Moray Offshore Wind Farm (West) Limited

Moray West
Gateway documentation:
Stage 2 Develop and Assess

2A(i): Airspace Change Design Options

Action	Role	Date
Produced	[redacted] - Airspace Change Specialist NATS	July 2020
Reviewed Approved	[redacted] - Manager, Airspace Change Compliance and Delivery NATS	July 2020
Reviewed Approved	[redacted] - Development Manager Moray Offshore Wind Farm (West) Ltd	August 2020
Reviewed Approved	[redacted] - Aviation Consultant Coleman Aviation	August 2020

Publication history

Issue	Month/Year	Change Requests in this issue
Issue 0.4	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 CAP1616 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 wind farm will cover an area of approx. 225 km². The site, shown in figure 1, is located 22.5 km from the Caithness coastline, with offshore consent granted for this project in 2019.

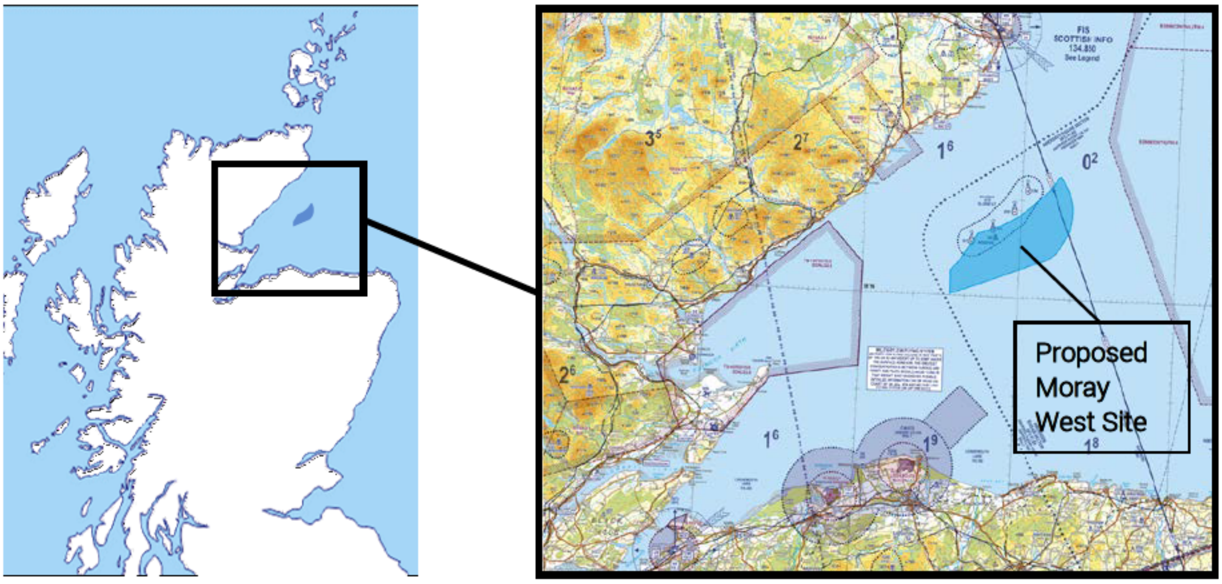

Figure 1 Moray Offshore Wind Farm (West) location

2.2 Planning consent was granted in 2019 for the Moray West Wind Farm, with the development subject to Section 36 Planning Consent Condition 23 due to the impact of this development on the Allanshill Radar. As such, a primary Radar Mitigation Scheme (PRMS) is required to be approved to meet this condition.

Condition 23	To mitigate adverse impact to the Allanshill radar and associated air traffic operations	No part of any WTG shall be erected above mean sea level until a Primary Radar Mitigation Scheme ("PRMS") has been submitted to and approved in writing by the Scottish Ministers following consultation with NATS (En Route) Public Limited Company ("NERL"). Commencement of the Development cannot take place until such approval is granted. No blades shall be fitted to any WTG until the technical mitigation measures set out in the approved PRMS have been implemented in accordance with its terms and the Development must thereafter be operated fully in accordance with such approved Primary Radar Mitigation Scheme.

2.3 Detection on the radar would have the potential to cause false 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 ATCO not detecting a conflict between aircraft. Large numbers of turbines could also lead to a saturation of the radar processing systems.

