Report

Oatfield Wind Farm

Aviation Review Statement

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Author:	PT\DMG			
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Executive Summary

Ai Bridges Ltd have been commissioned to review the potential impacts of the proposed wind farm on aviation systems in the vicinity of the proposed wind farm development at Oatfield. As part of the review, the following subjects were considered:

- Annex 14 - Obstacle Limitation Surfaces (OLS)
- Annex 15 – Aerodrome Surfaces
- Building Restricted Areas (BRA)
- Minimum Sector Altitudes (MSA)
- Instrument Flight Procedures
- Permitted Wind Farms in vicinity of Proposed Wind Farm
- Communications, Navigation
- Radar Surveillance Systems
- Flight Inspection and Calibration
- Aeronautical Obstacle Warning Light Scheme
- Irish Air Corps / Department of Defence Safeguarding
- Garda Air Support Unit (GASU) and Emergency Aeromedical Service (EAS)

This review has highlighted that in the absence of mitigation some potential aviation issues could arise due to the proposed development and confirmatory detailed technical assessments may be required by the IAA. However, mitigation measures are available to offset any of the possible impacts due to the proposed turbines and can be conditioned in the event of a successful planning application. These mitigation measures are outlined in Section 3 of this report.

Annex 14 - Obstacles Limitation Surfaces (OLS)

A review shows that the proposed wind farm would be located outside the Obstacle Limitation Surfaces for the runways at Shannon Airport, as defined in ICAO (International Civil Aviation Organization) Annex 14.

As there is no penetration of the aerodrome OLS surfaces, it is unlikely that there will be any Annex 14 OLS impacts due to the proposed wind farm.

Annex 15 - Aerodrome Surfaces

Following a review of "*Terrain and obstacle requirements Area* 1" as defined in ICAO Annex 15, wind turbines need to be registered if they are more than 100 meters above terrain.

From the centre point (ARP – Airport Reference Point) of Shannon Airport to the boundary of the Area 1 of the Annex 15 Aerodrome Surface is 45km. This area encloses the TMA area i.e. Total Maneuvering Area and this is used for circling and maneuvering by aircraft. Should the proposed wind farm be permitted, the turbines would be within 45km of Shannon Airport's ARP and would be greater than 100m in height. Therefore, the turbines would be required to be included in the IAA Electronic Air Navigation Obstacle Dataset.

Building Restricted Areas (BRA)

A Building Restricted Area is the airspace surrounding an aviation facility that needs to be clear from physical intrusions. The purpose of the safeguarded areas is to identify developments with the potential for causing unacceptable interference to navigation facilities. A review shows that the proposed development is over 9 km from the BRAs at Shannon Airport. At this distance there will be no impacts to the BRAs due to the proposed wind farm.

Minimum Sector Altitudes (MSA)

The Minimum Sector Altitudes (MSA) is the lowest altitude which may be used that will provide a minimum obstacle clearance of 1000ft above all obstacles within a sector of 25 nautical miles (46km) from the VOR/DME at Shannon Airport. The maximum turbine tip-height at the proposed wind farm site would be 1407 ft above mean sea level (AMSL). There is over 1000 ft from the maximum height of the wind farm to the MSA altitude and therefore there would be no impact on the published MSA altitudes for Shannon Airport.

Instrument Flight Procedures

There are nine published Instrument Flight Procedures for flights to/from Shannon Airport. A preliminary assessment of these Instrument Flight Procedures (IFPs) indicates that two IFPs are potentially impacted. In addition, the ATC-SMAC (which is used by Air Traffic Controllers to vector flights for landing into Shannon Airport) is penetrated by two of the proposed turbines.

In agreement with the IAA and Shannon Airport Confirmatory studies of the potential for impact of the proposed turbines on the IFPs and ATCSMAC will be carried out by an IAA approved Aviation Design Specialist who will undertake an IFP and ATCSMAC Safeguarding Assessment and specify the required changes to the IFP to be implemented by Shannon Airport if required.

Communications and Navigation System

As the proposed wind farm is approximately 15 km from the Localizer and transmitting antennas at Shannon Airport, it is very unlikely that wind turbines at the proposed development will have any impact on these ATS communications and radio navigational aids.

