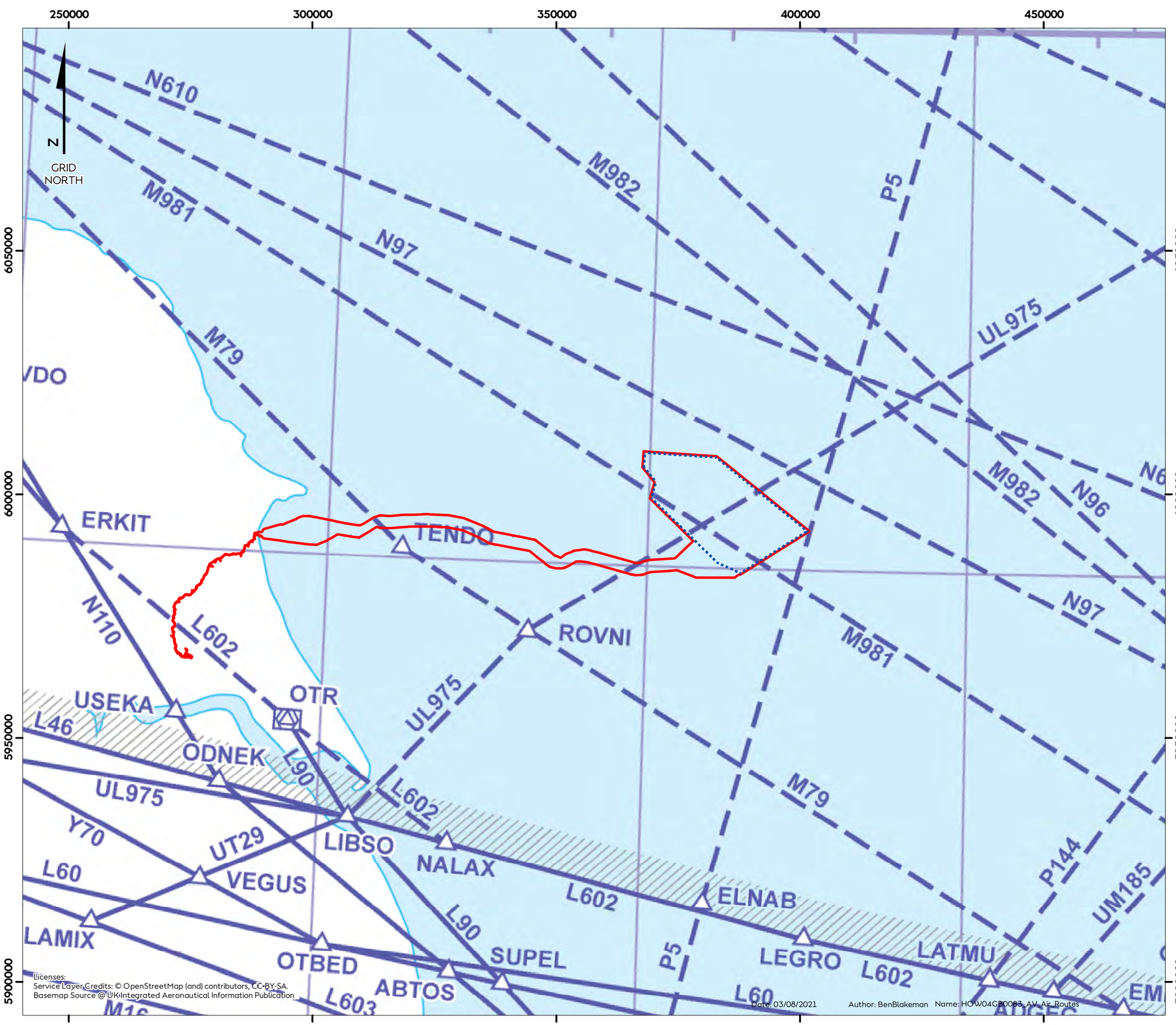
number of long-range PSRs and SSRs positioned to provide maximum coverage of UK airspace;

- Anglia Radar: based at Aberdeen Airport and employing NATS PSRs and SSRs, has its area of responsibility established for the provision of ATS to commercial helicopter operations that support the offshore oil and gas industry (discussed within Appendix A of **Annex 5.11: Offshore Installation Interfaces**), from the surface up to FL 65 (approximately 6,500 ft);
- Military En-route Area Control: Military air traffic controllers sitting alongside their civilian counterparts at Area Control Centres (ACC) utilise NATS radar for the provision of ATS to aircraft flying outside of CAS above FL 100 within radar/radio coverage. NATS have a contracted responsibility to provide appropriate PSR coverage to support this task; and
- MOD Air Surveillance and Control System (ASACS): uses MOD ADR resources in support of operational flights within UK airspace and for training exercises.

