Norfolk Vanguard & Norfolk Boreas Windfarms

Vanguard & Boreas Windfarms Gateway documentation: Stage 2 Develop and Assess

2A(i): Airspace Change Design Options

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Action	Role	Date
Produced	Airspace Change Specialist NATS	July 2020
Reviewed Approved	Manager, Airspace Change Compliance and Delivery NATS	July 2020
Reviewed Approved	Senior Strategy Advisor- Aviation Vattenfall Wind Power Ltd	August 2020
Reviewed Approved	Aviation Consultant Osprey Consulting Services	August 2020

Publication history

Issue	Month/Year	Change Requests in this issue
Issue 0.2	July/ 2020	First issue shared with stakeholders
Issue 1.0	August/ 2020	Submitted to CAA

Contents

1. Introduction

1.1 This document forms part of the document set required in accordance with the requirements of the Civil Aviation Publication (CAP) 1616 airspace change process.

1.2 This document aims to provide adequate evidence to satisfy Stage 2 Develop and Assess Gateway, Step 2A Airspace Change Design Options

2. Options development – brief history

2.1 In total, the proposed windfarms, Norfolk Boreas and Norfolk Vanguard, will cover an area of approx. 1300 kilometres (km)^2. The site shown in Figure 1, is located more than 47 km off the Norfolk coast at its closest point. Offshore consent has been granted for the Norfolk Vanguard windfarm (July 2020). A consent decision for Norfolk Boreas is expected to be reached in 2021.

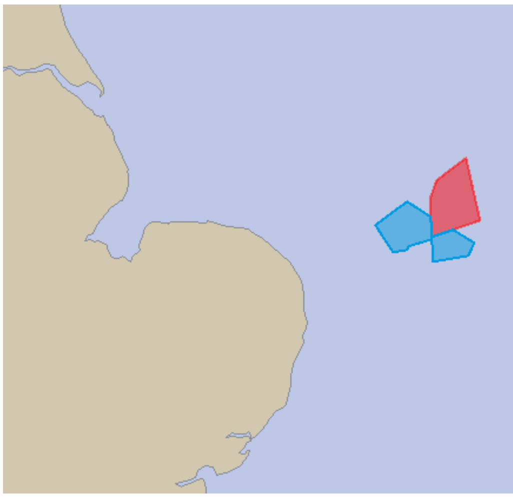

Figure 1: Norfolk Vanguard (Blue) and Norfolk Boreas (Red) wind farm locations.

2.2 Planning consent has been granted for the Norfolk Vanguard development. Condition 34 has been included within the consent that a Primary Radar Mitigation Scheme (PRMS) for the Cromer Primary Surveillance Radar (PSR) has been implemented prior to the installation of any Wind Turbine Generators (WTGs). It is anticipated that the consent for Norfolk Boreas, when received, will contain the same condition. As such, a PRMS is required to cover both the Norfolk Vanguard and Boreas sites.

Condition 34	Cromer PSR	No erection of any wind turbine generator forming part of the authorised development may commence until the Secretary of State having consulted with NATS has confirmed satisfaction in writing that appropriate mitigation will be implemented and maintained for the lifetime of the authorised development and that arrangements have been put in place with NATS to ensure that the approved mitigation is implemented and in operation prior to erection of the wind turbine generators.

2.3 Detection of the WTGs on the radar would have the potential to cause unwanted primary radar returns to be displayed to an Air Traffic Control Officer (ATCO). This radar "clutter" could obscure primary returns from actual aircraft and could also interfere with radar tracking. This could affect an ATCO's ability to identify primary radar returns and increase the risk of the controller not detecting a conflict between aircraft. Large numbers of WTGs could also lead to a saturation of the radar processing systems.

2.4 Previous windfarm developments have explored a variety of options to mitigate this risk with Range Azimuth Gating (RAG), commonly known as radar blanking, implemented in previous developments, alongside a Transponder Mandatory Zone (TMZ). The other potential mitigation options which have been considered are technical, non-airspace options, which are explained in Annex B. These other potential mitigation options do not involve change to airspace, and hence are outside of the Civil Aviation Authority (CAA) CAP1616 Airspace Change Process. Hence, they are included for information in Annex B but are not evaluated as airspace change options within the CAP1616 framework.

