Norfolk Vanguard Offshore Wind Farm

Chapter 16

Aviation and Radar

Environmental Statement

Volume 1

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Environmental Impact Assessment
Environmental Statement

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For and on behalf of Norfolk Vanguard Limited

Approved by: Ruari Lean and Rebecca Sherwood

Signed:

[redacted]

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Glossary

AARA	Air to Air Refuelling Area
AC	Alternating Current
ACC	Area Control Centre
ACP	Airspace Change Proposal
ADR	Air Defence Radar
agl	above ground level
AIP	Aeronautical Information Package
amsl	above mean sea level
ANSP	Air Navigation Service Provider
AOC	Aircraft Operator Certificate
ARA	Airborne Radar Approach
ASACS	Air Surveillance and Control System
ATC	Air Traffic Control
ATS	Air Traffic Services
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAS	Controlled Airspace
CAT	Commercial Air Traffic
CGOC	Coast Guard Operations Centre
CNS	Communication Navigation Surveillance
CTV	Crew Transfer Vessel
DC	Direct Current
DCO	Development Consent Order
DECC	Department for Energy and Climate Change
DGC	Defence Geographic Centre
DIO	Defence Infrastructure Organisation
ERCoP	Emergency Response Cooperation Plan
ES	Environmental Statement
FIR	Flight Information Region
FL	Flight Level
ft	Feet
GAAC	General Aviation Awareness Council
GPS	Global Positioning System
GW	Gigawatt
HAT	Highest Astronomical Tide
HMR	Helicopter Main Route
IAIP	Integrated Aeronautical Information Package
IFR	Instrument Flight Rules
Kt	Knot
ILT	Inspectie Leefomgeving en Transport
IMC	Instrument Meteorological Conditions
km	Kilometre
LARS	Lower Airspace Radar Service
LAT	Lowest Astronomical Tide
LOS	Line of Sight

LVNL	Luchtverkeersleiding Nederland
m	Metre
MAA	Military Aviation Authority
MAP	Missed Approach Procedure
MCA	Maritime and Coastguard Agency
MGN	Maritime Guidance Notes
Mil AIP	Military Aeronautical Information Publication
MoD	Ministry of Defence
m/s	Metres per Second
MRCC	Maritime Rescue Coordination Centre
MSA	Minimum Safe Altitude
MW	Megawatt
NATMAC	National Air Traffic Management Advisory Committee
NERL	NATS En Route Ltd
NM	Nautical Mile
NOTAM	Notice to Airmen
NPS	National Policy Statement
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
OREI	Offshore Renewable Energy Installation
OWF	Offshore Wind Farm
PAR	Precision Approach Radar
PD	Probability of Detection
PEXA	Practice and Exercise Area
PINS	Planning Inspectorate
PSR	Primary Surveillance Radar
RAF	Royal Air Force
RAP	Recognised Air Picture
RCS	Radar Cross Section
RDDS	Radar Data Display Screen
RDP	Radar Data Processor
REZ	Renewables Energy Zone
rpm	Rotations per Minute
SAR	Search and Rescue
SMS	Safety Management System
SOV	Service Offshore Vessel
SSR	Secondary Surveillance Radar
TCE	The Crown Estate
TMZ	Transponder Mandatory Zone
TOPA	Technical and Operational Assessment
UK	United Kingdom
UKHO	UK Hydrographic Office
UKLFS	UK Low Flying System
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

Terminology

0° isotherm	The altitude in which the temperature is at 0°C (the freezing point of water) in a free atmosphere.
Airborne Radar Approach (ARA)	A procedure used by helicopters for low-visibility approaches to offshore platforms which relies upon an aircraft's on-board weather radar for guidance and as a means of detecting obstacles in the approach path.
Air to Air Refuelling Areas (AARA)	A defined piece of airspace activated for the purpose of transferring aviation fuel from one aircraft to another.
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 a number of different topic-specific impacts resulting from the assessed project on a single receptor/resource in combination with the effects from a number of different projects, on the same single receptor/resource.
Development Consent Order (DCO)	A legal order which provides consent for the project. It combines the grant of planning permission with a range of other consents.
Effect	Term used to express the consequence of an impact (expressed as the 'significance of effect'), which is determined by correlating the magnitude of the impact to the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Flight Level (FL)	A standard nominal altitude of an aircraft, in hundreds of feet, based upon a standardised air pressure at sea-level.
Helicopter Main Route (HMR)	Routes which are established to facilitate safe helicopter flights in Instrument Flight Rules (IFR) conditions (i.e. when flight cannot be completed in visual conditions).
Impact	Change that is caused by an action; for example, land clearing (action) during construction which results in habitat loss (impact).
Instrument Flight Rules (IFR)	The rules governing procedures for flights conducted on aircraft cockpit instruments.
Instrument Meteorological Conditions (IMC)	Weather conditions which would preclude flight by the Visual Flight Rules, i.e. conditions where the aircraft is in or close to cloud or flying in visibility less than a specified minimum.
Minimum Safe Altitude (MSA)	Under aviation flight rules, the altitude below which it is unsafe to fly in IMC owing to presence of terrain or obstacles within a specified area.
Missed Approach Procedure (MAP)	The actions for the crew of an aircraft to take when an instrument approach procedure is not successful e.g. the crew are unable to see the runway, approach lights or helideck.
Mitigation	Actions which may include process or design to avoid/reduce/remedy or compensate for adverse impacts of a development. Avoids or reduces an effect, significant or otherwise.
Offshore accommodation platform	A fixed structure (if required) providing accommodation for offshore personnel. An accommodation vessel may be used instead.
Offshore cable corridor	The corridor of seabed from the Norfolk Vanguard OWF sites to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.

Offshore export cables	The cables which transmit electricity from the offshore substation platform to the landfall.
Offshore project area	The overall area of Norfolk Vanguard East, Norfolk Vanguard West and the offshore cable corridor
Norfolk Vanguard Offshore Wind Farm (OWF) sites	Norfolk Vanguard East and Norfolk Vanguard West Developments within the former East Anglia Zone.
Precision Approach Radar (PAR)	A military instrument approach system which provides both horizontal and vertical guidance for landing from 10 or 20 nautical miles (NM) from the airfield.
PEIR	A document which provides clarity to all consultees to understand the environmental effects of the project so as to inform their responses regarding the project.
Sensitivity	The extent to which a study subject can accept a change of a particular type and scale without unacceptable adverse effects.
Significance	The significance of an effect combines the evaluation of the magnitude of a potential impact and the sensitivity of the feature affected.
The Applicant	Norfolk Vanguard Limited.
The OWF sites	The two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West.
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure.
Transboundary	Crossing into other states/nations.
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.
Zone	The area of the seabed (which may be within the territorial limits of the UK and/or within the Renewables Energy Zone (REZ)) demarcated by The Crown Estate (TCE) for wind farm development in Round 5 and, in the context of this document, the Norfolk Vanguard Zone.

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16 AVIATION AND RADAR

16.1 Introduction

1. This chapter of the Environmental Statement (ES) describes the existing environment with regard to aviation within and around the proposed Norfolk Vanguard Offshore Wind Farm (OWF) (herein the project), through the evaluation of existing data sources and desk studies, and consultation with key stakeholders.

2. The chapter provides a summary description of key aspects relating to aviation, followed by an assessment of the magnitude and significance of the effects upon the baseline conditions resulting from the construction, operation and decommissioning of the project, as well as those effects resulting from cumulative interactions with other existing or planned projects.

3. This chapter has been prepared by Osprey Consulting Services Limited (Osprey).

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

   - Physical Obstruction; wind turbines can present a physical obstruction to aircraft in transit at low altitudes; and
   - Impacts on Radar / Air Traffic Services (ATS); wind turbine derived clutter appearing on radar displays can affect the safe provision of ATS as it can mask unidentified aircraft from the air traffic controller and / or prevent the controller from accurately identifying aircraft under control. In some cases, radar reflections from the wind turbines can affect the performance of the radar system itself.

5. The potential effects on aviation have been assessed conservatively using realistic 'worst case' scenarios for the proposed project. A detailed description of the project is contained in Chapter 5 Project Description; Table 16.6 of this document provides worst case scenarios for assessed impact.

6. As the offshore export cable corridor will be installed below sea level, it will not have an impact on aviation interests and therefore is not assessed in this chapter. No onshore construction infrastructure is expected to breach aviation stakeholder radar or airfield safeguarded surfaces.

16.2 Legislation, Policy and Guidance

7. The assessment of potential impacts on aviation has been undertaken with specific reference to the relevant National Policy Statements (NPS). The following documents

provide relevant guidance and legislation to the proposed project:

- Department of Energy and Climate Change[1] (DECC, 2011a) National Policy Statement for Renewable Energy Infrastructure (EN-3); and
- Overarching National Policy Statement for Energy (DECC, 2011b) (EN-1).

8. The relevant guidance from NPS EN-1 and EN-3 to which Norfolk Vanguard Limited has given due consideration is outlined in Table 16.1 below.

Table 16.1 NPS Assessment requirements

NPS Requirement	NPS Reference	Section Reference
Paragraphs 5.4.10 to 5.4.13 of EN-1 informs that if the proposed development could have an effect on civil and military aviation then the assessment should: • Consult the Ministry of Defence (MoD), the Civil Aviation Authority (CAA) and NATS and any aerodrome – licensed or otherwise – likely to be affected by the proposed development in preparing an assessment of the proposal on aviation or other defence interests; • Any assessment of aviation or other defence interests should include potential impacts of the project upon the operation of Communication, Navigation and Surveillance (CNS) infrastructure, flight patterns (both civil and military), other defence assets and aerodrome operational procedures. • Assess the cumulative effects of the project with other relevant projects in relation to aviation and defence.	NPS EN-1 Paragraph 5.4.10 to 5.4.13	Section 16.2
If there are conflicts between the Government's energy and transport policies and military interests in relation to the application, the decision maker should expect the relevant parties to have made appropriate efforts to work together to identify realistic and pragmatic solutions to the conflicts. In so doing, the parties should seek to protect the aims and interests of the other parties as far as possible.	NPS EN-1 Paragraph 5.4.15	Section 16.2 Paras 8 to 15
There are statutory requirements concerning lighting to tall structures where lighting is requested on structures that go beyond statutory requirements by any of the relevant aviation and defence consultees, the decision maker should satisfy itself of the necessity of such lighting taking into account the case put forward by the consultees. The effect of such lighting on the landscape and ecology may be a relevant consideration.	NPS EN-1 Paragraph 5.4.16	Section 16.7.2
Where after reasonable mitigation, operational changes, obligations and requirements have been proposed, the decision maker considers that: • A development would prevent a licensed aerodrome from maintaining its licence; • The benefits of the proposed development are outweighed by the harm to aerodromes serving business, training or emergency service needs, taking into account the relevant	NPS EN-1 Paragraph 5.4.17	Section 16.2 Paras 10, 11 and 14

[1] DECC was merged with the Department of Business, Innovation and Skills (BIS) during 2016

NPS Requirement	NPS Reference	Section Reference
importance and needs for such aviation infrastructure; • The development would significantly impede or compromise the safe and effective use of defence assets or significantly limit military training; or • The development would have an impact on the safe and efficient provision of en route air traffic control services for civil aviation, in particular through an adverse effect on the infrastructure required to support communications, navigation or surveillance systems consent should not be granted.		
Detailed discussions between the applicant for the offshore wind farm and the relevant consultees should have progressed as far as reasonably possible prior to the submission of an application to the decision maker. As such, appropriate mitigation should be included in any application to the decision maker, and ideally agreed between relevant parties.	NPS EN-3 Paragraph 2.6.187	Section 16.2 and Table 16.2
Aviation and navigation lighting should be minimised to avoid attracting birds, taking into account impacts on safety.	NPS EN-3 Paragraph 2.6.107	Section 16.7.3

9. A variety of aviation publications contain information and guidance relating to the potential effects of an offshore wind development on aviation stakeholders. The following documents informed the desk based study of potential impacts of the proposed project.