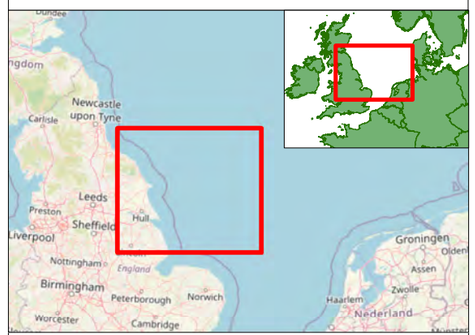
Hornsea Four

Figure 2

Air Routes



Order Limits
Array Area
Upper ATS Routes
Weekend or Conditional Routes
North Sea Reduced Co-ordination Area (NS RCA)
Reporting Point



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

REV	REMARK	DATE
...	First Issue	12/06/2019
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Air
Routes
Document no: HOW04GB0083
Created by: RM
Checked by: BPHB
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Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0083_AV_Air_Routes

3.1.2 NATS

3.1.2.1 The CAA, through CAP 764 (CAA 2016), advises that a range of 10 km between a wind farm and a SSR system should be used as the trigger point for further discussions with the appropriate service provider who can make a more detailed, accurate assessment of the likely effect of the wind farm project on their SSR. It is important to note that the Hornsea Four array area is in excess of 110 km from any SSR facility at its nearest point, therefore no impact is expected on SSR systems.

3.1.2.2 NATS En Route Ltd (NERL) use PSRs based in North Lincolnshire (Claxby) and Norfolk (Cromer) to support their provision of ATS to aircraft operating between the UK and mainland Europe, and to those overflying the UK Flight Information Region (FIR) near the study area.

3.1.2.3 NATS have completed a Technical and Operation Assessment (TOPA) which includes analysis of potential impact created by Hornsea Four to the Cromer and Claxby PSRs (NATS 2018). The TOPA provided results of a NATS radar LOS analysis at 370 m blade tip WTGs from the two PSR to the array area. The results of the TOPA indicates that there will be no predicted detection of 370 m blade tip WTGs contained within the array area from the Cromer PSR and therefore this PSR is not considered further within this Technical Report.

3.1.2.4 The Claxby PSR has been included within the assessment to establish if the potential for radar detectability of the Hornsea Four WTGs is theoretically possible.

3.1.2.5 Although the maximum number of WTGs will be 180 (MDS); the layout of WTGs for Hornsea Four has not yet been finalised. Therefore, to facilitate the radar LOS analysis between radar systems, an evenly spread, indicative grid placement of the 370 m blade tip WTGs within the Hornsea Four array area has been assumed for LOS analysis. **Figure 3** provides the theoretical results of the radar LOS analysis from the Claxby PSR across the indicative grid pattern of WTGs placed within the Hornsea Four array area.

Hornsea Four

Figure 3

LOS results Claxby PSR at a blade tip height of 370 m amsl.

360000 380000 400000

6000000

5980000

N

GRID NORTH

B2 T1 T2 T3 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 B6

Array Area

Definitions of LOS Results

Yes

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:150,000

0 4 8 Kilometres

0 2 4 Nautical Miles

REV	REMARK	DATE
....	First Issue	13/08/2021

LOS Results
Claxby
Document no: HOW04GB0253
Created by: BPHB
Checked by: RM
Approved by: LK

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Date: 13/08/2021 Author: BenBlakeman Name: HOW04GB0253_AV_Claxby_LOS

3.1.2.6 The results of the LOS analysis indicate that WTGs of 370 m within the Hornsea Four array area are, theoretically, highly likely (definition as stated in **Table 1**) to be detectable by the Claxby PSR system with the potential to create unacceptable radar clutter on NATS (and other users of the Claxby radar data) radar screen displays. The NATS TOPA agrees with the conclusions of the analysis (NATS 2018).

3.1.2.7 NERL published a note (NATS, 2020) in which it states that periodic observations of unexpected radar clutter has been recorded on radar data provided by the Cromer and Claxby PSRs at the location of the Hornsea Project One Offshore Wind Farm (Hornsea Project One). NERL concludes that more work is required to fully understand the implications of the unexpected detection of the Hornsea Project One by NATS PSRs.