2.5 This document evaluates the options considered against the design principles and presents the basis upon which decisions to proceed or reject options has been made. This document provides one proposal for mitigating the radar clutter associated with wind farm WTGs, (RAG blanking with TMZ) with 4 options as to how this could be implemented:

1. Option A: RAG Blanking and TMZ over the proposed windfarm locations.
2. Option B: RAG Blanking over the proposed windfarm locations. TMZ extended to include a 2 nautical mile (NM) buffer.
3. Option C: RAG Blanking over the proposed windfarm locations. Simplified polygon TMZ "rubber banded"[1] around proposed windfarm locations with no buffer.
4. Option D: RAG Blanking over the proposed windfarm locations. Simplified polygon TMZ "rubber banded" around proposed windfarm locations extended to include a 2 NM buffer.

2.6 The design principles used to evaluate these options are as described in detail in the Design Principles document (Stage 1 Gateway Assessment).

3. Stakeholder Engagement on Options Development

3.1 Engagement during Stage 2 has been with the stakeholders identified during Stage 1

3.2 Responses were received from 5 stakeholders supporting Option D, including; NATS En route, the Ministry of Defence (MOD), Aberdeen Air Traffic Control (ATC), NHV Helicopters and CHC Scotia. LVNL responded supporting Option C or D, the addition of a 2 NM buffer surrounding the TMZ would not affect their operation. Babcock Helicopters and The British Gliding Association responded that the ACP was not applicable due to its location.

3.3 The full list of stakeholder engagement is included as Annex D and evidenced in Annex E.

[1] Rubber banded- Shortest perimeter fully enclosing the wind farm development. It is used to smooth an irregular perimeter.

4. Proposal - Radar Range Azimuth Gating with Associated Transponder Mandatory Zone (TMZ)

4.1 RAG (commonly referred to as Radar Blanking), is the mitigation solution which is being proposed (see Annex A for a full description of this). RAG will need to be deployed over the area of the consented windfarm before it is constructed to prevent detection of radar returns from the WTGs. However, RAG will also remove primary radar returns from aircraft within the blanked area. To mitigate this removal of primary radar coverage, it is necessary to establish a TMZ over the consented windfarm so that only aircraft equipped with a transponder and hence visible via secondary radar, will be permitted to overfly the windfarm (RAG area). Hence all aircraft overflying the wind farm will need to be transponder equipped and will be visible to ATC. All commercial and military aircraft are transponder equipped. Only a small proportion of private General Aviation (GA) aircraft (e.g. vintage aircraft) are not transponder equipped. Note: analysis of 2 weeks of radar data (1st -14th August 2019) in the Norfolk Vanguard and Boreas windfarms area showed that out of 9855 aircraft transiting the region only 15 did not operate a transponder and hence were only detected by primary radar only. This represents <0.16% of flights.

Options Considered:

4.2 Do nothing

No mitigation against radar clutter. This option assumes that the wind farm is built but no measures are implemented to prevent radar clutter & interference. This option does not satisfy the suspensive condition 34 and would not meet the safety Design Principle, *DP1- Maintain or enhance current levels of safety*. As such the windfarm would not be built. It is included as a baseline for comparison only.

4.3 Option A: RAG Blanking and TMZ over the proposed windfarm locations

4.3.1 Figure 2 below shows the “Option A” TMZ which aligns with the proposed WTG locations. This option provides the minimum TMZ cover required to restrict non-transponder equipped aircraft overflying the RAG blanked area.

4.3.2 This is the same area that would be blanked on the Radar system by the RAG blanking. Hence a non-transponder equipped aircraft (primary radar only returns) would disappear from the radar screen if it inadvertently crosses into the red area and enters the RAG blanked region.

4.3.3 This option produces an irregularly shaped TMZ which will make it overly complicated for pilots and ATCOs alike. This could lead to a potential Human Factors issue.

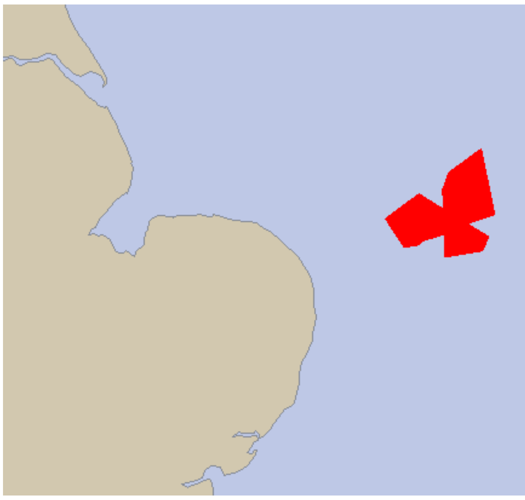

Figure 2: TMZ (Red shape) over the proposed windfarm locations

4.4 Option B: RAG Blanking over the proposed windfarm locations. TMZ extended to include a 2 NM buffer

4.4.1 Figure 3 below shows the proposed "Option B" TMZ which is designed to be aligned with the proposed WTG locations plus a 2 NM buffer.