2.1 Mitigations used by Other Proximate Wind Farms

2.1.1 Moray Offshore Wind Farm (West) Ltd (MOWWL) is to be built adjacent to the Beatrice Offshore Wind Farm Ltd (BOWL) and Moray Offshore Wind Farm (East) Ltd (MOWEL) developments. These wind farms have each required a Primary Radar Mitigation Scheme (PRMS) to be in place prior to construction.

2.1.2 Previous wind farm developments have explored a variety of options to mitigate the risk, with Range Azimuth Gating (RAG) (known commonly as radar blanking) implemented in previous developments including BOWL and MOWEL, alongside a Transponder Mandatory Zone (TMZ).

2.1.3 The PRMS in place for BOWL (RAG and TMZ implemented March 2018) and MOWEL (RAG and TMZ due to be implemented January 2021) covers an eastern portion of the MOWWL site, shown in Figure 2. As such, a new PRMS will only be required to cover the western portion of the MOWWL site not covered by the MOWEL and BOWL mitigation schemes which will already in place when MOWWL is constructed.

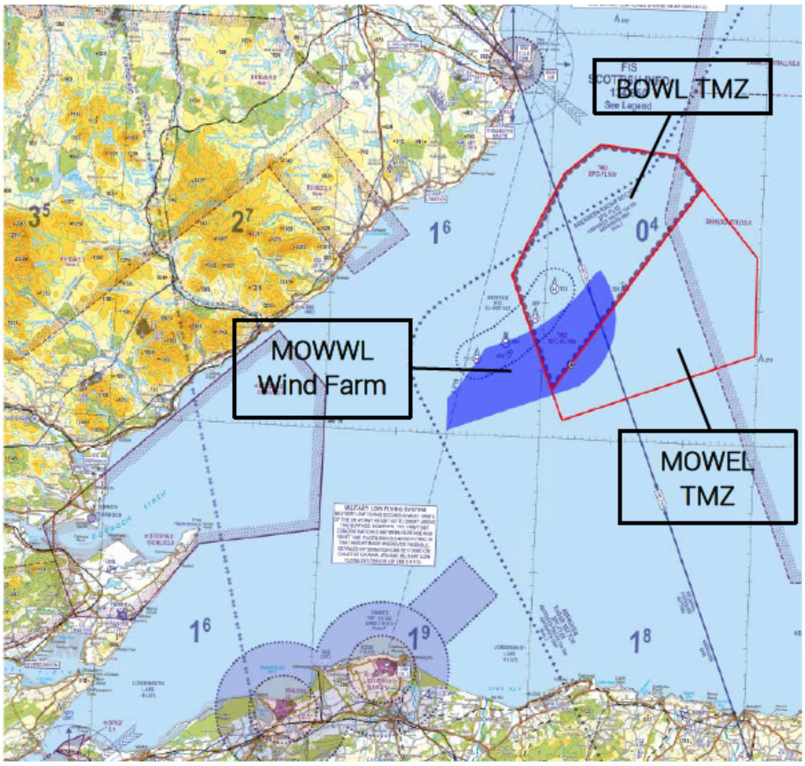

Figure 2: MOWWL site (Blue shape) with MOWEL and BOWL TMZs (Red outline) shown.

2.1.4 NERL has indicated that RAG blanking of the wind turbines with a corresponding TMZ would be an acceptable PRMS for the MOWWL site. This document proposes extending the MOWEL and BOWL mitigation schemes to cover the region of the MOWWL site not currently covered by the MOWEL and BOWL mitigation schemes. This document evaluates the options considered against the design principles and presents the basis upon which decisions to proceed or reject options have been made. This document provides 1 proposal for mitigating the radar clutter associated with wind farm Turbines

Generators (WTGs), RAG blanking of the wind farm area with a TMZ (Described in Annex A). Four options as to how this could be implemented are considered:

1. Do Nothing: Wind farm is built with no PRMS.
2. Option A: RAG Blanking of wind turbines and TMZ with no buffer implemented in line with the proposed wind turbine locations not covered by the BOWL and MOWEL TMZs.
3. Option B: Option A with a 2 NM TMZ buffer (as per the existing BOWL and MOWEL TMZs).
4. Option C: Option B with TMZ extended to align with existing and planned TMZ boundaries.

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

2.2 Alternate options in the case of MOWEL not being implemented

2.5.1 The MOWEL TMZ has been approved by the CAA and is planned to be implemented January 2021. Construction has commenced on the MOWEL site and the TMZ will be in place prior to construction commencing on MOWWL site.