- Civil Aviation Policy (CAP) 168: Licensing of Aerodromes sets out the standards required at UK licensed aerodromes relating to its management systems, operational procedures, physical characteristics, assessment and treatment of obstacles, and visual aids. (CAA, 2014b).
- CAP 393: The Air Navigation Order 2016 and Regulations sets out the provisions of the Air Navigation Order as amended together with regulations made under the Order. It is prepared for those concerned with day to day matters relating to air navigation that require an up to date version of the air navigation regulations and is edited by the Legal Advisers Department of the Civil Aviation Authority (CAA). CAP 393 also includes application of lighting to wind turbines in UK territorial waters. (CAA, 2017).
- CAP 437: Standards for Offshore Helicopter Landing Areas – Guidance on Standards provides the criteria applied by the CAA in assessing helicopter landing areas for worldwide use by helicopters registered in the UK. It includes design of winching area arrangements located on wind turbine platforms to represent current best practice. (CAA, 2016b).
- CAP 764: Policy and Guidelines on Wind Turbines provides assistance to aviation stakeholders to help understand and address wind energy related issues, thereby ensuring greater consistency in the consideration of the potential impact of proposed wind farm developments. (CAA, 2016a).

- CAP 670: Air Traffic Services Safety Requirements sets out the safety regulatory framework and requirements associated with the provision of an air traffic service. (CAA, 2014a).

10. Other data sources and guidance considered under the desktop review of the baseline environment definition include the following:

- CAA Visual Flight Rules Chart. (CAA, 2017a);
- Military Aeronautical Information Publication (Mil AIP) (MoD, 2018);
- MoD UK Low Flying System Priority Area Maps[2]. (MoD, 2011);
- CAP 032 UK Integrated Aeronautical Information Package (UK IAIP). The UK IAIP is the main resource for information and flight procedures at all licensed UK airports as well as airspace, en-route procedures, charts and other air navigation information. (NATS, 2018); and
- Maritime and Coastguard Agency (MCA) MGN 543: Safety of Navigation Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response (MCA, 2008) contains information for operators and developers in formulating their emergency response plans and site safety management.

16.3 Consultation

11. Consultation is a key part of the Development Consent Order (DCO) application process. Stakeholders relevant to aviation and radar have been consulted with throughout the development of the project to date. Relevant responses from consultees received to date are summarised in Table 16.2 below. The table includes responses received to the Preliminary Environmental Impact Report (PEIR) under Section 42 of the Planning Act 2008, and Regulation 11 of the Infrastructure Planning (EIA) Regulations 2009.

12. During 2010 Vattenfall Wind Power Ltd (a parent company of Norfolk Vanguard Limited) and Scottish Power Renewables joined in partnership to develop the East Anglia Zone. Consultation with potentially affected stakeholders has been ongoing throughout the development of the former East Anglia zone. During Q2 and Q3 of 2014, Section 42 consultation was undertaken in relation to the East Anglia THREE site (which formed part of the East Anglia zone) with NATS, the MoD the National Air Traffic Management Advisory Committee (NATMAC), transboundary stakeholders and offshore helicopter operators supporting the oil, gas and renewable energy industries and Search and Rescue (SAR) operations. During 2014, Vattenfall Wind

[2] The MoD UK Low Flying Priority Maps have since been withdrawn; however, it is considered that they do provide a valid indication of areas of low flying priorities; however, they do not indicate MoD policy or future planning.

Power Ltd and Scottish Power Renewables agreed to divide the zone, Vattenfall Wind Power Ltd independently developing the northern half of the zone where Norfolk Vanguard will be situated, and Scottish Power Renewables independently developing the southern half of the zone where the windfarm now known as East Anglia THREE Wind Farm will be located. Whilst it is considered that the consultation response provided for the East Anglia zone is relevant to Norfolk Vanguard, specific consultation has also been undertaken for the project.

13. Consultation responses of relevance to Norfolk Vanguard can be summarised as follows:

- MoD: Objection based on concerns with East Anglia Zone being detectable by the Trimingham Air Defence Radar (ADR).
- NATS: Following modelling, NATS indicated that there would be no effect to the Cromer Primary Surveillance Radar (PSR) from Norfolk Vanguard East (NV East); however, there would be a predicted effect to the Cromer PSR from Norfolk Vanguard West (NV West).
- CAA: Outlined requirements for the lighting and charting of wind turbines.
- Ministerie van Defensie (Netherlands MoD): Confirmation of no radar issues from the East Anglia Zone.
- Inspectie Leefomgeving en Transport (ILT) (Netherlands CAA): Recommendation, for consistency of obstruction lighting, that those wind turbines that are within the Amsterdam Flight Information Region (FIR) are lit in accordance with United Kingdom (UK) requirements.
- Luchtverkeersleiding Nederland (LVNL) (Netherlands equivalent of NATS): No effect to infrastructure.

14. During 2015, Norfolk Vanguard Limited submitted a request for completion of a NATS Technical and Operational Assessment (TOPA) (NATS, 2015) in relation to Norfolk Vanguard. The assessment was based on boundary positions of NV West and NV East and assumed a wind turbine blade tip height of 225 metres (m) above Highest Astronomical Tide (HAT). Results of the assessment predicted an impact to the NATS Cromer PSR from NV West; however, no impact would be created by NV East at this blade tip height. The worst case scenario for Norfolk Vanguard is for a maximum wind turbine blade tip height of 350m above HAT which may bring a portion of NV East into radar Line of Sight (LOS) to the Cromer PSR; however, the mitigation solution agreed with NATS will remove impacts created to the Cromer PSR at a maximum blade tip height of 350 m above HAT subject to regulatory approval of the Airspace Change Proposal (which will provide the mitigation solution) by the CAA.

15. The Planning Inspectorate Scoping Opinion (PINS, 2016) for Norfolk Vanguard noted the predicted unacceptable impact to the NATS Cromer PSR from Norfolk Vanguard

West and welcomed the fact that Norfolk Vanguard Limited is working with NATS to develop mitigation measures. During September 2017, NATS and Norfolk Vanguard Limited entered into an agreement under which NATS will conduct work to confirm a solution in order to mitigate impacts on the NATS Cromer PSR. Details of the agreed mitigation solution are provided at Sections 44 and 45.

16. The Scoping Opinion also advised close liaison with helicopter operators who support the offshore oil and gas industries in the southern North Sea. Consultation has been completed with relevant helicopter operators with the aim of establishing any safeguarding concerns, assessing potential impacts and developing suitable mitigation to reduce identified effects. This is summarised below.

17. Consultation with the MoD to better understand its aviation and air defence activities, including ADR, Practice & Exercise Areas (PEXAs), low flying and air-to-air refuelling activities, commenced in 2015.

18. The nearest ADR to Norfolk Vanguard is the TPS77 type radar located at RAF Trimingham, North Norfolk. An initial Serco Report (Serco, 2015), using representative Norfolk Vanguard (formerly East Anglia (North) Wind Farm) wind turbine positions at a blade tip height of 225 m, concluded that all of NV West would be within radar coverage and detectable by this ADR, as well as a western minority of NV East. The worst case scenario of a maximum wind turbine blade tip height of 350 m above HAT is likely to increase radar detectability of wind turbines to the Trimingham ADR.

19. Consultation with the MoD has confirmed the predicted radar detectability of the Norfolk Vanguard wind turbines by the Trimingham ADR through a MoD assessment of operational impact. Consultation is on-going with the MoD to agree a technical mitigation solution. Cumulative effects are considered further in Section 16.8

20. It is anticipated that the layout of wind turbines will be regular in plan (set out in rows) in order to optimise SAR surveillance capability during emergency operations and will be agreed in consultation with the MCA and Trinity House. Layout and SAR are discussed further in Chapter 15 Shipping and Navigation.

21. Offshore oil and gas platforms are supported by a number of helicopter operators who ferry crews and supplies to and from the mainland. The routes taken by helicopters on such flights may follow Helicopter Main Routes (HMRs) which form a network of corridors between offshore platforms and the main support bases at Norwich Airport and Humberside Airport. The use of HMRs is not mandatory and they are not religiously flown. Offshore helicopter operators as well as the Air Navigation Service Provider (ANSP) providing ATS in the area were consulted as recommended in the Scoping Opinion.

22. Anglia Radar based at Aberdeen Airport provide an ATS to helicopters operating in support of the offshore oil and gas industries and other aircraft operating in the area of Norfolk Vanguard utilising NATS radar systems. Anglia Radar stated that whenever possible they give offshore helicopters a direct routing from / to the airfield direct to the intended destination platform. Anglia Radar are aware that offshore installations could affect the routings and levels for offshore helicopter flights should they need to deviate around the area; however, Anglia Radar stated that Norfolk Vanguard would not create any impact to the Anglia Radar operation as obstacle clearance is the responsibility of the offshore helicopter companies whilst under an ATS from Anglia Radar over the sea and therefore they have no objection in this respect. Furthermore, as the clutter created to NATS radar systems is the subject of an agreed mitigation scheme, Anglia Radar have no objection based on predicted radar impact. The response from offshore helicopter operators is provided in Table 16.2 below.

Table 16.2 Consultation responses

Consultee	Date /Document	Comment	Response / where addressed in the ES
MoD	September 2016 October 2016 to July	A wind farm mitigation modelling report (known as the Serco Report (Serco, 2015)), using representative Norfolk Vanguard (formerly East Anglia (North) Wind Farm) wind turbine positions, indicated that the 655 wind turbines modelled would create an aviation specification[3] perimeter and to optimise air defence performance 16 circular Non- Automatic Initiation Zone (NAIZ) regions will be required to mitigate additional radar returns. During a meeting between Norfolk Vanguard Limited and the MoD, the MoD explained that the Serco Report (Serco, 2015) is valid and the radar impact to the Trimingham ADR can be mitigated. However, due to the size of the development zone (which analysed 655 wind turbines within East Anglia (North)), the detectability of wind turbines and the consequential predicted effects of shadowing, reduction in Probability of Detection (PD) and the radar clutter that detectable wind turbines will present to the ADR, the MoD cannot accept the mitigation solution presented within the Serco Report. The MoD described the process that the Defence Infrastructure Organisation (DIO) had taken with other offshore wind farms in which a designed reducing of effect was achieved by the consideration of a range of wind turbine heights (the lowering of wind turbine tip heights to	Section 16.7.6.2

[3] MoD requires that a volume of airspace above wind turbines must exist, which achieves agreed performance metrics when mitigation is in place. This is called an Aviation Specification, and provides guarantees for MoD that the radar performance is maintained immediately above and beyond the lateral confines of a proposed wind development.