4.4.2 The introduction of a 2 NM TMZ buffer is intended to give ATC some warning (and hence time to react) between a non-transponder equipped aircraft infringing the TMZ and it disappearing from the radar screen. For example, an aircraft travelling at 200 knots (kts) will take 36 seconds if heading directly into the TMZ, from crossing the proposed TMZ boundary to entering the RAG blanked region (and then disappearing). Hence the air traffic controller monitoring the radar will have 36 seconds to notice that the aircraft has infringed the TMZ before it disappears from the radar display.

4.4.3 Like Option A, this option still produces an irregularly shaped TMZ which will make it overly complicated for pilots and ATCOs alike.

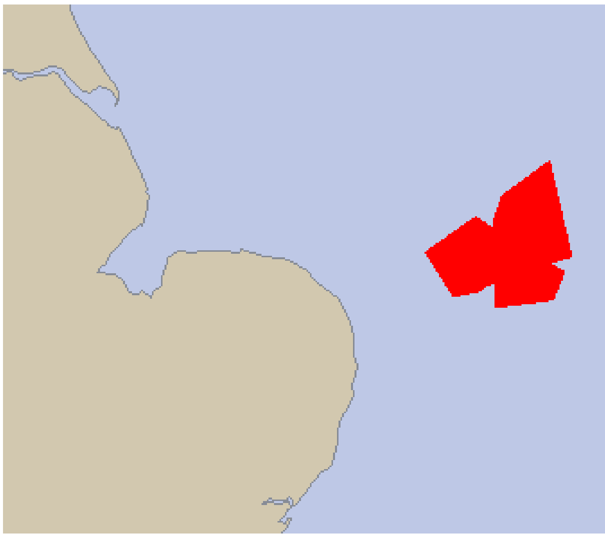

Figure 3: TMZ over the proposed WTG locations extended to include a 2 NM buffer

4.5 Option C: RAG Blanking over the proposed windfarm locations. Simplified polygon TMZ "rubber banded" around proposed windfarm locations with no buffer.

4.5.1 Figure 4 below shows the proposed "Option C" TMZ. This is designed to be a simplified polygon surrounding the locations of the proposed WTGs with no buffer. The proposed option is similar to "Option A" but provides a simplified boundary shape.

4.5.2 This design is advantageous for pilots to display on in-cockpit electronic flight information systems (EFIS) and ATCOs on radar displays. As such this is preferable for Human Factors reasons.

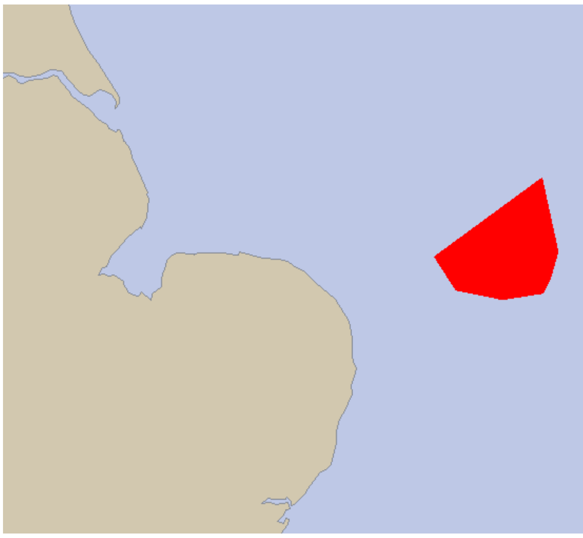

Figure 4: Simplified polygon TMZ "rubber banded" around proposed windfarm locations with no buffer.

4.6 Option D: RAG Blanking over the proposed windfarm locations. Simplified polygon TMZ "rubber banded" around proposed windfarm locations extended to include a 2 NM buffer

4.6.1 Figure 5 below shows the proposed "Option D" TMZ. This option is an amalgamation of "Options B and C". It combines the advantages of the simplified TMZ shape with the benefit of the 2 NM buffer.