2.3 Other Options

2.3.1 The other potential mitigation options which have been considered are technical (e.g. changes to radar systems), non-airspace options, which are explained in Annex B. These other potential mitigation options do not involve change of airspace, and hence are outside the scope of the CAP1616 Airspace Change Process. Two of the options (extending a second radar; and Project RM Raytheon) fail to meet the safety design principle and will not be considered. A new primary radar cannot be implemented within the required timescales so therefore is also not viable. The final two options, an upgrade to a 3D radar or an independent In-fill Radar system is emerging as a potential alternative to RAG with a TMZ in the future. This technology has been used for onshore wind farms within the UK but has not yet been evaluated for Offshore Developments. Until this is confirmed as a suitable alternative for offshore wind farm developments this option cannot be considered as a suitable mitigation scheme.

2.3.2 These five options are included for information in Annex B but are not evaluated as airspace change options within the CAP1616 framework.

3. Stakeholder Engagement on Options Development

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

3.2 Responses were received from 12 stakeholders supporting Option C, including; MoD, NATS En route, Aberdeen ATC (including Aberdeen Airport), HIAL (including Wick and Inverness Airports), Bristow Helicopters (includes MCA), NHC Helicopters, Babcock Helicopters and CHC Scotia. The British Gliding Association had indicated in the Design principle engagement that a TMZ would not affect their activities.

3.3 The full list of stakeholder engagement is published on the portal as Annex D and evidenced in Annex E.

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

4.1 Radar Range Azimuth Gating (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 wind farm before it is constructed to prevent detection of radar returns from the turbines. 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 Transponder Mandatory Zone (TMZ) over the consented wind farm so that only aircraft equipped with a transponder and hence visible via secondary surveillance radar (SSR), will be permitted to overfly the wind farm (RAG area). Hence all aircraft overflying the wind farm will need to be transponder equipped and will be visible to Air Traffic Control (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 1 month of radar data (August 2019) in the Moray West wind farm area showed that out of 962 aircraft transiting the region only 7 did not operate a transponder and hence were only detected by primary radar. This represents 0.7% of flights.

5. Options Considered

5.1 Do Nothing

5.1.1 No mitigation against radar clutter. This option assumes the wind farm is built but no measures are implemented to prevent clutter and interference. This Option would not meet the safety Design principle and is not a viable option. It is included as a Baseline comparison.

5.2 **Option A: Rag Blanking and TMZ Over the Proposed Wind Turbine Locations.**

5.2.1 Figure 3 below shows the proposed Option A TMZ which aligns with proposed wind turbine locations not covered by the existing (BOWL) and planned (MOWEL) TMZs. This option provides the minimum TMZ cover required. However, this option creates an irregular shape with existing and planned TMZ's and may make it overly complicated for pilots and ATC operators.

Note: 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 return) would disappear from the radar screen as soon as it crosses into the green area and enters the RAG blanked region.

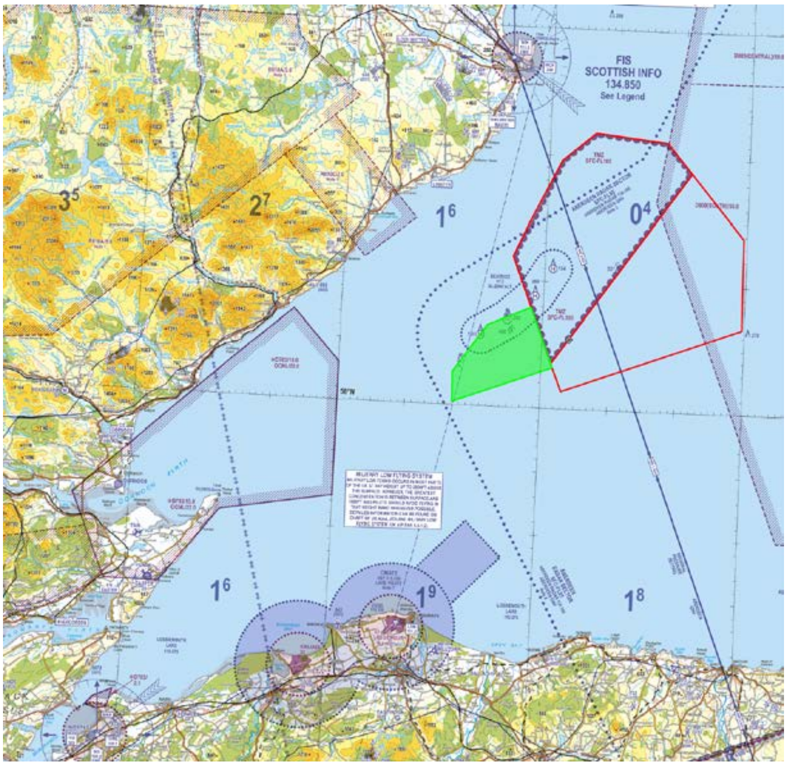

Figure 3: TMZ Aligned to proposed wind turbine locations outside of MOWEL and BOWL TMZs (green Shape), MOWEL and BOWL TMZs shown (Red shapes)