Consultee	Date /Document	Comment	Response / where addressed in the ES
	2017 December 2017	reduce radar detectability) and consideration of the layout required regarding spacing of wind turbines (reducing shadow effects). DIO offered assistance of modelling scenarios in order to find a more acceptable solution. Drawings, coordinates and shapefiles for four test scenarios which included four different wind turbine blade tip heights were provided to DIO during October 2016. During November 2016, DIO provided the results of the modelling of the four test scenarios. Analysis concluded that NV West would be detectable by the Trimingham ADR at all four blade tip heights; radar coverage over NV East varied. DIO requested a revised layout be submitted for further modelling which would reduce the expected impact to the Trimingham ADR. During July 2017, a revised layout was provided to the MoD on which discussions are ongoing regarding further Serco modelling and mitigation for the Trimingham ADR. However, Vattenfall is still awaiting feedback on the operational impacts and acceptability of the latest layout proposals, which were submitted to the MoD almost 12 months ago. The MoD (DIO) responded to Section 42 statutory consultation stating that the Norfolk Vanguard PEIR had taken account of the extent of maritime military PEXAs as well as the use of airspace in the vicinity of the proposed development for defence purposes. MoD (DIO) made the following observations: • Military low flying may be conducted over the sea beyond the mapped area of the UK Low flying system; the MoD may request that structures such as platforms are fitted with aviation warning lighting where there is no mandatory requirement for installation. • The MoD stated that it should not be assumed that a NAIZ mitigation solution will be technically or operationally acceptable to mitigate the impact to the Trimingham ADR; the MoD would welcome a mitigation proposal that addresses the impact on the Trimingham ADR. • With regard to the onshore cable route, the MoD provided defined heights of safeguarded zones encompassing the Trimingham ADR and RAF Marham airfield, to which the MoD require consultation upon development exceeding the defined heights. However the MoD does not anticipate that the proposed onshore scheme or associated works will affect these safeguarding requirements. Consultation with the MoD is ongoing to agree a suitable mitigation solution for effects on the Trimingham ADR	Section 98

Consultee	Date /Document	Comment	Response / where addressed in the ES
		system.	
Secretary of State	Scoping Opinion November 2016	The Secretary of State notes that an unacceptable impact is predicted on the Cromer PSR and welcomes that the Applicant is working with NATS to develop mitigation measures. The Secretary of State advises that it is necessary to take into account the aviation and air defence activities of the MoD, including ADR, PEXAs, low flying and air-to-air refuelling activities. The Secretary of State notes potential impacts relating to HMRs and recommends close liaison with helicopter operators to assess the potential impacts and develop suitable mitigation to reduce any identified effects.	Section 16.2
Secretary of State	Scoping Opinion November 2016	NATS technical safeguarding teams examined the proposals for NV East and West at a blade tip height of 275 m and concluded that NV West conflicts with its safeguarding criteria based on theoretical detection by their Cromer PSR system and that NV East would not conflict with their safeguarding criteria.	Section 16.2
NATS	March 2017	Norfolk Vanguard Limited entered contract negotiations with NATS for technical mitigation of the Cromer PSR. It is agreed with NATS that the technical mitigation solution will remove all wind turbine effects to the Cromer PSR.	Section 16.7.6.2
Netherlands ATC and MoD	June 2017 to August 2017	Netherlands civil ATC authorities responded that Norfolk Vanguard would not impact Netherlands ATC CNS infrastructure. The Netherlands MoD responded stating that Norfolk Vanguard will have no impact to Netherlands Air Force radar systems as the OWF sites are beyond the safeguarded area of the radar systems.	N/A
MCA	June to October 2017	The MCA were contacted with details of Norfolk Vanguard for comment. No direct reply was received; however, a reply to a request for formal statutory consultation was received during October 2017 which focussed on shipping and navigation elements of the PEIR. The following comments were included with regard to aviation. • Layout Design: The turbine layout design will require MCA approval prior to construction to minimise the risk to SAR aircraft operating within the Offshore Wind Farm (OWF) sites. • Lighting: MCA state that 'the boundary turbines, where they are more than 900 m apart, must be lit with a single 2000 candela, red aviation light, flashing Morse 'W' in unison with all other boundary turbines. All other turbines must be fitted with a	Section 16.7.2 Shipping and Navigation is covered in Chapter 15.

Consultee	Date /Document	Comment	Response / where addressed in the ES
		fixed single red 200 candela aviation light, visible through 360°, for SAR purposes.	
Offshore Helicopter Operators	November 2017 to January 2018	The following offshore helicopter operators were consulted in order to establish if any operational or safeguarding concerns were apparent with the development of Norfolk Vanguard. • Babcock Mission Critical Services Offshore; • British International Helicopters (BIH); • Bristow Group Inc (Bristow); • CHC Scotia Helicopters; • HeliHolland; • Noordzee Helicopters Vlaanderen (NHV); • Shell Helicopters Netherlands; and • Uni-Fly UK Limited. Of the eight helicopter operators contacted only BIH, Bristow Group and Uni-Fly UK provided a response. BIH and Uni-Fly had no comments to make regarding Norfolk Vanguard. Bristow provided the following comments: • Intense offshore helicopter activity takes place in the Leman Gas Field just to the North of Vanguard West. This activity continues in all weathers and also in the hours of darkness. Bristow recommend that the perimeter turbines be fitted with obstruction lights at a minimum of 150 m intervals from surface level. Bristow indicated that this will mitigate for the risk of the top obstruction light being obscured by low cloud when aircraft are manoeuvring at low level in adverse weather conditions. • Other than the operations above, Bristow state that they currently operate no regular helicopter routes that directly overfly the proposed offshore sites.	Section 16.6.7
Anglia Radar	January 2018	Post Section 42 consultation with Anglia Radar was completed. Anglia Radar stated that they have no concerns with the development of Norfolk Vanguard.	N/A

16.4 Assessment Methodology

16.4.1 Impact Assessment Methodology

23. Potential aviation receptors were identified in accordance with CAP 764 (CAA, 2016a). This assessment considers all radar systems within operational range of the proposed project, as well as military areas of operation. For each identified receptor, the physical obstruction and / or radar effect, and then subsequently the operational impacts were considered with any other potential impacts. The operational range of a radar system is dependent on the type of radar used and its operational requirement. CAP 764 provides a guide of 30 km for assessment of radar impact; however, any impact is dependent on radar detectability of operational wind

turbines, the radars operational range and the use of airspace in which the project sits. The operational impact considers the orientation of approach and departure flight paths, physical safeguarding of flight, airspace characteristics and flight procedures as published in the UK IAIP (NATS, 2018) and the Mil AIP (MoD, 2018). This assessment has been informed by the results of baseline studies and consultation, with reference to the existing evidence base regarding the effects of offshore wind farm projects.

24. In assessing the significance of the effects from the proposed project, it was necessary to identify whether or not there would be an impact on aviation operations. The aviation industry is highly regulated and subject to numerous mandatory standards, checks and safety requirements, many international in nature and requiring the issue of operating licences. In all cases, the sensitivity and magnitude of the impact on operations can only be identified by the appropriate aviation organisation conforming to the Risk Classification Scheme used to quantify and qualify the severity and likelihood of a hazard occurring. The Risk Classification Scheme is a fundamental element of an aviation organisation's Safety Management System (SMS), which must be acceptable to, and approved by, the UK CAA or the Military Aviation Authority (MAA), as appropriate. As such, for the purposes of this assessment, no detailed grading has been made of the magnitude of the impact or sensitivity of the receptor on the basis that any potential reduction in aviation safety cannot be tolerated. Instead, definitions of basic significance have been defined in Table 16.3. This represents a deviation from the standard methodology presented within Chapter 6, Environmental Impact Assessment Methodology.

Table 16.3 Impact significance definitions

Potential Significance	Definition
Major Significance	Receptor unable to continue safe operations or safe provision of air navigation services (radar) or effective air defence surveillance in the presence of wind turbines. Technical or operational mitigation of the impact is required.
Moderate Significance	Receptor able to continue safe operations but with some restrictions or non-standard mitigation measures in place.
Not Significant	The proposed project would have little impact on the aviation stakeholder or the level of impact would be acceptable to the aviation stakeholder.
No change	The proposed project would have no impact on the aviation stakeholder and would be acceptable to the aviation stakeholder.

25. Significance of aviation impacts are typically difficult to establish; they are not strictly based on the sensitivity of the receptor or magnitude of change but on whether the industry regulations for safe obstacle avoidance or radar separation (from radar clutter) can be maintained in the presence of wind turbines.

26. The determined effects have been informed by the results of the desktop assessment, additional receptor consultation and with reference to the existing evidence base regarding the effects of wind turbines on aviation receptors.

16.4.2 Cumulative Impact Assessment

27. The approach to cumulative assessment for Norfolk Vanguard takes into account the Cumulative Impact Assessment Guidelines issued by RenewableUK in June 2013, together with comments made in response to other renewable energy projects and the Planning Inspectorate 'Advice Note 9: Rochdale Approach'. The proximity of the proposed Norfolk Boreas Offshore Wind Farm, together with the consented and in development East Anglia Offshore Wind Farms listed in Table 16.8, indicates there is the potential for cumulative radar impact.

16.4.3 Transboundary Impact Assessment

28. Similar to the cumulative impacts, this section considers transboundary offshore wind farms with regards to physical obstruction, radar impact and future airspace management.

16.5 Scope

16.5.1 Study Area

29. Whilst not definitive, Civil Aviation Authority (CAA), CAP 764 (CAA, 2016a) provides criteria for assessing whether any wind turbine project might have an impact on civil aerodrome related operations. Consideration of the proposed project's potential to impact on aviation stakeholders and receptors has been undertaken in accordance with the standard consultation distances stated in CAP 764. A number of consultees and receptors were scoped out from the consultation process as they were out-with the CAP 764 consultation zones or criteria which include:

- Within 30 kilometres (km) of an aerodrome with surveillance radar – although it is acknowledged that the distance quoted in CAP 764 can be greater than 30 km dependent on a number of factors at individual aerodromes, including type and coverage of radar utilised; there are no such operational aerodromes within 30 km of the project;
- Airspace coincident with published Instrument Flight Procedures (IFP) to take into account the requirement for an aerodrome's requirement to protect its IFP's; there is no such airspace within the project vicinity;
- Within 17 km of a non-radar equipped licensed aerodrome with a runway of 1,100 m or more; there are no such aerodromes within 17 km of the project.