3.1.3 MOD Radar systems

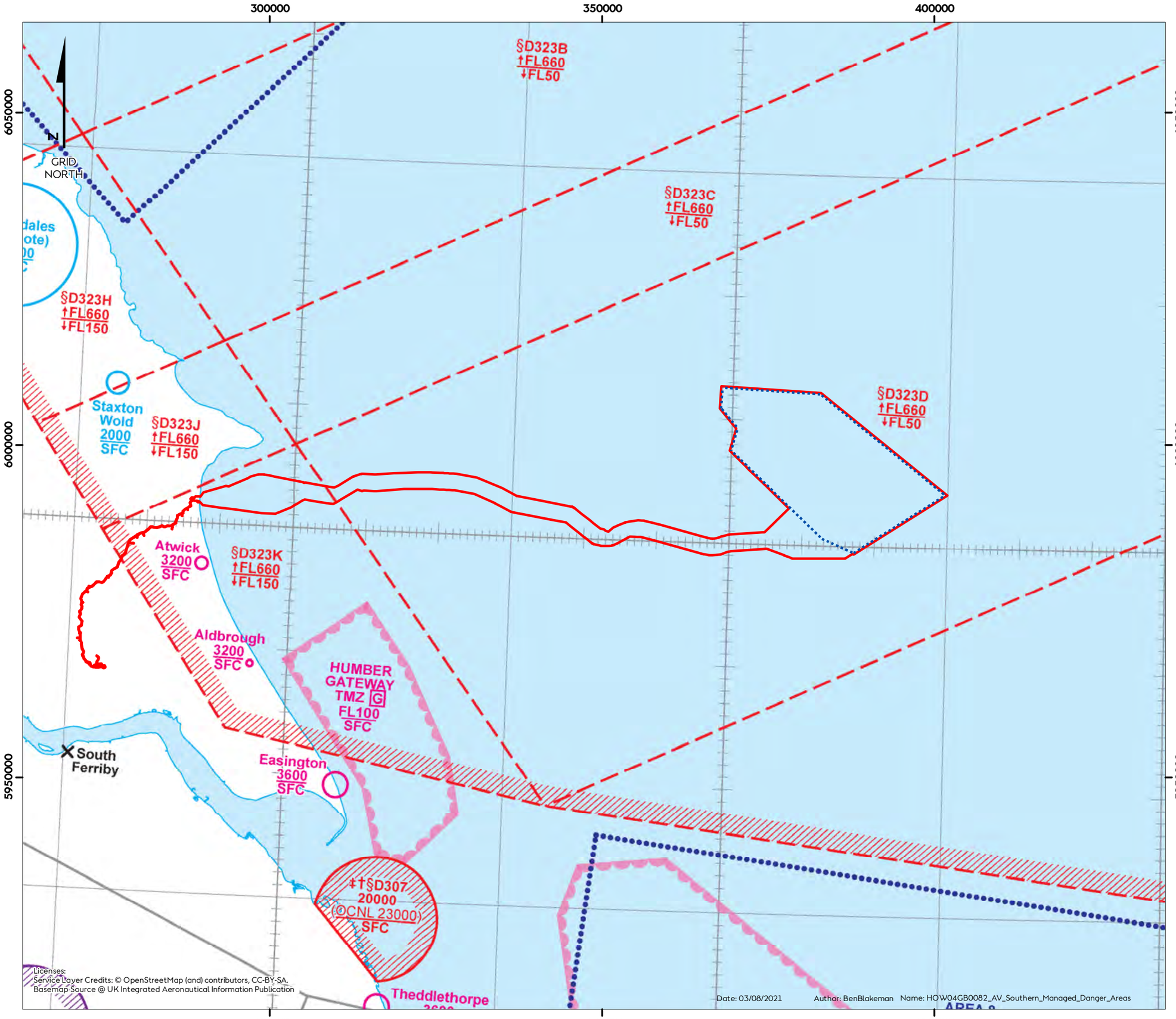
3.1.3.1 The MOD, through the ASACS Force, is responsible for compiling a Recognised Air Picture (RAP) to monitor the airspace in and around the UK in order to launch a response to any potential airborne threat. This is achieved through the utilisation of a network of long-range ADR, some of which are located along the east coast of the UK. Any effect of WTGs on the ASACS radars that serve the airspace above the Hornsea Four array area has the potential to reduce the capability of the ASACS Force.

3.1.3.2 ASACS radar resources are also used in support of MOD training and exercises on an almost daily basis. A network of Managed Danger Areas (MDAs) are established over the North Sea; within the lateral and vertical confines of the MDAs, air combat training, high energy manoeuvres and supersonic flight can be expected. **Figure 4** provides an illustration of the array area within the lateral boundary of D323D.

Hornsea Four

Figure 4

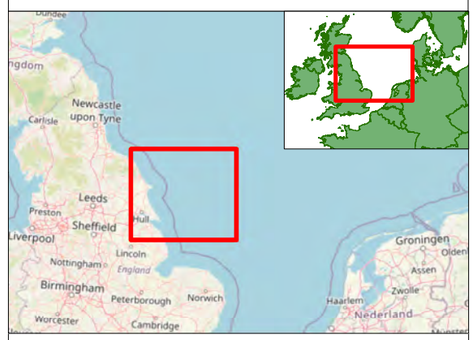
Southern Managed Danger Areas



- Order Limits
- Array Area
- Air to Air Refuelling Area
- High Intensity Radio Transmission Area
- Gas Venting Site
- Transponder Mandatory Zone (TMZ)
- Extent of Southern Managed Danger Zone

AIRSPACE RESTRICTIONS

Prohibited 'P', Restricted 'R' and Danger Areas 'D' are shown with identification number/ effective altitude (in thousands of feet AMSL) or a Flight Level.
Areas activated by Notam are shown with a broken boundary line .....



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:550,000

0 10 20 Kilometres

0 5 10 Nautical Miles

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Southern Managed Danger Areas
Document no: HOW04GB0082
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Checked by: BPHB
Approved by: LK

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3.1.3.3 It is important to note that when the MDAs are not required for specific military training or exercise use, the airspace is then available for use for civil and military en-route operations.

3.1.3.4 The Southern MDA is located above the North Sea; EG D323D (an element of the Southern MDA) is located directly above the Hornsea Four array area, and when active, operates from FL 50 up to FL 660.