Radar Surveillance Sensors

For Radar Surveillance Systems, EUROCONTROL Guidelines require a 16 km safe distance from the secondary surveillance radar system (SSR), for a "*Zone 4 - No Assessment*" condition. It has been highlighted in the analysis that turbines located at the proposed farm would be located at a distance of 17 km from the radar station at Shannon and in Assessment Zone 4 of the EUROCONTROL Guidelines. As turbines at the proposed development would be located in Assessment Zone 4, a detailed impact assessment on Radar Surveillance Systems should not be required for the Radar Station at Shannon Airport. The proposed turbines will be within the 16km safe distance from the secondary surveillance radar at Woodcock Hill and in an Assessment Zone 2 of the EUROCONTROL Guidelines. It has also been found that the proposed turbines are deemed to be outside the 15km safe distance from the primary surveillance radar (PSR) at Shannon Airport but within maximum instrumented range and within partial line of sight. The proposed turbines will be within an Assessment Zone 3 the EUROCONTROL Guidelines.

Following any statutory state consultation process with the IAA and the Shannon Airport Authority it may be likely that a confirmatory study of the potential for impact of the proposed turbines on the Woodcock Hill Radar Secondary Surveillance Sensor and the Primary Surveillance Radar at Shannon Airport will be carried out by an IAA approved Aviation Design Specialist who will specify the required changes to the Woodcock Hill software to be implemented by Shannon Airport if required.

Flight Inspection and Calibration

Flight checks are conducted annually to ensure that flight procedures and associated navigational aids are safe and accurate. These flight checks are carried out by an IAA approved Flight Inspection Service Provider. The checks are carried out during annual inspections consisting of radial and orbital test flights around Shannon Airport for calibration of instrument landing systems.

A desk-top analysis review indicates that the Flight Inspection and Calibration procedures will not be impacted by the proposed wind farm development.

Aeronautical Obstacle Warning Light Scheme

In the event of a grant of planning consent the IAA are likely to request lighting of the proposed wind turbines in the interest of aviation safe-guarding as the proposed development would be considered as an en-route obstacle.

Irish Air Corps / Department of Defence (DoD) Safeguarding

The Irish Air Corps position on wind farms / tall structures are outlined in the paper which was published in 2014: "*Air Corps Wind Farm/ Tall Structures Position Paper*". In the position paper the Irish Air Corps outlines restricted areas where they would object to the installation of wind turbines /tall structures. The areas defined by the Air Corps have been mapped and analysis shows that the proposed wind farm site is located outside the restricted areas. As the proposed wind farm is not located in a restricted area it should have no impacts on the Irish Air Corps activities.

Garda Air Support Unit (GASU) and Emergency Aeromedical Service (EAS)

The proposed wind farm is 7.9 km from the nearest Irish Air Corps (IAC) restricted zone and is located in a largely rural area. The terrain at the proposed wind farm site is forested / mountainous. For these reasons, it is highly unlikely that the proposed wind farm development would have any impacts on GASU fixed-wing aircraft or helicopter flights / operations.

Any potential EAS operations in the area are also unlikely to be impacted, as helicopter landings would not occur at the proposed wind farm site due to its forested/mountainous terrain. In the unlikely event of an EAS operation in the general area, the pilot would seek a Helicopter Landing Site (HLS) that is clear of wires, loose objects, is relatively clear of obstacles (e.g. trees) and have good road access (to link up with the local ambulance service).

Abbreviations

AGL	Above Ground Level
AMSL	Above Mean Sea Level
ARP	Airport Reference Point
ATCSMAC	Air Traffic Control Surveillance Minimum Altitude Chart
BRA	Building Restricted Area
DME	Distance Measuring Equipment
DoD	Department of Defence
EAS	Emergency Aeromedical Service
GASU	Garda Air Support Unit
GP	Glide Path
HLS	Helicopter Landing Site
ICAO	International Civil Aviation Organization
IFP	Instrument flight Procedure
ILS	Instrument Landing System
OLS	Obstacle Limitation Surface
PSR	Primary Surveillance Radar
RWY	Runway
SID	Standard Instrument Departure Route
STAR	Standard Arrival Route
SSR	Secondary Surveillance Radar
NATS	National Air Traffic Services (UK)
NM	Nautical Miles
VOR	VHF Omni-directional Range Station

Sections

Appendices

1. Introduction

This section provides a brief summary of the proposed development at Oatfield and of the nearest significant aviation installation at Shannon Airport.