30. The study area encapsulates Norfolk Vanguard, Norfolk Boreas (a second OWF also being developed by Vattenfall Wind Power Ltd.) and the East Anglia OWF projects,

and for the purposes of the assessment of cumulative effects 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 study area covers:

- Radars (civil and military) on the eastern coast of England that could potentially detect 350 m above HAT (blade tip) wind turbines within the proposed project boundaries (the final wind turbine blade tip height is yet to be finalised but may include blade tip heights of up to 350 m HAT);
- HMRs within the proximity of Norfolk Vanguard; and
- Offshore Platforms that have nine nautical mile (NM) consultation buffers overlapping with Norfolk Vanguard.

16.5.2 Data Sources

31. Aviation stakeholders considered throughout this chapter utilise several different radar systems. Relevant additional data sources used in this chapter are presented in Table 16.4.

16.5.3 Assumptions and Limitations

32. For the purpose of undertaking the assessment and for ensuring that the assessment is robust, all assumptions have been made on a worst case basis. No significant technical difficulties arose and there have been no issues which have prevented the assessment of potential impacts or the identification of mitigation measures.

Table 16.4 Additional data source features

Data	Year	Confidence	Notes
Cromer ASR-10SS Solid State PSR (NATS)	Accessed online 2018	High	One of a number of radar systems utilised by NATS for the provision of En-route ATC services.
Trimingham Lockheed Martin TPS-77 ADR (MoD)	Accessed online 2018	Medium	Limited data available as ADR systems are covered by the International Traffic in Arms (ITAR) restrictions
Dutch IAIP	2018	High	Similar to the UK IAIP the Netherlands Airports and Airspace Information is the main resource for information and flight procedures at all licensed Netherlands airports as well as airspace, en-route procedures, charts and other air navigation information.

16.6 Existing Environment

16.6.1 Overview

33. Norfolk Vanguard will be situated in an area of Class G uncontrolled airspace, which is established from the surface up to Flight Level (FL) 195 (approximately 19,500 feet (ft)). Class C controlled airspace (CAS) is established above FL 195. 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)[4] 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.

34. In the area of the Norfolk Vanguard OWF sites, the Class G uncontrolled airspace below FL 195 is sub-divided into areas with the following aviation stakeholder responsibility:

- Anglia Radar, based at Aberdeen Airport and employing NATS PSRs, has its area of responsibility established for the provision of ATC services to commercial air traffic (CAT) helicopter operations that support the offshore Oil & Gas Industry, from the surface up to FL 65 (approximately 6,500 ft);
- Military En-Route Area Control, military air traffic controllers located at the Swanwick Area Control Centre (ACC) utilise NATS radar for the provision of ATS to aircraft flying outside of CAS above FL 100 within radar and radio coverage; and
- MoD Air Surveillance and Control System (ASACS), uses its ADR resources in support of operational flights within UK airspace and for training exercises.

16.6.2 Military Low Flying Operations, PEXA and Air-to-Air Refuelling

35. Mapping of the UK Low Flying System (UKLFS) covers the open airspace of the whole UK land mass and surrounding sea areas out to 2 NM, from the surface to 2,000 ft above ground level (agl) or above mean sea level (amsl); however, military low flying may be conducted beyond this area over the sea. Military PEXAs are areas available for training use primarily by the UK armed force but also those of overseas nations. They can be over land or water, or both, and may involve the firing of live ammunition. Norfolk Vanguard does not lie within any aviation military training

[4] A set of regulations under which a pilot operates an aircraft in weather conditions clear enough to allow the pilot to see where the aircraft is going; the pilot must be able to operate the aircraft with visual reference to the ground, and by visually avoiding obstructions and other flying machines.

areas, PEXAs or Air to Air Refuelling Areas (AARA) and therefore physical obstruction impacts to military operations within these areas are not considered further within the assessment.

16.6.3 Norwich Airport

36. Norwich Airport provides radar services to pilots on request of a Lower Airspace Radar Service (LARS). The service is available to all aircraft flying outside CAS up to FL 100, within the limits of radar and radio cover. The service is provided by Norwich Airport to a service radius of 30 NM from the airport; the western boundary of NV West is located approximately 40 NM from Norwich Airport and therefore will not impact LARS provision and is not considered further within the assessment.

16.6.4 Transboundary Considerations

37. Amsterdam Schiphol Airport is approximately 105 km from the eastern boundary of NV East and therefore no direct impact on the airport is assessed. Relevant Dutch aviation authorities for the project have all been consulted during the scoping stage of the East Anglia Zone and during Section 42 statutory consultation for Norfolk Vanguard. This includes; Inspectie Leefomgeving en Transport (ILT), Luchtverkeersleiding Nederland (LVNL), and Ministerie van Defensie. These authorities have all confirmed that there will no impacts to aviation radar infrastructure and operations conducted by them.

38. A network of HMRs is established in the Netherlands to support the transport of personnel and material to offshore oil and gas installations. It is assumed that helicopters operating from the Netherlands could be required to fly within the region of the proposed project and may utilise a Dutch HMR known as KZ50 which originates and is located in the Amsterdam FIR. KZ50 becomes part of existing HMRs in the London FIR in UK airspace (HMRs 447 and 450) which cross the Norfolk Vanguard OWF sites. As aviation operations are regulated by international criteria, there would be little difference in the impacts perceived by receptors in the Netherlands over those experienced in the UK. Consultation has been completed with helicopter operators in the UK, Netherlands and Belgium; none stated any concerns to operating on HMRs within the region of Norfolk Vanguard. Furthermore, Anglia Radar the provider of ATC services to aircraft operating in the region has no concerns to the operations conducted by Anglia Radar.

16.6.5 NATS

39. NATS provide ATS at some airports in the UK and provide ATS to traffic en-route (overflying or flying between airports) in UK airspace. NATS operate a number of long range PSRs and Secondary Surveillance Radar (SSR) positioned to provide maximum coverage of UK airspace. Additionally, NATS has a licence obligation to

provide radar data to other, remote, aviation stakeholders to a high quality and performance standard for the benefit of UK aviation as a whole. Any effect that Norfolk Vanguard might have on NATS radar system must be considered both in terms of effect on the civilian en-route services and in the context of its remote users.

40. In addition, Military ATC personnel are based at the Swanwick ACC to facilitate the control of aircraft that require ATS outside and crossing CAS. NATS have a contracted responsibility to provide appropriate PSR coverage to support this task.

41. The CAA, through CAP 764 (CAA, 2016a), advises that impact to SSR systems are typically only a consideration when wind turbines are located close to the SSR i.e. less than 10 km. The closest SSR facility to Norfolk Vanguard is co-located at the location of the Comer PSR in excess of 40 km from the project and therefore no impact is assessed on SSR.

16.6.5.1 En-Route operations

42. The world is divided into FIRs for the responsibility of the provision of ATS to aircraft. The boundary between London FIR (under the regulation of the UK CAA) and Amsterdam FIR (under the regulation of the Netherlands ILT) crosses through the eastern edge of NV East. NV West is wholly within the UK FIR.

43. NATS En Route Ltd (NERL) use its PSRs located in North Lincolnshire (Claxby) and Norfolk (Cromer) to support its provision of ATS to aircraft operating between the UK and mainland Europe, and to those overflying the London FIR in the vicinity of Norfolk Vanguard except where responsibility for ATS has been formally delegated to the service provider in the Netherlands, LVNL, the agency responsible for the provision of ATC services in the Netherlands.

44. NV East lies beneath a volume of airspace delegated to LVNL. In this delegated airspace (FL 175 (17,500 ft) to FL 245 (24,500 ft)), LVNL is responsible for providing ATS. Below and above the delegated airspace, NATS is responsible for providing ATS. The Cromer PSR will theoretically detect NV West and the worst case scenario may bring a portion of NV East within radar LOS to the Cromer PSR. NATS and Norfolk Vanguard Limited have agreed mitigation of the Cromer PSR in the form of a Transponder Mandatory Zone (TMZ) which will remove impact created by Norfolk Vanguard to the Cromer PSR subject to regulatory approval of the required airspace change proposal by the CAA. No effect is predicted to the Claxby PSR.

45. A TMZ is a defined piece of airspace in which the carriage and operation of a pressure-altitude transponder is mandatory within an aircraft. The creation of a TMZ allows the airspace above the development to retain its original classification, yet also allows for enhanced situational awareness for all users and for air traffic

controllers. Provision can be made for non-compliant aircraft to gain access to the TMZ; the creation of the TMZ will require regulatory approval by the CAA trough an airspace change proposal.

16.6.6 MoD Air Defence Operations

46. 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 systems, some of which are located along the east coast of the UK. Any identified effect of wind turbines on the ASACS radars that serve the airspace above Norfolk Vanguard would potentially reduce the capability of the ASACS force.

47. The proposed project will be detectable by the TPS77 type radar located at RAF Trimingham, North Norfolk. Consultation with the MoD continues with the aim of agreeing a suitable mitigation solution regarding the detectability of the proposed wind turbines by the Trimingham ADR.

16.6.7 Offshore Helicopter Operations

48. CAP 764 (CAA, 2016a) states that a large number of wind turbines beneath an HMR might force a helicopter to fly higher (and thus risk entering cloud) to avoid compromising the minimum vertical separation height above the wind turbines. HMRs 447, 450, cross through the Norfolk Vanguard OWF sites (Dutch HMR KZ50 terminates in the eastern edge of NV East to become UK HMR 450); HMR 1 lies approximately 20 km to the northwest of NV West.

49. A HMR is not a mandatory routing for helicopter operators offshore and in the area of Norfolk Vanguard serves to remind other aircrews that it is likely that offshore helicopters operate in the airspace. The region of Norfolk Vanguard OWF is served by radar coverage and provision of ATC services to aircraft operating offshore; where this is the case helicopter flights may be given a direct routing to their offshore destination and therefore HMRs are likely to be rarely used (as Anglia Radar have confirmed). Where ATC coverage is less comprehensive (as in the Northern North Sea, northeast of Aberdeen), flights are more likely to be conducted along HMRs.

50. In addition, a 9 NM radius consultation zone around offshore installations is established to allow for the safe operation of helicopter instrument approaches to platforms in poor weather conditions. Individual 9 NM consultation zones of a number of these installations extend across the Norfolk Vanguard boundaries.

16.6.7.1 HMR operational impacts

51. CAP 764 (CAA, 2016a) states that HMRs have no defined lateral dimensions, although 2 NM either side of the route centreline should ideally be kept obstacle free. HMRs 447, 450, (Dutch HMR KZ50 becomes part of HMR 450 within the eastern part of NV East) cross through the Norfolk Vanguard OWF sites. These non-mandatory routes may be used for transit from both Norwich International Airport to the Leman Bank and Indefatigable offshore installations to the north of the proposed project area, although helicopters are highly likely to be given a direct route to their offshore location without the use of a HMR. Consultation on the proposed project has been completed with helicopter operators potentially using these HMRs; none of the helicopter operators or the ATS provider (Anglia Radar) has indicated that they have any safeguarding or operational concerns with the development of Norfolk Vanguard.