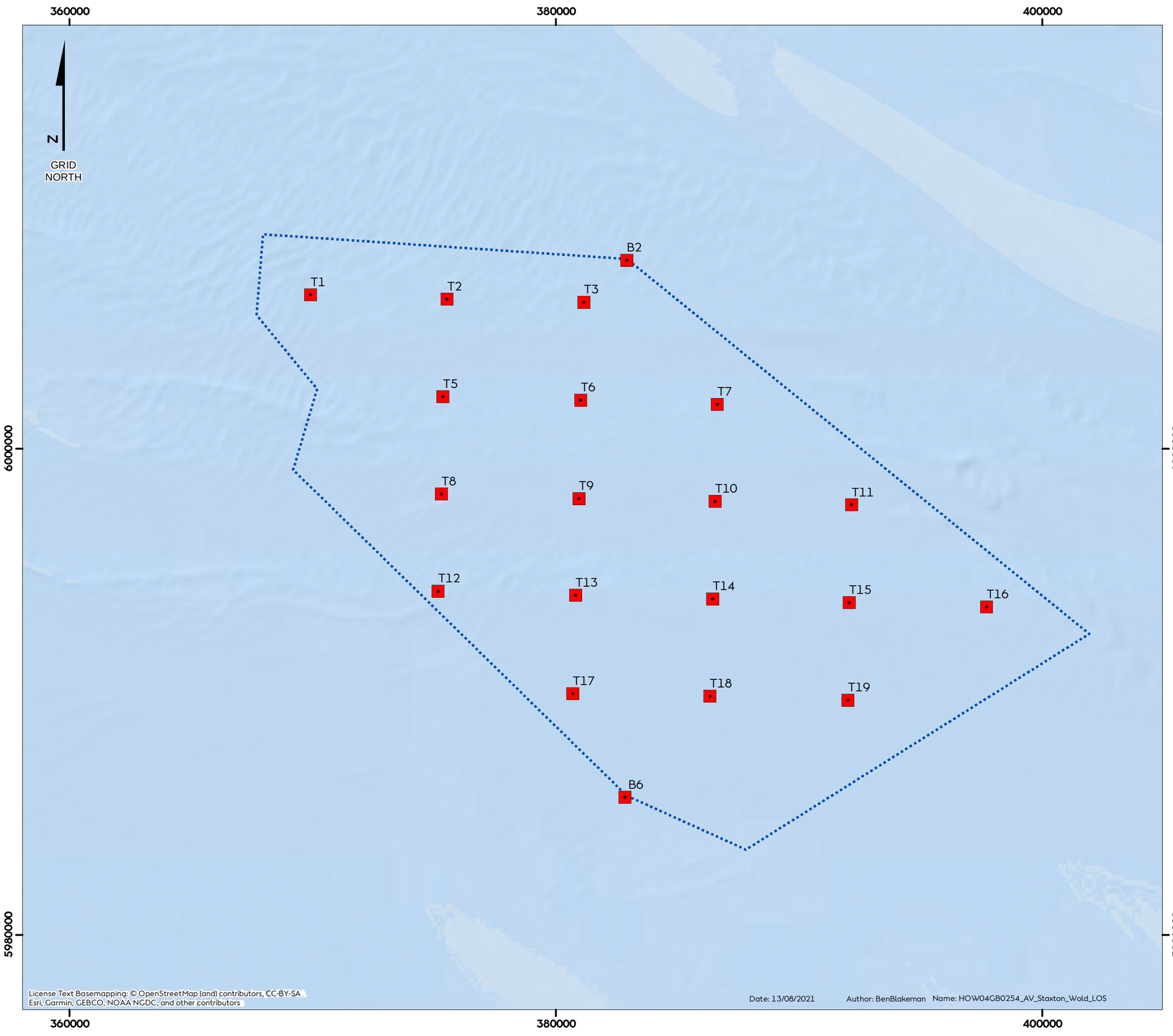
3.1.3.5 The MOD currently has the capability of utilising two ADR systems in the region of the Hornsea Four array area; the Trimingham ADR, situated in North Norfolk, and the Brizlee Wood ADR located in Northumberland, both of which have an operational range of approximately 450 km. The MOD have stated during their Section 42 response that the Brizlee Wood ADR would not detect the Hornsea Four WTGs. Furthermore, the MOD have confirmed by email (MOD 2021)that none of the Hornsea Four turbines will be radar LoS to the ADR at Trimingham and that, as such, the MOD don't have any concerns in respect of Hornsea Four impacting the Trimingham ADR. In view of this, Brizlee Wood and Trimingham ADR are not considered further.

3.1.3.6 Previously an TPS-77 ADR system, manufactured by Lockheed Martin, was located at Staxton Wold, located south of Scarborough, North Yorkshire. The MOD have recently acquired a Lanza Long Range Tactical ADR (LR-25), manufactured by Indra. The LR-25 is undergoing a series of Site Acceptance Tests (SAT's) at Staxton Wold during 2021 and, following acceptance into service, will be utilised as a deployable resource in support of worldwide operations. However, the 'home' base of the LR-25 is expected to be Staxton Wold.

3.1.3.7 The MOD Scoping response (MOD 2018) indicated that an assessment of effects needs to consider the site at Staxton Wold. Furthermore, the MOD's Section 42 response (MOD 2019) confirmed that the Hornsea Four WTGs will be detectable to an ADR located at Staxton Wold, and that impacts on a Staxton Wold ADR will require appropriate technical mitigation.

3.1.3.8 A radar LOS analysis has been completed for the Staxton Wold ADR based on the TPS-77 legacy radar parameters against the MDS of WTGs located in the Hornsea Four array area. Further details of the MDS for aviation impacts are presented in **Volume A2, Chapter 8: Aviation and Radar**.

3.1.3.9 As SAT for the Indra LR-25 remains incomplete at the time of this EIA the radar LOS assessment has been completed based on known TPS-77 radar parameters and therefore the results are indicative. The results are provided in **Figure 5** below. This indicates that if a TPS-77 radar is installed at Staxton Wold, the Hornsea Four array area would theoretically be detectable by the radar system and would therefore have the potential to create radar clutter on MOD monitoring systems. It is assumed that the LR-25 radar would be installed in the same position with similar antenna height as the TPS-77. Its coastal location, the lack of terrain shielding, and the height of the WTGs leads to the assumption that it will similarly detect the Hornsea Four WTGs. The MOD in their Section 42 response (MOD 2019) stated that a Staxton Wold ADR is a relevant consideration and will need to be taken account of and any impacts mitigated. Further consideration of a Staxton Wold ADR will be undertaken by Hornsea Four once final radar parameters have been provided by the MOD in relation to the radar system that will operate at the site.