1.1 Wind Farm Site Information

The proposed development is located in County Clare approximately 5 km northeast of Sixmilebridge. Figure 1 shows the proposed wind farm site with respect to Shannon Airport and the IAA radar stations at Shannon and Woodcock Hill. The proposed development consists of 11 wind turbines with a maximum turbine tip-height of 180m AGL. The co-ordinates of the proposed turbines are provided in Appendix A.

Figure 1. Location of proposed wind farm at Oatfield

1.2 Shannon Airport

Table 1 below shows the co-ordinates of Shannon Airport and the distance from the Airport Reference Point (ARP) to each of the proposed turbines. Shannon Airport operates in Class C controlled airspace with Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) Flight rules.

Location	Installation	Description	Airport Reference Point (ARP)	ARP Distance to nearest Turbine (T02)
Shannon, Co Clare	International Airport	Single Asphalt Runway Airspace: Class C	52 42 07 N 08 55 29 W (Mid-point of Runway 06/24).	16.6 km

Table 1. Shannon Airport Details

The aeronautical navigation aids at the aerodrome include; Doppler VHF Omni Directional Range (DVOR), Distance Measuring Equipment (DME), Non-Directional Beacon (NDB), Instrument Landing System (ILS), Localizer (LOC) and ILS Glide Path (GP).

Figure 2. Shannon International Airport

2. Aviation Review

In this section a review of the following a review of the following Aviation topics is provided.

- Annex 14 - Obstacle Limitation Surfaces (OLS)
- Annex 15 – Aerodrome Surfaces
- Building Restricted Areas (BRA)
- Minimum Sector Altitudes (MSA)
- Instrument Flight Procedures
- Permitted Wind Farms in vicinity of proposed Wind Farm
- Communications and Navigation Systems
- Radar Surveillance Systems
- Flight Inspection and Calibration
- Aeronautical Obstacle Warning Light Scheme
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- Garda Air Support Unit (GASU) and Emergency Aeromedical Service (EAS)

2.1 Annex 14 Obstacle Limitation Surfaces (OLS)

A review of the Annex 14 Obstacles Limitation Surfaces (OLS) was first was carried out by first plotting the proposed wind farm and the airport obstacle surfaces. The obstacle limitation surfaces are plotted based on the following:

- *Annex 14 to the Convention on International Civil Aviation Aerodromes Volume I - Aerodrome Design and Operations Seventh Edition July 2016*
- *Certification Specifications and Guidance Material for Aerodromes Design CS-ADR-DSN Issue 4, 8th of December 2017*

Figure 3 below shows the OLS in relation to the proposed wind farm. The distance from the Shannon Airport ARP, runway centre-point, to the nearest proposed wind turbine is 16.6 km. The analysis of the OLS plots indicates that the proposed turbines do not penetrate the Outer Horizontal Surface which extends to 15km from the Shannon Airport Reference Point (ARP) or runway centre-point.