52. 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 route, which would indicate that whilst operating above the physical obstruction of the Norfolk Vanguard wind turbines, offshore helicopters would be required to fly at 2,200 ft amsl (1,149 ft (350 m) plus 984 ft rounded up to nearest 100 ft). When operating under VFR and Visual Meteorological Conditions (VMC), helicopters are required to maintain a minimum of 500 ft separation from terrain, aircraft and obstacles. Whilst operating under IFR helicopters are likely to be under Anglia Radar ATS provision; helicopter operators and Anglia Radar have indicated no concerns with regard to operations with the development of Norfolk Vanguard, therefore no impact is predicted on the use of HMRs in the location of the development.

16.6.7.2 Offshore installations operational impact

53. In order to help achieve a safe operating environment, a consultation zone of 9 NM radius (CAP 764, 2016a) exists around offshore helicopter installations. This consultation zone is not considered a prohibition on wind turbine development within a 9 NM radius of offshore operations but a trigger for consultation between the platform operators, the offshore helicopter operators, the operators of existing installations and wind developers to maintain a safe coexistence between wind turbines and offshore helicopter operations. The nine platforms within the vicinity of Norfolk Vanguard are detailed in Table 16.5.

Table 16.5 Offshore platforms within 9 NM of Norfolk Vanguard requiring consultation

Platform	Operator	Latitude	Longitude	Approx. Distance to NV West Northern Boundary
Shell D	Shell UK	53 00 32N	002 11 03E	8.9 NM/14.2km
Shell B	Shell UK	53 03 01N	002 17 01E	8.1 NM/13 km
Leman 27D	Perenco UK	53 00 59N	002 20 20E	5.6 NM/9.0 km
Leman 27F	Perenco UK	53 02 24N	002 18 49E	6.0 NM/9.6 km
Leman 27F	Perenco UK	53 02 24N	002 18 49E	7.0 NM/11.2 km
Leman 27G	Perenco UK	53 02 12N	002 22 49E	4.5 NM/7.2 NM
Leman 27H	Perenco UK	53 00 14N	002 12 49E	8.5 NM/13.6 km
Thames	Perenco UK	53 05 01N	002 32 44E	3.8 NM/6.1 km
Davy	Perenco UK	53 00 16N	002 53 41E	7.9 NM/12.6 km

54. The basic requirement of the 9 NM consultation zone is to provide airspace for the safe operation of helicopter instrument approaches in poor weather conditions where a low visibility approach profile is needed. In addition, the zone provides a safe area for helicopters to carry out a Missed Approach Procedure (MAP), in the event that an approach to land at the intended installation is not completed. The Norfolk Vanguard boundaries would extend into 9 NM consultation zones where established around the platforms listed in Table 16.5.

55. Wind turbines within the consultation zones are considered as physical obstructions, under IFR, requiring a minimum of 1,000 ft vertical avoidance; furthermore, during the approach to an installation, all radar contacts (including radar contacts which are assumed to be wind turbines) have to be avoided laterally by at least 1 NM. These combined avoidance requirements within a 9 NM consultation zone of an offshore installation might impair the safety of helicopter operations to that installation and affect the installation operators' regulatory requirements with regard to safety of operation.

16.6.7.3 Helicopter airborne radar approach

56. Helicopters which operate to and from offshore platforms (installations) are fitted with weather radar which can be used to conduct an instrument approach in poor visibility. Airborne Radar Approaches (ARA) are normally used as a low-visibility approach procedure to the platforms where required, and rely upon the on-board weather radar for obstacle detection and navigation. The radar is designed to display weather phenomena, such as rain, as well as obstacles such as shipping, oil and gas platforms or wind turbines. In Instrument Meteorological Conditions (IMC) combined with certain wind conditions, which dictate the area of approach to the platform, a standard ARA procedure might not be available due to the proximity of

wind turbines, requiring 1,000 ft vertical or 1 NM lateral avoidance under IFR, to the approach track. Consequently, any such restrictions have the potential to affect not only normal helicopter operations but could also threaten the integrity of offshore installation safety cases where emergency procedures are predicated on the use of helicopters to evacuate the installation.

57. It can generally be assumed that offshore support helicopters will be able to fly an ARA from any direction if the wind speed is below 2.5 m per second (m/s) (5 knots (Kt)). Strong cross-wind components to an ARA procedure are unacceptable, and therefore an ARA procedure must take place predominantly into wind. The platforms in Table 16.5 lie to the north of the Norfolk Vanguard OWF sites where they infringe a 9 NM consultation zone. The prevailing winds in the southern North Sea are south-westerly; however, it is possible in some wind conditions, other than the prevailing conditions, that ARAs would be required to take place over the Norfolk Vanguard developments. As outlined previously this might not be achievable due to the requirement to avoid wind turbine radar contacts.

58. It is understood that flying to offshore platforms is conducted 365 days per year, and that IFR (in IMC) ARA procedures are conducted to each platform during each year due to limited inflight visibility; assuming inflight wind and visibility conditions are independent from each other. During other periods, it is assumed that approaches will be conducted under VFR which dictates a minimum in-flight visibility of 5 km (approx. 3 NM). As the nine platforms are greater than 3 NM from any Norfolk Vanguard boundary, it is considered that no VFR operations to these platforms will be impacted by wind turbines within the development area.

59. Helicopter operator's ARA charts indicate that for a worst case scenario, when flying an ARA, helicopters could be within 8 NM of the destination platform. Furthermore, during the approach to a platform, all radar contacts (including radar contacts that are assumed to be wind turbines) have to be avoided laterally by at least 1 NM.

60. Helicopter operations using ARA will be restricted in accessing platforms under certain weather conditions (in poor visibility (IMC) coupled with strong winds), for a limited period of time during a year. The extent of this effect can be defined spatially; however, the temporary nature of the effect will vary on a case by case basis. This is due to the fact that both the length of time in which helicopters can operate VFR will vary due to different weather conditions and the fact there are inherent restrictions on other phases of flight in certain weather conditions not attributed to the presence of wind turbines near the destination platform. This variation in weather conditions is something that currently has an effect on helicopter operations. Of the offshore helicopter operators consulted by Norfolk Vanguard Limited, only Bristow have indicated offshore helicopter activity takes place in the Leman Gas Field just to the North of Vanguard West. Bristow have

stated that this activity continues in all weathers and also in the hours of darkness. Bristow recommend that the perimeter turbines be fitted with obstruction lights at a minimum of 150 m intervals from surface level. Bristow indicated that this will mitigate the risk of the top obstruction light being obscured by low cloud when aircraft are manoeuvring at low level in adverse weather conditions. In relation to navigational practice, safety and emergency response issues, Norfolk Vanguard will comply with the MCA recommendations contained within MGN543 "Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response Issues". This is discussed further in Chapter 15 Shipping and Navigation and secured within conditions 15(6) (DCO Schedules 9 and 10) and 10(6) (DCO Schedules 11 and 12) of the Deemed Marine Licences (DMLs) for Norfolk Vanguard.

61. CAP 764 (CAA, 2016a) states that obstacles within 9 NM of an offshore destination would potentially impact upon the feasibility to conduct some helicopter operations (namely, low visibility or missed approach procedures) at the associated site. Owing to the obstruction avoidance criteria, inappropriately located wind turbines could delay the descent of a helicopter on approach such that the required rate of descent (at low level) would be excessive and impair the ability of a pilot to safely descend to 200 / 300 ft by the appropriate point of the approach (2 NM). If the zone is compromised by an obstruction, it should be appreciated that routine low visibility flight operations to an installation may be impaired with subsequent consequences for the platform operator or drilling unit charterer.

62. Norfolk Vanguard Limited has undertaken consultation with all relevant O&G operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary. Impacts on other marine users are discussed further in Chapter 18 Infrastructure and Other Users.

16.6.8 Search and Rescue (SAR) Airborne Operations

63. The SAR force provides 24 hour aeronautical SAR cover in the UK. The SAR role is operated from ten strategically located bases across the UK. The bases are positioned close to SAR hotspots so that aircraft can provide support as quickly and efficiently as possible. Bristow helicopters were awarded the contract to provide SAR helicopter services for the UK in 2013.

64. The development of Norfolk Vanguard will lead to a change of the operating environment should an airborne SAR operation be required within or close to the project. When on an operational mission, SAR aircraft are not constrained by the normal rules of the air, and operate in accordance with their (Bristow) Aircraft Operator Certificate (AOC). This allows SAR pilots total flexibility to manoeuvre using

best judgement thus making them highly adaptable to the environment and conditions in which they are operating.

65. An Emergency Response Co-operation Plan (ERCoP) will be in place for the construction, operation and decommissioning phases of Norfolk Vanguard (DML Condition 15(6) (DCO Schedule 9 and 10) and Condition 10(6) (DCO Schedules 11 and 12)). The ERCoP is completed initially in discussion between the developer and the MCA, SAR and Navigation Safety Branches. Detailed completion of the plan will then be in cooperation with the Maritime Rescue Coordination Centre (MRCC), responsible for maritime emergency response. The ERCoP must then be submitted to and approved by the MCA. The ERCoP will detail specific marking and lighting of the wind turbines. The SAR helicopter bases will be supplied with an accurate chart of the Norfolk Vanguard wind turbine Global Positioning System (GPS) positions. The requirements for the lighting of wind turbines are contained in Article 223 of CAP 393 (CAA, 2017).

16.6.9 Anticipated Trends in Baseline Conditions

66. There is no expected change to airspace or airspace users.

16.7 Potential Impacts

67. The receptors for each impact are described within the text for each assessment and have been identified in Section 16.6. Those receptors which are not considered to have any potential to be impacted by the proposed project have not been presented within the baseline.

16.7.1 Notification of Activity

68. It is good practice to notify aviation stakeholders of the location and dimension of any wind energy development and the associated construction activities. Information regarding construction should be passed to the Defence Geographic Centre (DGC) and the General Aviation Awareness Council (GAAC) at least six weeks in advance of the erection of the first wind turbine and to follow up on the day with a confirmation that the activity has taken place. The data would include:

- Location, height (of all structures over 150 ft (45.7 m), date of erection, date of removal and lighting type (none, infra-red or lighting brightness); and
- Local aerodromes identified during consultation should be notified, particularly any police helicopter or air ambulance unit.

69. Information would be circulated to relevant aviation stakeholders including NATS and the MoD. Information on potential aviation obstructions would be promulgated within the UK IAIP (NATS, 2018) and notified to DGC for marking on aeronautical related charts and documentation.

16.7.2 Embedded Mitigation

70. Norfolk Vanguard Limited has committed to a number of techniques and engineering designs/modifications inherent as part of the project, during the pre-application phase, in order to avoid a number of impacts or reduce impacts as far as possible. Embedding mitigation into the project design is a type of primary mitigation and is an inherent aspect of the EIA process.