5.3 Option B: Option A with a 2 NM TMZ Buffer.

5.3.1 Figure 4 below shows the proposed Option B TMZ which is designed to be aligned with the proposed wind turbine locations not covered by the existing (BOWL) and planned (MOWEL) TMZs plus a 2 NM buffer. The 2 NM buffer is intended to give ATC some delay (and hence time to react) between a non-transponder equipped aircraft infringing the TMZ before entering the RAG blanking area and 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 that the aircraft has infringed the TMZ before it disappears from the radar display. The 2 NM buffer aligns the TMZ with the southern edge of the proposed MOWEL TMZ but leaves an irregular boundary to the north. Like option A, this irregular boundary may make it overly complicated for pilots and ATC operators.

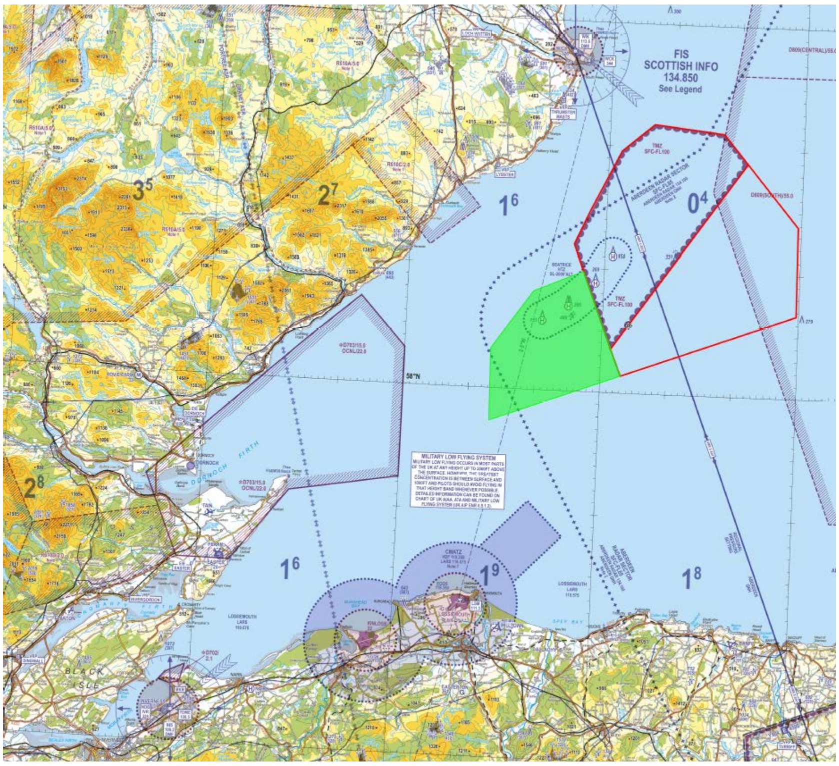

Figure 4: TMZ plus 2 NM buffer (Green shape) aligned with proposed wind turbine locations not covered by the MOWEL and BOWLTMZs (Red shapes)

5.4 Option C: Option B with TMZ extended to align with existing and planned TMZ boundaries.

5.4.1 Figure 5 below shows the proposed Option C which benefits from a simplified shape and aligns the TMZ boundaries with the BOWL (existing) and MOWEL (planned) TMZs and incorporating a 2 NM buffer. The 2 NM buffer is intended to give ATC some delay (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 kts will take 36 seconds if heading directly into the TMZ, from crossing the proposed TMZ boundary to entering the RAG blanked region (and disappearing). Hence the air traffic ATCO monitoring the radar will have 36 seconds to notice that the aircraft has infringed the TMZ before it disappears from the radar display.