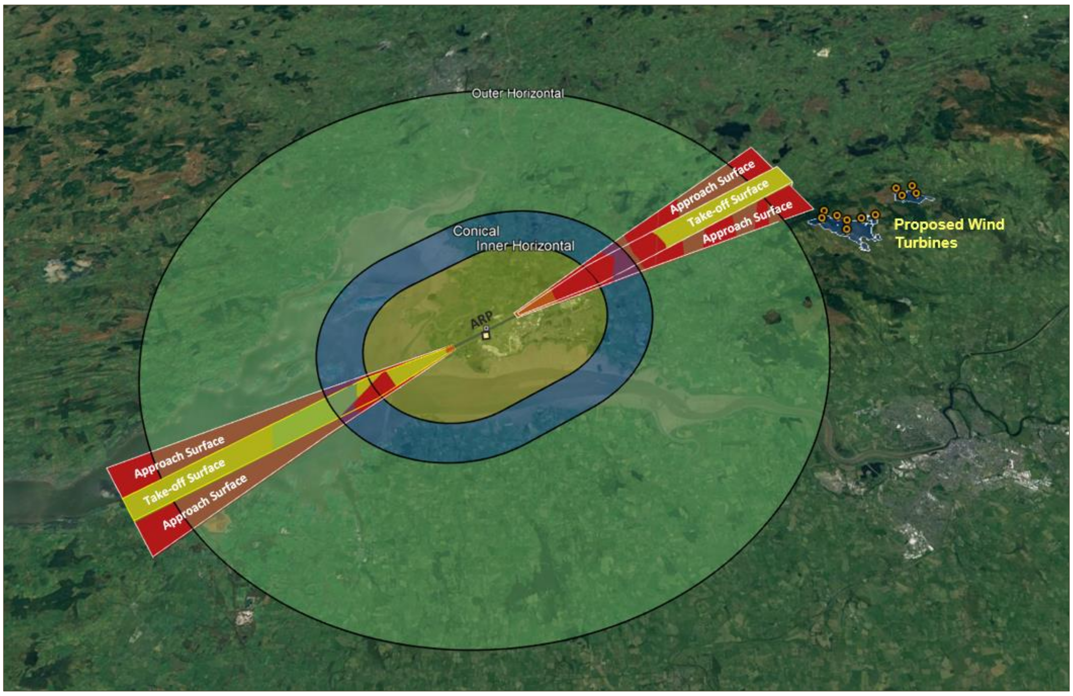


Figure 3. Proposed Wind Farm in relation to Aerodrome OLS Surfaces.

A 3D-modelling assessment was carried out based on the 11-turbine layout which showed that the proposed turbines will not penetrate the Take-Off or Approach Surfaces for the runways (RWY06 and RWY24) at Shannon Airport. Figure 4 below shows the turbines modelled in 3D relative to the Take-Off and Approach surfaces based on the 11-turbine layout.

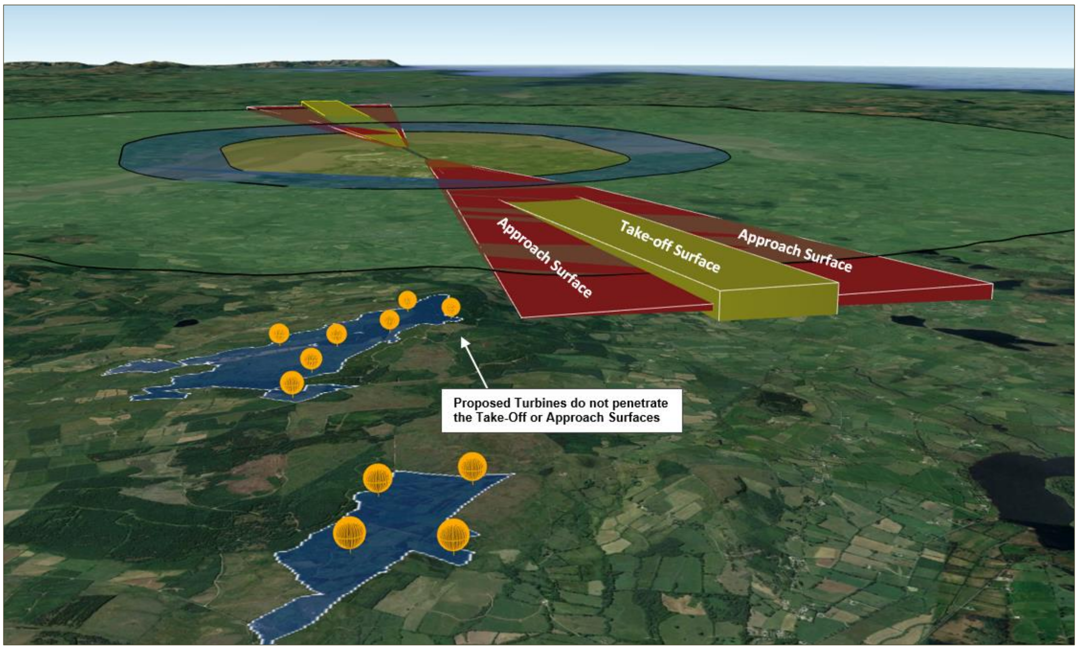


Figure 4. 3D Analysis showing the proposed turbines do not penetrate the Take-Off or Approach Surfaces

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Annex 14 Obstacle Limitation Surfaces	No action	None

2.2 Annex 15 Aerodrome Surfaces

The "*Terrain and obstacle requirements Areas 2*" is defined in ICAO Annex 15 as an area which can extend up to 45km from the Aerodrome ARP. (An illustration of ICAO Annex 15 Area 2 Surface is provided in Appendix C).