71. A range of different information sources has been considered as part of embedding mitigation into the design of the project (for further details see Chapter 5 Project Description, Chapter 4 Site Selection and Assessment of Alternatives) including engineering requirements, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

72. These mitigation measures would comply with current guidelines and be agreed with the appropriate stakeholders, as follows:

- CAP 393 Article 223 (CAA, 2017) sets out the mandatory requirements for lighting of offshore wind turbines.
    - Legislation requires the fitting of obstacle lighting on offshore wind turbines with a height of 60 m or more above the level of the sea at HAT;
    - Where four or more wind turbines are located together in the same group, with the permission of the CAA, only those on the periphery of the group need to be fitted with at least one medium intensity steady red light positioned as close as reasonably practicable to the top of the fixed structure; and
    - The obstruction light or lights must be fitted to show when displayed in all directions without interruption. The requirements of the angle of the plane of the beam and peak intensity levels are defined within CAP 393 (CAA, 2017).
- CAP 437 (CAA, 2016b) sets out a procedure to indicate to a helicopter operator that the wind turbine blades and nacelle are safely secured in position prior to helicopter hoist operations commencing.
    - CAP 437 states that this is best achieved through the provision of a helihoist status light located on the nacelle of the wind turbine within the pilot's field of view, which is capable of being operated remotely and from the platform itself or from within the nacelle.
    - A steady green light is displayed to indicate to the pilot that the wind turbine blades and nacelle are secure and it is safe to operate. A flashing green light is displayed to indicate that the wind turbine is in a state of preparation to accept hoist operations or, when displayed during hoist operations, that parameters are moving out of limits. When the light is

extinguished this indicates to the operator that it is not safe to conduct helicopter hoist operations.

- Obstruction lighting in the vicinity of the winching area that has a potential to cause glare or dazzle to the pilot or to a helicopter hoist operations crew member should be switched off prior to, and during, helicopter hoist operations.

73. An ERCoP would be in place for the construction, operation and decommissioning phases of Norfolk Vanguard, in accordance with DML Requirement 15(6) (DCO Schedules 9 and 10) and DML Requirement (10(6) (DCO Schedules 11 and 12).

74. The ERCoP would be completed initially in discussion between the developer and the MCA, SAR and Navigation Safety Branches. Detailed completion of the plan would then be in cooperation with the Coastguard Operations Centre (CGOC) responsible for maritime emergency response in the area of Norfolk Vanguard. The ERCoP would then be submitted to and approved by the MCA (MCA, 2008).

75. The ERCoP would detail specific marking and lighting of the wind turbines. The SAR helicopter bases would be supplied with an accurate chart of Norfolk Vanguard wind turbine GPS locations and would provide agreed SAR access lanes, helicopter access positions and spacing between wind turbines. Furthermore, the arrangements of liaison between the wind farm developer and HM Coastguard in the event of an emergency response would be detailed together with an explanation of procedures and processes carried out at the Norfolk Vanguard control centre to shut down the wind turbines and the procedures for the CGOC to request a wind turbine shut down.

16.7.3 Monitoring

76. An in Principle Monitoring Plan (document reference 8.12) is submitted with the DCO application. The development of the detailed design and a Project Environmental Management Plan (PEMP) (as required under condition 14(1)(d) (DCO Schedules 9 and 10) and condition 9.(1) (d) (DCO Schedules 11 and 12) of the DMLs) will refine the worst-case impacts assessed in this EIA.

16.7.4 Worst Case Scenario

77. The potential development parameters and scenarios are defined as a design envelope presented in Chapter 5 Project Description. The assessment of potential impacts on civil and military aviation is based on the worst case scenario as identified

from this design envelope, and is specific to the potential impacts identified in this chapter. The key parameters for the worst case scenario include consideration of the maximum number of wind turbines across the largest area and the maximum blade tip height of 350 m above HAT.

78. During construction, and prior to commissioning, wind turbine blades will not be rotational. As a result, the infrastructure will not be processed and presented onto Radar Data Display System (RDDS) by the radar system; therefore, there will be no impacts on aviation radar during these phases. The worst case scenario for impacts on aviation radar services assumes that the entirety of the Norfolk Vanguard OWF sites will be populated with wind turbines at the maximum blade tip height of 350 m above HAT. This is because the largest area of the highest wind turbines will create the largest impact from an obstruction perspective, leading to a greater effect on aviation services. Any aspects of the infrastructure that are lower in height than the wind turbines and less than the extent of the NV East and NV West boundaries will not create an incremental effect on aviation interests.

79. Table 16.6 presents the worst case scenarios for each assessed impact.

Table 16.6 Worst case assumptions

Impact	Key Design parameters forming realistic worst case scenario	Rationale
Construction		
Creation of aviation obstacle	Wind turbines: • 200 x 9 MW wind turbine with max blade tip height of 350 m above HAT. 2 offshore electrical platforms at 80 m (including crane) above HAT 2 accommodation platform or helicopter platforms at less than the offshore electrical platform height 2 met masts at wind turbine height	Maximum number of the tallest wind turbines; or Maximum number of wind turbines in the Norfolk Vanguard site Maximum physical obstruction to aviation operations due to size and number of above sea level infrastructure within the Norfolk Vanguard site. Impact starting from a point of zero infrastructure present to full presence over an indicative maximum 4 year construction window.
Wind turbines causing permanent interference on civil and military radar	200 x 9 MW wind turbine with max blade tip height of 350 m above HAT.	Maximum number of wind turbines in the Norfolk Vanguard site. During construction, and prior to commissioning wind turbine blades would not be rotational. As a result, the infrastructure would not be processed and presented onto RDDS by the radar. Therefore, there would be no impact to radar systems

Impact	Key Design parameters forming realistic worst case scenario	Rationale
		during the construction phase.
Increased air traffic in the area related to wind farm activities	14 return helicopter trips per week	Maximum number of helicopter trips as a result of being engaged on works for Norfolk Vanguard causing a slight increased likelihood of aircraft to aircraft collision.
Operation		
Creation of aviation obstacle in environment	200 x 9 MW wind turbines with max blade tip height of 350 m above HAT. 2 offshore electrical platforms at 80 m (including crane) above HAT 2 accommodation platforms or helicopter platforms at less than offshore electrical platform height. 2 met masts at wind turbine height	Maximum number of wind turbines in the Norfolk Vanguard site Maximum physical obstruction to aviation operations due to size and number of above sea level infrastructure within the Norfolk Vanguard site. Impact duration present during operational period.
Wind turbines causing permanent interference on civil and military radars	200 x 9 MW wind turbines with max blade tip height of 350 m above HAT.	Maximum number of wind turbines in the Norfolk Vanguard site UK ADR detection capability and therefore national security could be compromised. ATC may be unable to provide an effective surveillance service due to interference on radar displays Impact duration present during operational period.
Increased air traffic in the area related to wind farm activities	14 return helicopter trips per week	Maximum number of helicopter trips as a result of being engaged on works for Norfolk Vanguard causing increased likelihood of aircraft to aircraft collision.
Decommissioning		
Creation of aviation obstacle in environment	200 x 9 MW wind turbines with max blade tip height of 350 m above HAT. 2 offshore electrical platforms at 80 m (including crane) above HAT 2 accommodation platform or helicopter platforms less than offshore electrical platform height 2 met masts at wind turbine height	Maximum number of wind turbines in the Norfolk Vanguard site Maximum physical obstruction to aviation operations due to size and number of above sea level infrastructure within the Norfolk Vanguard site. Impact starting from a point of full presence infrastructure to zero presence over a decommissioning period of approximately 1 year.
Wind turbines causing permanent	200 x 9 MW wind turbines with max blade tip height of 350 m above HAT.	Maximum number of wind turbines in the Norfolk Vanguard site.

Impact	Key Design parameters forming realistic worst case scenario	Rationale
interference on civil and military radar		Any agreed mitigation would be maintained until the last wind turbine is non-operational in the decommissioning phase, or as agreed with the aviation stakeholder. Once all wind turbines are stationary the decommissioning infrastructure is not predicted to affect the radar system, or be processed and presented as clutter on the RDDS by the radar.
Increased air traffic in the area related to wind farm activities	14 return helicopter trips per week	Maximum number of helicopter trips as a result of being engaged on works for Norfolk Vanguard causing increased likelihood of aircraft to aircraft collision.

16.7.4.1 Notes on radar operation

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

81. 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 aviation 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).

16.7.4.2 Notes on wind turbine effects on radar

82. Wind turbines are a significant 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 aircraft

movements. Significant effects have been observed on radar sensitivity caused by the substantial Radar Cross Section (RCS) of the wind turbine 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.

83. It is mainly for the above reasons that airport operators and other ANSP object to wind farm developments that are within radar LOS to their radar. However, 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.

16.7.5 Potential Impacts during Construction

16.7.5.1 Creation of an aviation obstacle

84. Wind turbine construction infrastructure above HAT could pose a physical obstruction to flight operations in the vicinity and specifically to helicopters operating on HMRs and to offshore platforms. Wind turbines can be difficult to see from the air, particularly in poor meteorological conditions leading to potential increased obstacle collision risk. Furthermore, during the construction phase, the presence and movement of construction infrastructure may present a potential obstacle collision risk to aircraft flight operations.

85. Helicopter operators and ATC service providers have been consulted with regard to establishing if a perceived impact would be created to helicopters operating on HMRs in the region of Norfolk Vanguard. No potential effects of operating on HMRs were notified from either the helicopter operators or Anglia Radar (the ATS provider).

86. Military low flying takes place within the UKLFS which utilises all Class G airspace below 2,000 ft above ground level (agl) or amsl, with the exception of certain specified designated areas. When operating in the Class G airspace above the development area, pilots are ultimately responsible for seeing and avoiding other aircraft and obstructions. Operations will be conducted in VFR conditions which dictate a minimum in-flight visibility of 5 km (approximately 3 NM). In the response to scoping, the MOD (DIO) have not raised concerns with regard to low flying other than to request additional aviation lighting be fitted to structures featured in the development area (such as platforms) where there is no mandatory requirement for installation, to mitigate any effect to military low flying aircraft operating over the sea.

87. A range of embedded mitigation measures for the project, as detailed in Section 16.7.2, in the form of appropriate notification to aviation stakeholders, lighting and marking to minimise effects to aviation flight operations would apply to the development of the proposed project and will reduce impact to low flying aircraft operating in the vicinity of the wind farm. These will comply with current guidelines and be agreed with the appropriate stakeholders and are outlined in sections 16.7.1 and 16.7.2. Pilots are obliged to plan their flying activities in advance and to be familiar with any en-route obstacles they may encounter; however, during flight, weather conditions or operational requirements may necessitate route adjustments. Under VFR conditions, pilots are ultimately responsible for seeing and avoiding obstructions such as wind turbines and will be aware of their presence for the proposed project through notification procedures. Embedded mitigation and notification of construction, operation and decommissioning of the wind farm and the lighting and promulgation on aviation charts will reduce any physical obstruction effect to aviation activities in the region of Norfolk Vanguard. Appropriate liaison will be completed to ensure information on the construction and decommissioning of the wind farm is circulated in a Notice to Airmen (NOTAM) and other appropriate media. The impact to offshore helicopter operations utilising HMRs and military low flying operations is assessed as **not significant**.

88. Norfolk Vanguard Limited has undertaken consultation with all relevant O&G operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary. Impacts on other marine users are discussed further in Chapter 18 Infrastructure and Other Users.

16.7.5.2 Wind turbines causing permanent interference on civil and military radar

89. During construction, and prior to commissioning wind turbine blades will not be rotational. As a result, the infrastructure will not be processed and presented onto an RDDS by the radar. Therefore, there will be no impacts on radar systems during the construction phase. As a result of non-detection during construction the impact is considered to be of **no change**.