Hornsea Four

Figure 5

LOS results Staxton Wold (TPS-77) at a blade tip height of 370 m amsl.

Array Area

Definitions of LOS Results

Yes

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:150,000

0 4 8 Kilometres

0 2 4 Nautical Miles

REV	REMARK	DATE
....	First Issue	13/08/2021

LOS Results
Staxton Wold
Document no: HOW04GB0254
Created by: BPHB
Checked by: RM
Approved by: LK

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3.1.4 Conclusions of the Radar LOS Analysis

The NATS Claxby PSR will theoretically detect WTGs of a blade tip of 370 m throughout the whole of the array area. The radar LOS analysis utilising legacy radar parameters indicates that a TPS-77 ADR placed at the Staxton Wold site would theoretically detect WTGs with a blade tip of height of 370 m across the whole of the offshore array area.

3.1.4.1 In June 2019, the MOD provided an update on MOD Air Defence Radar Mitigation (MOD 2019a) which stated that "*the MOD has continued to work with wind farm developers where it has been able to mitigate the risk of wind farms impacting on the MOD's ability to meet operational requirements*". The MOD has also conducted two trials regarding the impact of specific wind farms on specific ADR systems which has provided further evidence on which the MOD will base their understanding of the current issues. The MOD are working with industry, principally through the MOD-Offshore Wind Industry Council (OWIC) Joint Task Force, to resolve the current issues and to mitigate all risks to military air surveillance capabilities.

3.1.5 Offshore Helicopter Operations

Helicopter Main Routes (HMRs)

3.1.5.1 A network of HMRs are established adjacent to and within the Hornsea Four array area to support the transport of personnel and material to offshore oil and gas installations. **Figure 6** provides the location of the adjacent HMRs to Hornsea Four.

3.1.5.2 HMR 8 routes from the Lincolnshire coast to the Munro Platform and bisects the array area. Furthermore, HMR 8, 9 and 10 cross the route of the offshore ECC.

3.1.5.3 When operating under Instrument Flight Rules (IFR), helicopters require a Minimum Safe Altitude (MSA) of 300 m (984 ft) height clearance from obstacles within 1 NM of the aircraft, which would indicate that whilst operating above the physical obstruction of the WTGs, offshore helicopters would be required to fly not below 2,300 ft amsl (1,213 ft (370 m) plus 1000 ft rounded up to nearest 100 ft). When operating under VFR and Visual Meteorological Conditions (VMC), helicopters will highly likely route direct to their destination point and require a minimum of 500 ft separation from obstacles. ATC may also provide direct routing to IFR flights.

3.1.5.4 CAA CAP 764 (CAA, 2016) indicates that many WTGs beneath an HMR could result in helicopters flying higher in order to maintain a safe vertical separation from those WTGs beneath the route. However, this option may not be available on days of low cloud base when the 0° isotherm is at or below 2,000 ft. The proliferation of WTG close to an HMR could restrict a pilot's freedom to manoeuvre when flying conditions are not ideal however current helicopters operating over the North Sea have the option of a limited icing approval which could improve the current operating envelope.

3.1.5.5 An HMR is not a mandatory routing for helicopter operators offshore but are promulgated for the purpose of signposting concentrations of helicopter traffic; however, they do not predicate the flow of helicopter traffic. Where ATC coverage is less comprehensive (as in the Northern North Sea, northeast of Aberdeen), flights are more likely to be conducted along HMRs. The region covered by the array area is, however, served by radar coverage and provision of ATC services by Anglia Radar to aircraft operating offshore; where this is the case helicopter flights are likely to be provided a direct routing to their offshore destination whilst operating VFR or IFR over the WTGs at the specified MSA.