All obstacles, if they are more than 100 meters above terrain for a distance of up to 45km from an aerodrome ARP, need to be registered in the IAA Air Navigation Obstacle Data Set. This area is known as the TMA area i.e. Total Maneuvering Area and is used for en-route circling and maneuvering and is shown in Figure 5.

For Shannon International Airport the TMA Area extends 45 NM (nautical miles) from its ARP. Turbines at the proposed wind farm site would penetrate the ICAO Annex 15 Aerodrome Surfaces as shown in Figure 5. Therefore the turbines would be required to be included in the IAA Electronic Air Navigation Obstacle Dataset.

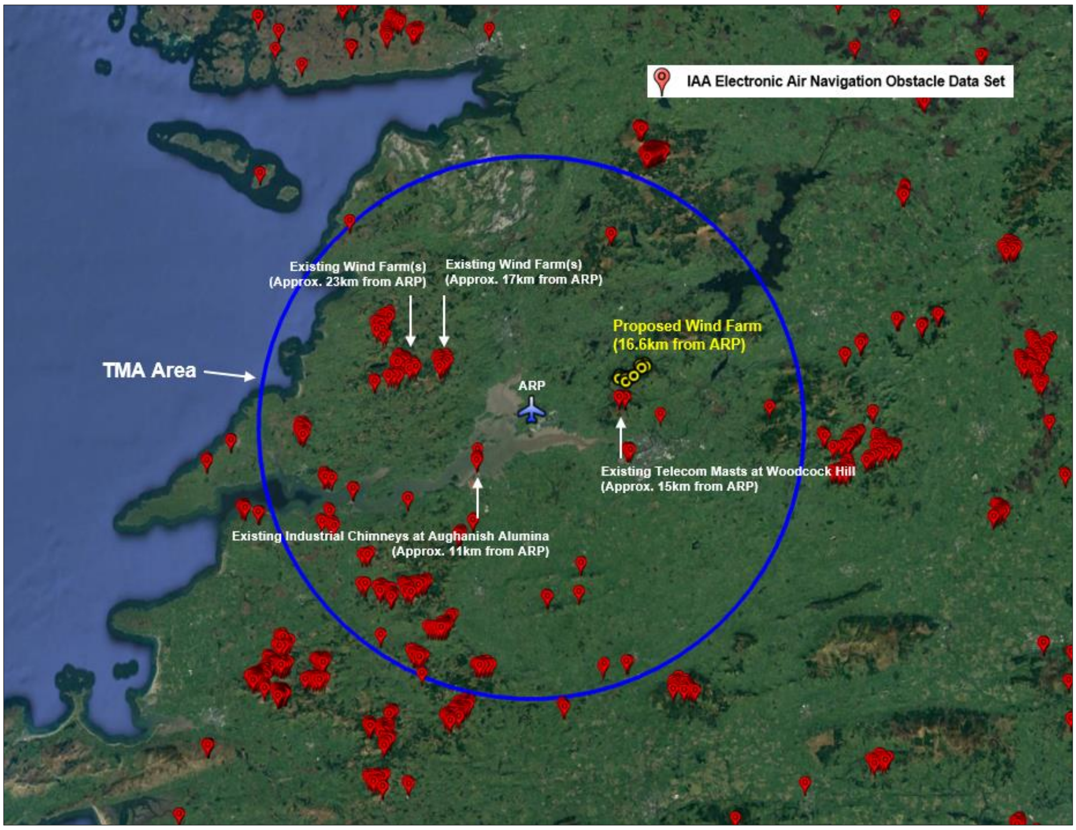


Figure 5. Annex 15 Aerodrome Surface and IAA Electronic Air Navigation Obstacle Data Set

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Annex 15 Aerodrome Surfaces	The proposed wind turbines would penetrate the ICAO Annex 15 Aerodrome Surface and should be included in the IAA Obstacle Data Set.	None

2.3 Building Restricted Areas (BRA)

A Building Restricted Area is the airspace surrounding an aviation facility that needs to be clear from physical intrusions. The purpose of the safeguarded areas is to identify developments with the potential for causing unacceptable interference to navigation facilities.