16.7.5.3 Increased air traffic in the area related to wind farm activities

90. There will be a maximum number of 14 return helicopter trips per week during construction as a result of being engaged on works for Norfolk Vanguard. Helicopters, if required, would operate from a local base. Use of helicopters would provide a small increase in helicopters routinely operating in the area, however, the increase could impact on existing air traffic operating in the area.

91. As detailed in Section 16.7.2, a range of embedded mitigation measures for the project, (including notification, lighting and marking) to minimise environmental effects have been designed as part of the development of the proposed project.

These will comply with current guidelines and be agreed with the appropriate stakeholders and are outlined in section 16.7.1. The airspace surrounding Great Yarmouth and the proposed project is well served by existing HMRs and ATC units providing an ATS. When helicopters are operating under VFR rules and VMC, aircraft can be in receipt of an ATS and be provided with traffic information on other aircraft, but ultimately pilots are responsible for their own separation from other aircraft, obstacles and terrain. Due to the low number of helicopter movements predicted in support of the construction of the proposed project, the procedures existing and the availability of existing ATS, the impact to aircraft operators in the vicinity of Norfolk Vanguard, is considered to be **not significant.**

16.7.6 Potential Impacts during Operation

16.7.6.1 Creation of an aviation obstacle

92. During the operation of the proposed project wind turbines could pose a physical obstruction to flight to aircraft in the vicinity of offshore platforms. Helicopter operators and ATC service providers have been consulted to establish if a perceived impact would be created to helicopters operating in the region of Norfolk Vanguard; potential impact to operating on HMRs was not raised as a concern by either the helicopter operators or the ATC service provider.

93. A range of specific and embedded mitigation measures (notification, lighting and marking) to minimise environmental effects would apply to the development of the proposed project. These will comply with current guidelines and be agreed with the appropriate stakeholders and are outlined in section 16.7.1.

94. Pilots are obliged to plan their flying activities in advance and to be familiar with any en-route obstacles they may encounter; however, during flight, weather conditions or operational requirements may necessitate route adjustments. Pilots are ultimately responsible for seeing and avoiding obstructions such as wind turbines and will be aware of the proposed project through notification procedures. The impact to offshore helicopter operations utilising HMRs and military low flying operations is assessed as **not significant.**

95. Norfolk Vanguard Limited has undertaken consultation with all relevant O&G operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary. Impacts on other marine users are discussed further in Chapter 18 Infrastructure and Other Users.

16.7.6.2 Wind turbines causing permanent interference on civil and military radar

96. The proposed project would be theoretically detectable by the NATS Cromer PSR and the MoD Trimingham ADR. Wind turbines detectable by PSR / ADR systems are

highly likely to degrade the system by creating false targets, reducing system sensitivity, creating radar shadowing behind the wind turbines and saturating the radar receiver leading to clutter potentially concealing real aircraft targets.

97. Mitigation of the Cromer PSR has been identified and it would be implemented prior to construction of the proposed project.

98. The MoD Trimingham TPS77 ADR has an inherent resilience, utilising hardware and software, to wind turbine induced clutter through the use of pulse Doppler processing; however, where the inherent radar performance is not considered to be satisfactory for ADR purposes, the TPS77 has an enhanced signal processing capability which enables the implementation of a NAIZ.

99. A NAIZ prevents the radar from automatically creating tracks from any returns that originate within the NAIZ. In creating an NAIZ around a wind farm, none of the wind turbine returns will be processed, thereby significantly reducing the possibility of unwanted tracks. Tracks which have been formed from returns originating outside the NAIZ (an aircraft transiting through the NAIZ), will still be tracked. The MoD is reported to be satisfied that the Trimingham ADR adequately mitigates the Sheringham Shoal Wind Farm however, in response to statutory consultation the MoD (DIO) have indicated that it should not be assumed that NAIZ mitigation will be technically or operationally acceptable to mitigate the impact of Norfolk Vanguard on the Trimingham ADR. It is expected that a technical solution / mitigation will be agreed with the MoD prior to construction, however, Vattenfall is still awaiting feedback on the operational impacts and acceptability of the latest layout proposals, which were submitted to the MoD in July 2017; consultation with the MoD (DIO) continues.

100. It is anticipated that the potential risk posed to civil and military radar systems will be wholly and successfully mitigated through the application of technical solutions to the two radar systems, consultation with the MoD (DIO) continues with the expectation that a technical mitigation solution will be agreed as has been agreed for the Sheringham Shoal Wind Farm. Mitigation of the Cromer PSR has been agreed with NATS which will remove impact on the PSR. Until mitigation is agreed with the MoD; the impact to the Trimingham ADR without mitigation is considered to be of **major significance**. Mitigation of the Trimingham ADR will be agreed with the MoD which will remove the impact created by Norfolk Vanguard which will reduce the impact to **not significant**.

16.7.6.3 Increased air traffic in the area related to wind farm activities

101. The operational phase may see increased helicopter air traffic over the proposed project in support of operational and maintenance missions. The effect of this is to create a slight increase in the potential risk of a mid-air collision between aircraft

engaged in such operations and / or aircraft in transit across the proposed project. A range of embedded mitigation measures (notification, lighting and marking) to minimise environmental effects would apply to the development of the proposed project. These will comply with current guidelines and be agreed with the appropriate stakeholders and are outlined in sections 16.7.1 and 16.7.2. The safety of aircraft operating in the uncontrolled airspace immediately above the proposed project ultimately resides with aircrew, who may request the provision of an ATS that would be provided in accordance with national procedures. The infrastructure and provision of an appropriate level of ATS and the see and avoid principle is considered to reduce potential impacts to **not significant**.

16.7.7 Potential Impacts during Decommissioning

16.7.7.1 Creation of an aviation obstacle

102. During the decommissioning phase, the presence and movement of decommissioning infrastructure may present a potential collision risk to aircraft in the vicinity.

103. A range of mitigation measures (notification, lighting and marking) to minimise environmental effects would apply to the decommissioning of the proposed project. These will comply with current guidelines and be agreed with the appropriate stakeholders and are outlined in section16.7.2. Pilots are obliged to plan their flying activities in advance and to be familiar with any en-route obstacles they may encounter; however, during flight, weather conditions or operational requirements may necessitate route adjustments. Pilots are ultimately responsible for seeing and avoiding obstructions such as wind turbines and decommissioning infrastructure and will be aware of the proposed project through notification procedures. The impact to offshore helicopter operations and military low flying operations is assessed as **not significant**.

104. Norfolk Vanguard Limited has undertaken consultation with all relevant Offshore Platform Operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary.

16.7.7.2 Wind turbines causing permanent interference on civil and military radar

105. During the gradual decommissioning of above sea level infrastructure at the proposed project, the impact on radar would be incrementally reduced. Firstly, as wind turbines are decommissioned and the blades cease rotation, before being removed from the site. In addition, any agreed mitigation will be maintained until the last wind turbine is non-operational and unable to rotate in the decommissioning phase. The impact on radar during decommissioning is therefore expected to be **no change**, as the site is returned to pre-development conditions.

16.7.7.3 Increased air traffic in the area related to wind farm activities

106. The use of helicopters during the decommissioning phase of the proposed project could impact on aircraft operations in the vicinity of Norfolk Vanguard. Due to the low number of movements predicted during the decommissioning period of the proposed project, the existing mitigation inherent for operation on HMRs and operating in uncontrolled airspace and the availability of existing ATS and by complying with embedded mitigation outlined in sections 16.7.1 and 16.7.2, the impact to aircraft operators in the vicinity of the proposed project, including those using the HMRs, is expected to be **not significant**.

16.8 Cumulative Impacts

107. Cumulative impacts refer to impacts upon receptors arising from the proposed project when considered alongside other proposed developments and activities and any other reasonably foreseeable project(s) proposals. In this context the term projects is considered to refer to any project with comparable effects and is not limited to offshore wind projects.

108. In assessing the potential cumulative impact(s) for Norfolk Vanguard, it is important to bear in mind that for some projects, predominantly those 'proposed' or identified in development plans etc. may or may not actually be taken forward. There is thus a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, relevant projects / plans that are already under construction are likely to contribute to cumulative impacts with Norfolk Vanguard whereas projects / plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors.

109. By virtue of its distance from centres of aviation activity, the proposed project produces fewer direct adverse effects on aviation operations than an equivalent onshore development. In the case of Norfolk Vanguard, aviation impacts are confined to the introduction of a remote obstacle environment, the effect of wind turbine detection on the Cromer PSR and the Trimingham ADR, and the increase of air traffic in the vicinity of the proposed project. The potential for cumulative impact created by the radar detection of the Norfolk Vanguard OWF exists to those radar systems that will also detect the wind farm developments listed in Table 16.8 below.

110. With specific and embedded mitigation in place the cumulative impact to the use of military low flying is considered to be **not significant**.

111. Without mitigation for radar a wind farm in operational range of the radar system will likely create cumulative effects in terms of the area affected by radar clutter and the distances between areas of clutter on the RDDS. Following implementation of mitigation, it can be expected that the stand-alone and cumulative effects of the

proposed project in terms of the Cromer PSR, for which mitigation has been secured in a commercial agreement, are also reduced in proportion to this reduced level of local impact and are therefore assessed as **not significant**. In terms of the Trimingham ADR, without mitigation in place the cumulative impact on the ADR system remains of **major significance,** with mitigation in place the residual impact are likely to be **not significant**.

112. In broader ATS terms, the establishment of Norfolk Vanguard in the southern North Sea provides for adequate airspace around the development in which aircraft can be operated to enable the prescribed radar separation standards to be achieved without incurring adverse impacts from other developments, either onshore or offshore and therefore the affect to civil and military provision of ATS is assessed as **no change**.

113. The construction, operation and decommissioning phases may see increased helicopter air traffic over the proposed project in support of logistics missions; however, they are specific to the project. The effect of this is to create a slightly increased potential risk of a mid-air collision between aircraft engaged in such operations and / or aircraft in transit across the proposed project. A range of embedded mitigation measures (notification, lighting and marking) to minimise environmental effects would apply to the development of the proposed project. These will comply with current guidelines and be agreed with the appropriate stakeholders and are outlined in sections 16.7.1 and 16.7.2. The safety of aircraft operating in the uncontrolled airspace immediately above, and around, the proposed project ultimately resides with aircrew, who may request the provision of an ATS that would be provided in accordance with national procedures. With the infrastructure and provision of an appropriate level of ATS, and embedded measures to be adopted, potential cumulative impacts of increased helicopter traffic are considered **not significant**. Table 16.7 provides a summary of the potential for cumulative impacts.