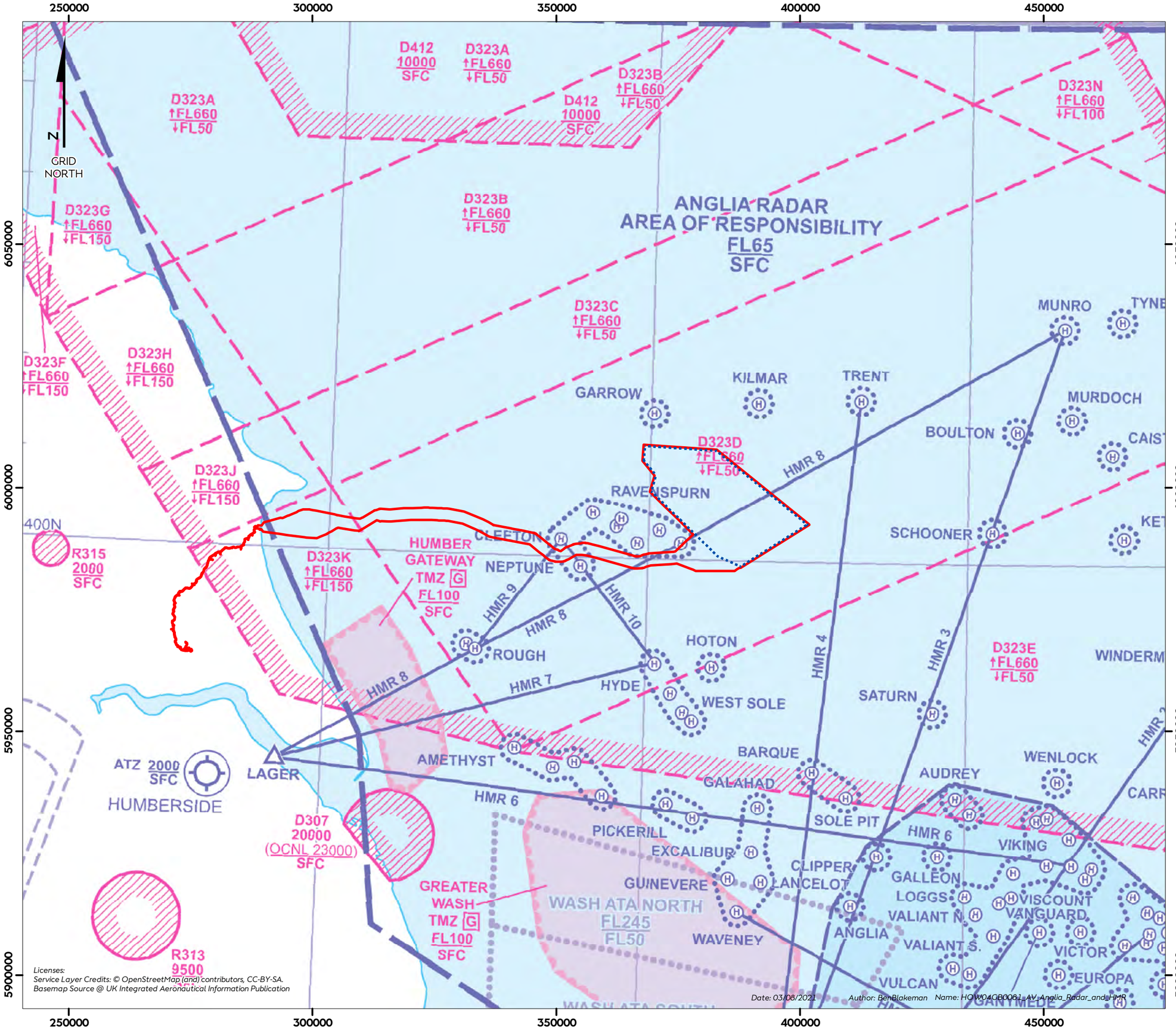
Helicopter Operations at Offshore Platforms

3.1.5.6 CAP 764 (CAA 2016) provides for a 9 NM radius 'consultation zone' around offshore installations; this consultation zone is not considered a prohibition on WTG development but a trigger for consultation between the platform operators, the offshore helicopter operators and the wind farm developer to determine a solution for WTG positioning that would maintain safe offshore helicopter operations. Individual 9 NM consultation zones for several installations extend across the Hornsea Four array area. **Figure** 7 provides the location of the array area and oil and gas platforms consultation zones that overlap the array area. Detailed assessment of the potential to impact helicopter operations to helideck operated oil and gas platforms is provided in Appendix A of **Annex 5.11: Offshore Installation Interfaces**.

Hornsea Four

Figure 6

Anglia Radar Area of Responsibility and Helicopter Main Route Structure



Order Limits

Array Area

Heliport

Reporting Point

Aerodrome (Civil)

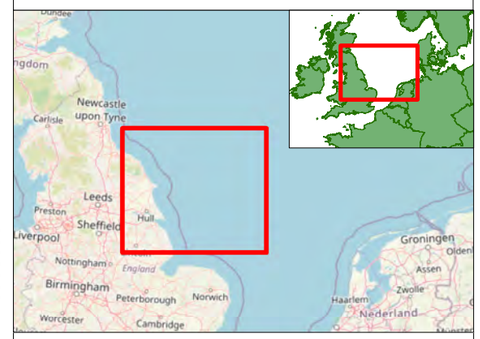
Helicopter Main Route Indicators (HMRIs)

Helicopter Transit Zones (HTZ)

Transponder Mandatory Zone (TMZ)

AIRSPACE RESTRICTIONS

Prohibited 'P', Restricted 'R' and Danger Areas 'D' are shown with identification number/ effective altitude (in thousands of feet AMSL) or a Flight Level. Areas activated by Notam are shown with a broken boundary line .....



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

REV	REMARK	DATE
....	First Issue	12/06/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Anglia Radar Area of Responsibility and Helicopter Main Route Structure
Document no: HOW04GB0081
Created by: RM
Checked by: BPHB
Approved by: LK