The navigation facilities to be considered at Shannon Airport are the ILS Localisers, Glidepaths and DMEs that provide guidance for aircraft landing on runways 06 and 24. The minimum safeguarded areas for these facilities are defined by the International Civil Aviation Organisation (ICAO) in the document ICAO EUR DOC 015, Section 7. The BRA parameters as specified by the ICAO are provided in Appendix B of this report.

Figure 6 below illustrates that the proposed wind farm at Oatfield is 9 km from the Shannon Airport BRAs (safeguarded areas for Runway 06 and Runway 24). At this distance turbines at the proposed wind farm will have no impact on the navigation facilities associated with the Building Restricted Areas for Shannon Airport.

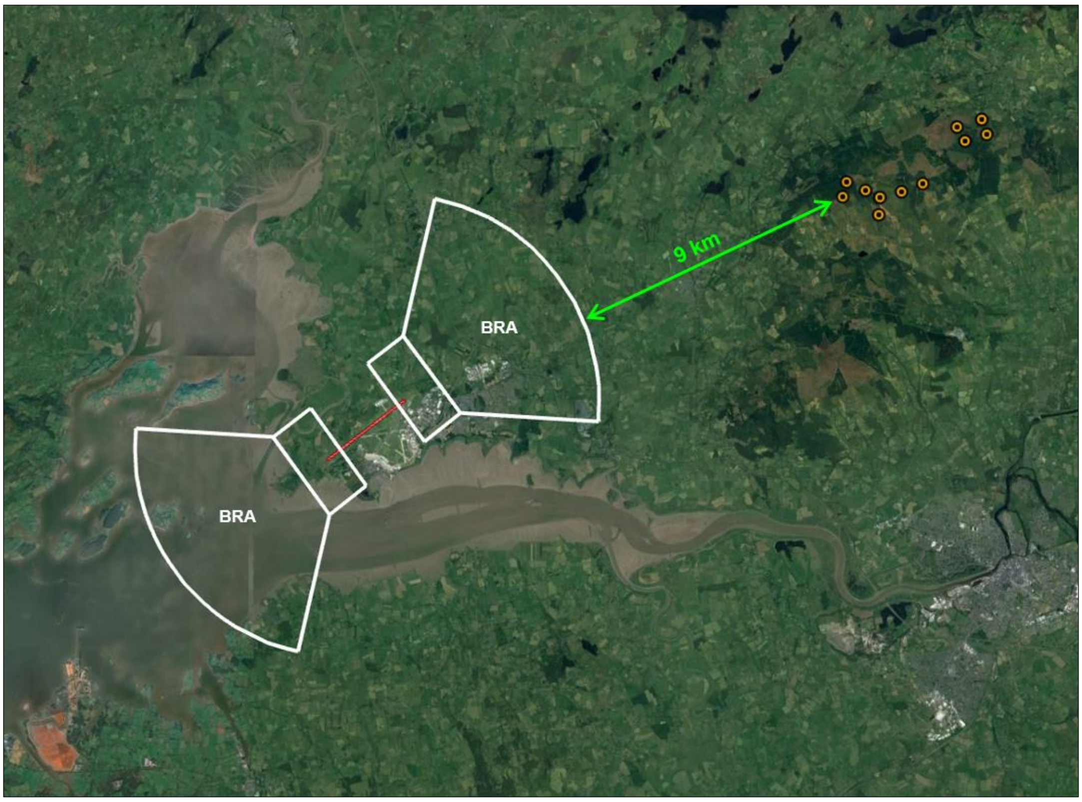


Figure 6. Proposed Wind Farm relative to Shannon Airport BRAs (RWY 06 and RWY 24)

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Building Restricted Areas	No action	None.