Table 16.7 Potential cumulative impacts

Impact	Potential for cumulative impact	Data confidence	Rationale
Creation of an aviation obstacle	No	High	Aircraft captains have the responsibility for the safety of their aircraft and are required to avoid any obstacle by legislated minimum distances. There would be no cumulative effects from the establishment of the proposed project.
Wind turbines causing permanent interference on civil and military radar	Yes, until mitigation is in place	High	The proposed project is approximately 66 to 91 km, from existing offshore wind farm developments located in the southern North Sea. Other developments are at a sufficient distance in ATS terms that they would not

Impact	Potential for cumulative impact	Data confidence	Rationale
			create cumulative impacts on aviation operations in the area of Norfolk Vanguard. With respect to onshore wind farm sites, these would all be of a sufficient distance from the proposed project that there would be no cumulative effects on aviation operations that arise from any combined adverse impacts. Adjacent offshore wind farms have the potential to create a cumulative effect on radar systems similarly impacted by the development of Norfolk Vanguard. Norfolk Boreas is being developed by Norfolk Boreas Limited and it is anticipated that mitigation for Norfolk Vanguard will be equally suitable for the effects Norfolk Boreas will create to identified radar systems. Similarly, it is assumed that operational wind farms and those proposed will mitigate their effects on aviation radar; therefore, any potential for a cumulative effect will be removed once mitigation is in place for current and future wind farms.
Increased air traffic in the area related to wind farm activities	No	High	The area in the vicinity of the proposed project is likely to see increased helicopter air traffic over the current baseline levels due to the use of helicopters in the provision of operational support. The implementation of specific and embedded mitigation outlined in sections 16.7.1 and 16.7.2, the reliance of pilots to comply with the rules of the air and the distances between other wind farms included in the cumulative assessment is expected to nullify any possibility of cumulative impact.

Table 16.8 Summary of projects considered for the CIA in relation to aviation

Project	Status	[5]Distance from Norfolk Vanguard OWF sites (km)	Distance from Norfolk Vanguard offshore cable corridor (km)	Project definition	Included in CIA	Rationale
Norfolk Boreas	Planning	1	N/A	Planning information available	Yes	Proximity to proposed project
East Anglia ONE	Under Construction	49	N/A	Consented information available	Yes	Proximity to proposed project.
Dudgeon Offshore Wind Farm	Commissioned	66	N/A	Consented information available	Yes	Proximity to proposed project
Race Bank	Commissioned	99	N/A	Consented information available	Yes	Proximity to proposed project
Triton Knoll	Consented	101	N/A	Consented information available	Yes	Proximity to proposed project
Hornsea Project 1	Consented	95	N/A	Consented information available	Yes	Proximity to proposed project
Hornsea Project 2	Consented	107	N/A	Consented information available	Yes	Proximity to proposed project
Hornsea Project 3	Planning	73	N/A	Planning information available	Yes	Proximity to proposed project
East Anglia THREE	Consented	0	N/A	Consented information available	Yes	Proximity to proposed project

[5] Shortest distance between the considered project and Norfolk Vanguard – unless specified otherwise.

Project	Status	[5]Distance from Norfolk Vanguard OWF sites (km)	Distance from Norfolk Vanguard offshore cable corridor (km)	Project definition	Included in CIA	Rationale
East Anglia TWO	Planning	56	N/A	No information available	Yes	Proximity to proposed project
East Anglia ONE North	Planning	38	N/A	No information available	Yes	Proximity to proposed project

114. Table 16.8 above provides a summary of projects considered for the CIA in relation to aviation. There may be an element of uncertainty associated with the design envelope of proposed projects; therefore, a judgement is made on the confidence associated with the latest available design envelope.

115. Radar LOS modelling has not been completed for those projects listed above. For radar systems for which impacts are not mitigated, it is assumed that any effects are deemed acceptable; however, the addition of further unmitigated clutter created by the Norfolk Vanguard OWF could create a cumulative effect where existing detectable wind turbines are currently considered manageable. Those developments which are detectable by the Trimingham ADR are likely to create a cumulative effect until they are mitigated however; it is considered that those other developments similarly detectable by the Trimingham ADR will be subject to a mitigation requirement to remove impact and therefore there will be no cumulative impact.

16.9 Transboundary Impacts

116. Other EU member states that could be impacted by the proposed project are detailed in Table 16.9.

Table 16.9 List of other EU Member States retained in the transboundary impact assessment in relation to the topic

EU member state	Commentary
Netherlands	Norfolk Vanguard would be located adjacent to and abutting the London / Amsterdam FIR. HMR KZ50 which is located in the Amsterdam FIR is a continuation of HMRs originating in the London FIR in UK airspace (HMRs 447 and 450) which cross the Norfolk Vanguard OWF sites.

117. The strategies applied to mitigate any impact to UK HMRs should be equally effective in the Netherlands as aviation operations are regulated by international criteria. Consultation with helicopter operators based in the UK, Netherlands and Belgium has been completed with no concerns expressed by helicopter operators or the UK ATS provider of an impact to operations on HMRs, the impact has been assessed to be of **no significance**.

118. During consultation for the East Anglia Zone which is considered relevant for Norfolk Vanguard, both the Dutch Ministerie Van Defensie and LVNL considered that there would be no effect to their radar or infrastructure, whilst ILT requested that any aviation lighting requirement should be in accordance with UK requirements. Both Netherlands ATC (LVNL) and the Dutch Air Force (Dutch Ministerie Van Defensie) have confirmed that there will be no impact to their operations created by Norfolk Vanguard. The transboundary impact with regard to charting, lighting and marking of

wind turbines and radar operations is considered to be limited and to be **not significant**.

16.10 Inter-relationships

119. This chapter has an inter-relationship with Chapter 15 Shipping and Navigation. Aviation lighting to offshore wind turbines could cause confusion to maritime activities as the specification for lighting to be displayed below the horizontal plane of the light fitment itself could cause mariners some confusion. To resolve concerns from the maritime community, work to develop an aviation warning light standard which is clearly distinguishable from maritime lighting has been undertaken. Within CAP 764 (CAA, 2016a) the CAA state that where it is evident that the default aviation warning lighting standard for offshore obstacles may generate issues for the maritime community, a developer can make a case, that is likely to receive CAA approval, for the use of a flashing red Morse Code Letter 'W' instead. *MCA state that 'the boundary turbines, where they are more than 900 m apart, must be lit with a single 2000 candela, red aviation light, flashing Morse 'W' in unison with all other boundary turbines. All other turbines must be fitted with a fixed single red 200 candela aviation light, visible through 360°, for SAR purposes'*. There is however, no intent to change the lighting intensity specifications set out for offshore obstacles; indeed, those specifications remain the default aviation warning lighting requirement. Provision is made within CAP 393 that requires the reduction in lighting intensity at or below the horizontal and allows for a further reduction in lighting intensity when the visibility in all directions from every wind turbine is more than 5 km. Table 16.10 provides chapter topic relationships.

Table 16.10 Chapter topic inter-relationships

Topic and description	Related Chapter	Where addressed in this Chapter	Rationale
Aviation obstruction lighting	Chapter 15 Shipping and Navigation	Section 16.10	Potential confusion to the maritime community caused by aviation obstruction lighting

16.11 Interactions

120. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The worst case impacts assessed within the chapter take potential for interactions into account. The potential for individual impacts identified through the impact assessment to interact and create new or more significant impacts on aviation and radar has been assessed. No such interactions have been identified.

16.12 Summary

121. Table 16.11 presents a summary of the impact assessment undertaken with respect to the proposed project in relation to Aviation and Radar, which is discussed in section 16.6.

Table 16.11 Potential impacts identified for aviation

Potential Impact	Receptor	Significance	Mitigation	Residual Impact
Construction				
Creation of an aviation obstacle	Oil and Gas platform operators and the use of specific helicopter operations to / from offshore oil and gas platforms	Not significant	Norfolk Vanguard Limited has undertaken consultation with all relevant Offshore Platform and helicopter Operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary.	**Not significant**
Wind turbines causing permanent interference to civil and military radar	NATS Cromer PSR MoD Trimingham ADR	No change	N/A	**N/A**
Increased air traffic in the area related to wind farm activities	Helicopters operating in support of Norfolk Vanguard	Not significant	N/A	**N/A**
Operation				
Creation of an aviation obstacle	Oil and Gas platform operators and the use of specific helicopter operations to / from offshore oil and gas platforms	Not significant	Norfolk Vanguard Limited has undertaken consultation with all relevant Offshore Platform and helicopter Operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary.	**Not significant**
Wind turbines causing permanent interference to civil and military radar	NATS Cromer PSR MoD Trimingham	Major Significance	A mitigation agreement between Norfolk Vanguard Limited and NATS will remove any impact to the Cromer PSR subject to regulatory approval of the TMZ	**Not significant**

Potential Impact	Receptor	Significance	Mitigation	Residual Impact
	ADR		solution by the CAA. Consultation with the MoD (DIO) is continuing, mitigation of the Trimingham ADR will be agreed with the MoD which will remove the impact created by Norfolk Vanguard.	
Increased air traffic in the area related to wind farm activities	Helicopters operating in support of Norfolk Vanguard	Not significant	N/A	**N/A**
Decommissioning				
Creation of an aviation obstacle	Oil and Gas platform operators and the use of specific helicopter operations to / from offshore oil and gas platforms	Not significant	Norfolk Vanguard Limited has undertaken consultation with all relevant Offshore Platform and helicopter Operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary.	**Not Significant**
Wind turbines causing permanent interference to civil and military radar	NATS Cromer PSR MoD Trimingham ADR	No change	Technical mitigation for the impacts of wind turbine detectability by radar systems will remain operational until the last wind turbine is decommissioned and incapable of rotation.	**N/A**
Increased air traffic in the area related to wind farm activities	Helicopters operating in support of Norfolk Vanguard	Not significant	N/A	**N/A**
Cumulative				
Norfolk Boreas Offshore Wind Farm, East Anglia THREE Wind Farm – Creation of an aviation obstacle	IFR ARA helicopter operations to offshore oil and gas platforms and the continuation of emergency evacuation procedures	Not significant	Norfolk Vanguard Limited has undertaken consultation with all relevant Offshore Platform and helicopter Operators, during which no specific concerns were raised and it is expected that users could co-exist. This will be managed through coexistence agreements where necessary.	**Not Significant**

Potential Impact	Receptor	Significance	Mitigation	Residual Impact
Norfolk Boreas Offshore Wind Farm, East Anglia ONE and THREE, Scroby Sands, Greater Gabbard, Galloper Wind Farm, Dudgeon, Race Bank, Triton Knoll, Hornsea 1, 2, 3 – wind turbines causing interference to civil and military radar	NATS Cromer PSR MoD Trimingham ADR	Major Significance	Mitigation of the two radar systems would remove any cumulative impact of the project as it is considered that mitigation will be required for wind farm developments that are similarly detectable by the two radar systems.	**Not Significant**
Norfolk Boreas Offshore Wind Farm, East Anglia THREE Wind Farm – increased air traffic in the area related to wind farm activities	Helicopters operating in support of Norfolk Vanguard	Not significant	N/A	**N/A**
Transboundary				
Impacts to aircraft operators using HMR KZ50	Helicopters using HMR which transit the proposed project	Not Significant	N/A	**Not significant**
Impacts on Dutch PSR	LVNL Ministerie Van Defensie	Not significant	N/A	**Not significant**

16.13 References

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