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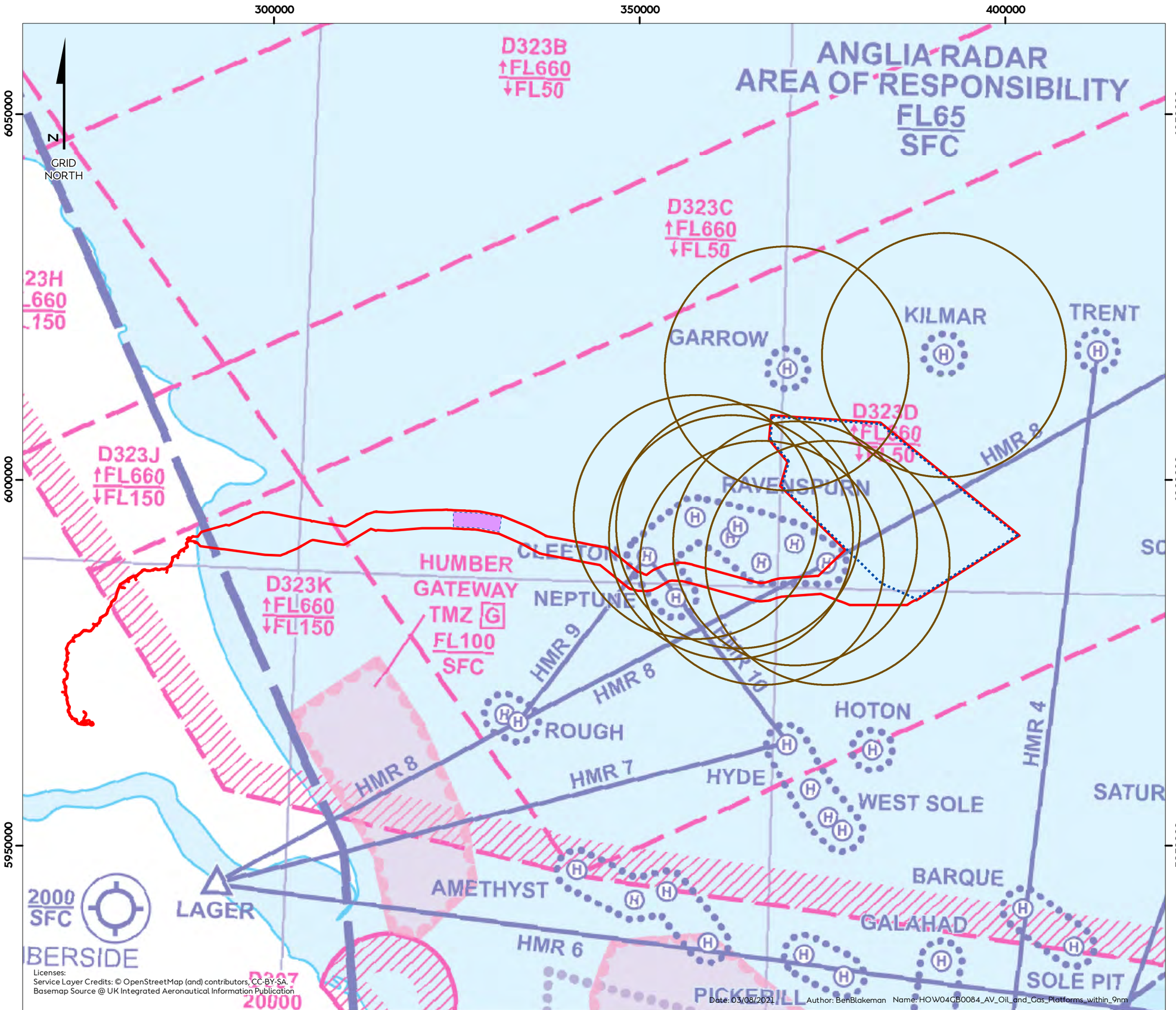
Date: 03/08/2021 *Author: BenBlakeman* *Name: HOW04GB0081_AV_Anglia_Radar_and_HMR*

Hornsea Four

Figure 7

Helideck equipped Oil and Gas Platforms 9 Nautical Miles Consultation Zones



- Order Limits
- Array Area
- HVAC Booster Station Works Area
- 9 Nautical Mile Radius around Platforms with Helidecks
- Platform with Helideck
- Reporting Point
- Aerodrome (Civil)
- Helicopter Main Route Indicators (HMRIs)
- Helicopter Transit Zones (HTZ)
- Transponder Mandatory Zone (TMZ)

AIRSPACE RESTRICTIONS

Prohibited 'P', Restricted 'R' and Danger Areas 'D' are shown with identification number/ effective altitude (in thousands of feet AMSL) or a Flight Level. Areas activated by Notam are shown with a broken boundary line .....

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
....	First Issue	12/06/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Oil and Gas Platforms within 9 Nautical Miles of the Hornsea Four Array
Document no: HOW04GB0084
Created by: RM
Checked by: BPHB
Approved by: LK

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4 Other Aviation Considerations

4.1.1 Military ATC Radar

4.1.1.1 Military Air Traffic Management (ATM) is supported by Military ATC radars. These are typically standard airfield ATC radars with an instrumented range of 60 NM.

4.1.1.2 Analysis of the array area boundary and preliminary parameters (assuming 370 m WTG height) predicts that WTGs would not be detectable by any aerodrome based Military ATC PSRs.

4.1.2 Military Low Flying Operations

4.1.2.1 The military UK Low Flying System (UKLFS) covers the open airspace of the whole UK land mass (excluding certain areas of dense urban conurbation) and surrounding sea areas out to 2 NM from the UK coast, from the surface to 2,000 ft above ground level (agl) or amsl; however, military low flying may be conducted beyond this area over the sea.

4.1.2.2 Notification through publication of the wind farm location in appropriate documentation together with the fitting of aviation lighting to WTGs will mitigate the impact to military low flying activities.

4.1.2.3 The requirements for the lighting of WTGs are contained in Article 223 of CAP 393 The Air Navigation Order (2021) and Regulations (CAA 2019).