4.6.2 The simplified shape of the TMZ boundary is advantageous for the simplicity of display to pilots on in-cockpit EFIS displays and ATC operators on radar displays. As such this is preferable for Human Factors reasons.

4.6.3 The introduction of a 2 NM TMZ buffer is intended to give ATC some warning (and time to react) between a non-transponder equipped aircraft infringing the TMZ and it disappearing from the radar screen. For example, an aircraft travelling at 200 kts will take 36 seconds if heading directly into the TMZ, from crossing the proposed TMZ boundary to entering the RAG blanked region (and then disappearing). Hence the ATCO monitoring the radar will have 36 seconds to notice and rectify that the aircraft has infringed the TMZ before it disappears from the radar display

4.6.4 This option has been utilised as a PRMS in previous wind farm developments requiring mitigation.

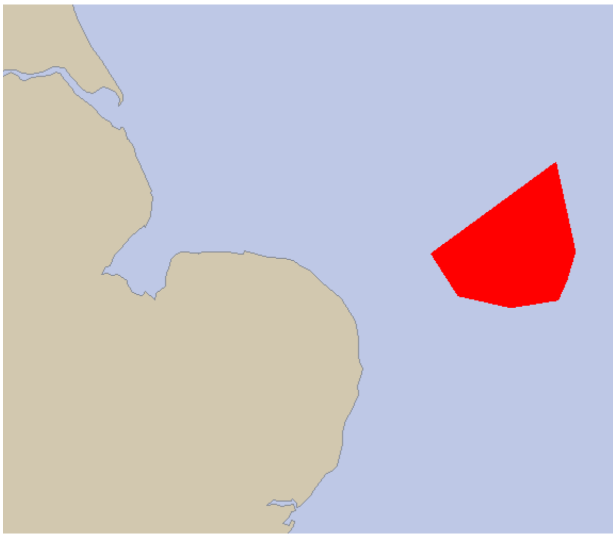

Figure 5: Simplified polygon TMZ "rubber banded" around proposed windfarm locations extended to include a 2 NM buffer

Annex A: Background Information

Background information

Primary Surveillance Radar (PSR): a conventional radar sensor that illuminates a large portion of space with an electromagnetic wave and receives back the reflected waves from targets within that space. Primary radar detects all aircraft (and other objects, such as flocks of birds, weather phenomena, other environmental factors and WTGs) without selection, regardless of whether or not they possess a transponder. It can also detect and report the position of anything that reflects its transmitted radio signals, including the rotating blades of the WTGs. It indicates the position of targets but does not identify them. Because WTG blades are moving targets, it is hard for a radar to distinguish them from aircraft. Radar data processing connects returns from successive sweeps of the radar, and from this infers speed. Multiple WTGs in a wind farm create multiple radar returns and these can appear as stationary or rapidly moving primary returns on the radar display.

Secondary Surveillance Radar (SSR): Secondary radar works together with transponders which are installed on the aircraft. The ground based SSR radar interrogates the transponder which transmits a signal which is captured by the radar. The information transmitted by the transponder identifies the aircraft, along with details as to aircraft altitude etc. (note that transponder equipage is mandatory for instrument flight, and flight above FL100. As such all commercial aircraft and the vast majority of general aviation aircraft are transponder equipped.)

Composite Radar. The radar displays used by ATC have feeds from multiple primary and secondary radar sensors. Hence a non-transponder-equipped aircraft will still be picked up by primary radar and displayed. Those with transponders are picked up by both primary and secondary radar, and hence more information with enhanced accuracy is provided to ATC.

Primary Radar RAG blanking. RAG radar blanking blocks *any* primary radar return within selected ranges and azimuth sectors. This can be mapped to suppress plots within WTG clutter regions. However, the primary blanking in any given area is complete, hence the primary return from any aircraft entering this area would also be suppressed. Thus, the aircraft would not appear on the radar unless they were operating with a transponder, and hence detected by the SSR.

Transponder Mandatory Zone. Where a TMZ is implemented it helps to ensure that aircraft are equipped with a transponder, so that they can continue to be detected over a RAG blanked area (e.g. above a wind farm). Non-transponding aircraft would not be allowed within the confines of the TMZ.