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

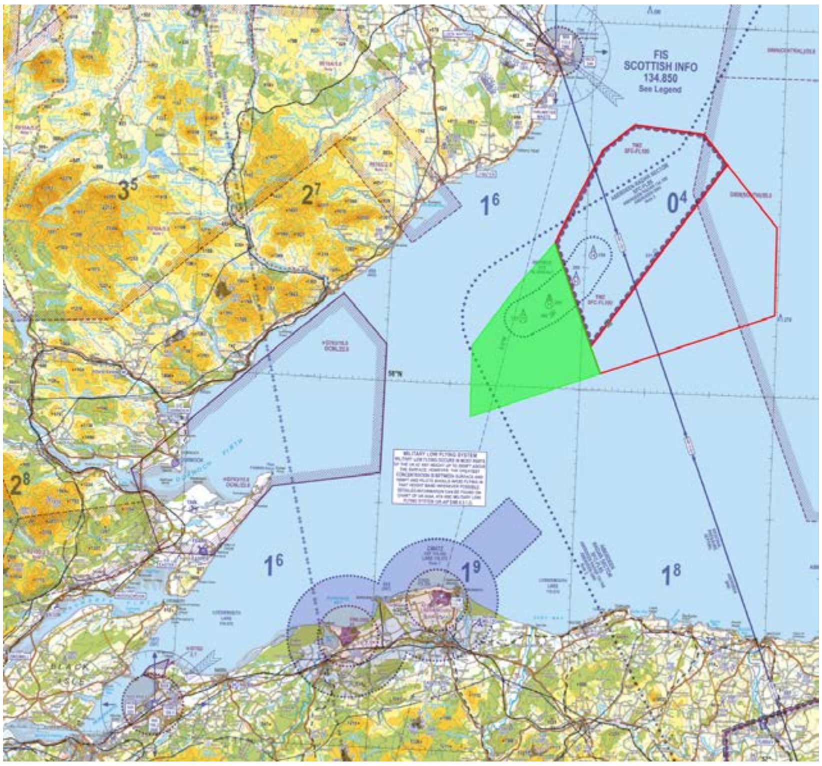

Figure 5: TMZ incorporating a minimum 2 NM buffer (Green shape) aligned with existing and planned TMZ boundaries (Red shapes)

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 and wind turbines) 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 blades of the wind turbines. It indicates the position of targets, but does not identify them. Because wind turbine 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 wind turbines 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. Range-Azimuth Gate (RAG) radar blanking blocks *any* primary radar return within selected ranges and azimuth sectors. This can be mapped to suppress plots within wind turbine 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 Transponder Mandatory Zone (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 wind farm. Non-transponding aircraft would not be permitted to overfly the wind farm, and would be required to route around it. If a non-transponding aircraft were to infringe the TMZ and overfly the wind farm they would be invisible to radar due to the RAG blanking. As such ATC would not detect them and there is a risk of collision with other aircraft.
>
> 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 Allanshill PSR

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

This option has previously been investigated via a flight trial for the MOWEL and BOWL wind farm developments.

> Viability. A flight trial completed in June 2015 for the MOWEL and BOWL wind farms used 3 altitudes to identify performance against the operational criteria. This found that the range extension is unsuitable in this region. As this is highly unlikely to meet the safety design principle, it is not a viable option for MOWWL and has been discounted.

ii) Project RM - Raytheon upgrade to the Allanshill PSR

This involves converting the Allanshill radar to one that is not affected by wind farm turbines

> 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, so is not a viable option.

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 wind farm turbines that could provide cover for the area blanked out at Allanshill.

> 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. This requires 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 so is not a viable option.

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 wind farm turbines and that could in future be used to provide cover for the area blanked out at Allanshill – Terma Systems Radar; Aveillant Holographic Radar, and C Speed Lightwave Radar.

> Impact. These systems are currently used within the UK to mitigate against Onshore wind farms but have not been evaluated for offshore wind farms. A suitable site (within 40 NM) of MOWWL may not be available to purchase or lease for the lifetime of the wind farm. Planning consents will also be required.
>
> Viability. This option requires the purchase of land, provision of power, and telecommunications links. 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.

v) 3D Radar Upgrade to the Allanshill 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 wind farms, 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 wind farms 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 can not be guaranteed to be achieved within the required timeframe. However, this option could potentially replace any PRMS in the future.

Annex C: Glossary

ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
GA	General Aviation
kts	knots
NATS	National Air Traffic Services
NERL	NATS En-route plc
NM	Nautical miles
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.

End of document