4.1.2.4 For other offshore developments, the MOD have requested that offshore platforms are fitted with specific aviation lighting to maintain safety to military aviation activities, (MOD Scoping response (MOD 2018)). Hornsea Four has made several Commitments of relevance to the assessment of impacts to aviation and radar receptors. Commitment Co93 states that *"Aids to navigation (marking and lighting) will be deployed in accordance with the latest relevant available standard industry guidance and as advised by Trinity House, Maritime and Coastguard Agency (MCA), Civil Aviation Authority (CAA) and MOD as appropriate."*. Additionally, Commitment Co200 states that *"Lighting at the HVAC Booster Station(s) will accord with the design set out in the HVAC Booster Station Lighting Plan to ensure that the night-time effects of the HVAC Booster Station lighting on the special characteristics of the Flamborough Head Heritage Coast will be not significant"*. Full details of commitments are included within the **Volume A4, Annex 5.2: Commitments Register**.

4.1.3 Military Practice and Exercise Areas (PEXA)

4.1.3.1 Military PEXAs are areas available for training use primarily by the UK armed forces but also those of overseas nations. They can be over land or water, or both, and may involve the firing of live ammunition.

4.1.3.2 The Hornsea Four array area is located below a PEXA known as the southern MDA which is established from FL 50 to FL 660. **Figure 4** provides an illustration of the array area within the lateral boundary of MDA D323D. Due to the base height of the MDA airspace, no physical obstruction is expected to be created to operations conducted in this MDA or other PEXAs.

4.1.4 Meteorological Radar

4.1.4.1 The Meteorological Office (Met Office) radar infrastructure is safeguarded by the MOD. Its weather radar network currently consists of 16 sites. The Met Office employs WTG safeguarding guidelines that may result in an objection for any development within 20 km of any affected weather radar.

4.1.4.2 Analysis of the array area and WTG parameters concludes that there are no weather radar stations within 20 km of the array area and therefore no impact on the Met Office radar capability is predicted.

4.1.5 Airborne Search and Rescue Operations

4.1.5.1 When on an operational mission, SAR aircraft are operated as state aircraft, are not constrained by the normal rules of the air and operate in accordance with their Aircraft Operator Certificate (AOC). This allows SAR pilots total flexibility to manoeuvre using best judgement, thus making them highly adaptable to the environment in which they are operating. SAR response operations and layout design principles are provided in **Annex 7.1: Navigational Risk Assessment** and **Volume A4, Annex 4.7: Layout Principles** which are a commitment included as part of Hornsea Four (Co96 within **Volume A4, Annex 5.2: Commitments Register**).

5 Conclusions

5.1.1.1 NATS utilise the Claxby PSR to support their provision of ATS to aircraft operating between the UK and mainland Europe, and to those overflying the UK across the region of the study area. Additionally, Anglia Radar, based at Aberdeen Airport also employs NATS Claxby radar to support its ATS provision to aircraft of the Oil and Gas Industries within the lateral confines of its area of responsibility over the southern North Sea. A NATS TOPA was completed by NATS which predicted an unacceptable impact to the Claxby PSR caused by the radar detectability of the WTGs.

5.1.1.2 The MOD through the ASACS Force is responsible for compiling a RAP to monitor the airspace in and around the UK in order to launch a response to a potential airborne threat. This is achieved through the utilisation of a network of long-range ADR. Any identified effect of WTGs on ASACS radars that serve the airspace above the study area will have the potential to reduce the capability of the ASACS force. Impact is predicted to the Staxton Wold ADR. At the time of writing an Indra LR-25 ADR is undergoing SAT at the Staxton Wold site. Staxton Wold will be the 'home base' for the LR-25, however, the radar will be deployable worldwide at short notice. A radar assessment has been completed based on legacy TPS-77 radar parameters provided by the MOD, and therefore the results are indicative. An impact is predicted for an ADR installed at the Staxton Wold site due to radar detectability.

5.1.1.3 A network of HMRs is established to support the transport of personnel and materiel to offshore oil and gas installations; HMR 8 crosses the offshore array. HMR 8, 9 and 10 crosses the route of the offshore ECC.

5.1.1.4 Analysis of the study area and preliminary WTG parameters predicts that the Hornsea Four WTGs would not be detectable by any aerodrome based Military ATC PSRs. Once notification procedures and lighting fitment is completed no impact is predicted to military low flying operation or activity in PEXAs.

5.1.1.5 Analysis of the study area and preliminary WTG parameters concludes that there are no weather radar stations within 20 km of Hornsea Four array area and therefore no impact on the Met Office radar capability is predicted.

5.1.1.6 Live (operational) SAR operations are not constrained by certain aspects of the rules of the air and operate with reduced constraint in accordance with the SAR AOC. This allows SAR pilots flexibility to manoeuvre using best judgement thus making them highly adaptable to the environment in which they are operating.

6 References

Civil Aviation Authority (2016) CAP 764 Policy and Guidelines on Wind Turbines.

Civil Aviation Authority (2021) CAP 393 The Air Navigation Order (2016) and Regulations.

Ministry of Defence (2018) Scoping Response.

Ministry of Defence (2019) Section 42 Response.

Ministry of Defence (2021) Aeronautical Information Publication.

Ministry of Defence (2021a) Email MOD to Ørsted 22 January 2021.

Ministry of Defence (2019a) Air Defence Radar Mitigation Update June 2019.

NATS (2018) Hornsea Project Four Offshore Windfarm Development Technical and Operational Assessment.

NATS (2021) United Kingdom Integrated Aeronautical Information Package.

NATS (2020) Turbines and Anomalous Propagation in the Southern North Sea.