> Impact. Transponding aircraft should be unaffected by the windfarm. Non-transponding aircraft would not be permitted to overfly the windfarm and would be required to route around it. If a non-transponding aircraft were to infringe the TMZ and overfly the radar blanked windfarm they would be invisible to radar due to the RAG blanking. Therefore, a TMZ buffer surrounds the blanked area so that the ATCO has time to spot and react to any infringing aircraft before they enter the blanked area.
>
> Viability. This is a viable mitigation.

Annex B: Non-airspace Options:

Additional options that have been considered which do not require airspace change are as follows.

i) Extending the radar coverage of a second PSR to provide infill coverage for the Cromer PSR

This involves extending the range of another radar station and blanking out the affected area at Cromer.

This option has previously been investigated without success for other windfarm developments e.g. Moray Offshore Windfarm (East) Ltd and Beatrice Offshore Wind farm Ltd.

Viability. Experience from previous flight trials has demonstrated that this is highly unlikely to meet the safety design principle, it is not a viable option for the Norfolk Boreas and Norfolk Vanguard developments. Hence this option has been discounted.

ii) Project RM - Raytheon upgrade to the Cromer PSR

This involves converting the Cromer radar to one that is not affected by WTGs.

Impact. At an early stage of development and testing, this project is not easy to implement and requires limited new hardware and substantial software and set-up changes. The cost of this option would be in the range of £12 – 15 million

Viability. This is an expensive option and at the current time does not have sufficient operational assurance to meet the safety design principle. Hence this is not a viable option and has been discounted.

iii) Installation of a new PSR

This option is to install a new radar within 50 NM of the furthest reaches of the development. The site would need to be inland to provide terrain shielding of the WTGs that could provide cover for the area blanked out at Cromer.

Impact. The criteria for ensuring acceptable operation of the new radar limits the locations for radar siting as suitable land for siting the radar may not be available to purchase or lease for the lifetime of the wind farm. Planning consents will also be required for any new radar.

Viability. The Norfolk Vanguard and Boreas sites extends to ~60 NM offshore. This is beyond the required range for this option. This option would also require the purchase of land, provision of power, and telecommunications links suitable for the new primary radar and the most expensive option at approx. £20 million. It could not be achieved in the required timescales. Hence this is not a viable option and has been discounted.

iv) In-fill Radar System options

There are several short range (40 NM) in-fill radar system projects, which have the aim of not being affected by WTGs and that could in future be used to provide cover for the area blanked out at Cromer – Terma Systems Radar; Aveillant Holographic Radar, and C Speed Lightwave Radar.

Impact. These systems are currently used within the UK to mitigate against Onshore windfarms but have not been evaluated for offshore windfarms. The Vattenfall site extends further than 40 NM from land. Therefore, this option would require an offshore siting which has not been evaluated before and may not be available to purchase or lease for the lifetime of the windfarm. Planning consents will also be required.

Viability. This option requires a suitable site, provision of power, and telecommunications links. These might not be available. It is estimated to have an upfront cost of at least £10.5m not including any land lease or utilities. This option is not yet viable but *could* potentially replace any PRMS in the future. Since this is not currently a viable option it has been discounted.

v) 3D Radar Upgrade to the Cromer PSR

Traditional ATC Primary Radars only provide 2-dimensional (2D) data, range and bearing to the target. As such they can-not discern the height of a target. 3D Primary Radars also provide data in a third dimension, altitude. This altitude data means that these radars can in-fill the airspace radar picture above windfarms, thus removing the need of a second radar system to in fill the radar picture.

Impact. These systems have the potential to mitigate against the interference caused by windfarms on PRS systems and they do not necessarily require a new site or installation. If the existing radar site is suitable an upgrade of existing Radar equipment is required. This option would cost approximately £15 million.

Viability. This is an expensive option that cannot be guaranteed to be achieved within the required timeframe. However, this option could potentially replace any PRMS in the future.

Annex C: Glossary

ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
EFIS	Electronic Flight Information System
GA	General Aviation
kts	Knots
NATS	National Air Traffic Services
NERL	NATS En-route plc
NM	Nautical miles
PRMS	Primary Radar Mitigation Scheme
PSR	Primary Surveillance Radar
RAG	Radar Range Azimuth Gating
SSR	Secondary Surveillance Radar
TMZ	Transponder Mandatory Zone
WTG(s)	Wind Turbine Generator(s)

Annex D: Record of Stakeholder Engagement

See separate document.

Annex E: Evidence of Stakeholder Engagement

See separate document.

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