2.4 Minimum Sector Altitudes

A review of the Minimum Sector Altitudes (MSA) shows that the proposed wind farm is within 25 nautical miles from the VOR/DME at Shannon Airport. The MSA provides a minimum obstacle clearance of 1000 ft above the highest obstacle within specified sectors. The wind turbines are located within the Eastern Sector (MSA 3400 ft), as shown in Figure 7. According to the wind farm location, the maximum construction height for the site would be 2400 ft/731.5m AMSL (3400 ft MVA minus 1000 ft).

Turbine T02 is tallest of the proposed turbines with a maximum tip-height of 1407 ft AMSL. This is below the 2400 ft threshold, therefore the MSA of the Eastern MSA sector will not be affected and there will be no impact on the published MSA altitude figures.

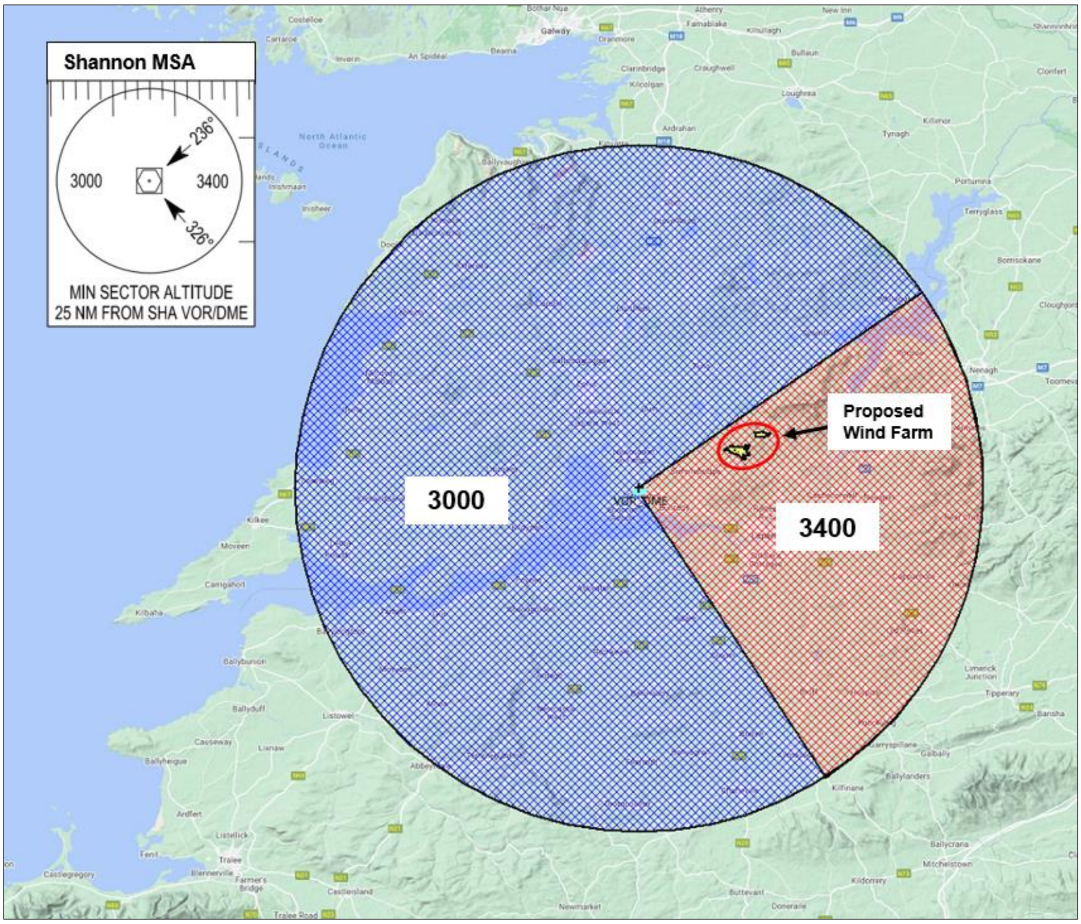


Figure 7. Shannon Airport (EINN) Minimum Sector Altitudes

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Minimum Sector Altitudes	No action	None.

2.5 Instrument Flight Procedures

There are 9 published Instrument and Visual Flight Procedures for arrivals to and departures from Shannon Airport. Table 2 below lists the Instrument Flight Procedures for Shannon Airport. An assessment for each of these procedures is provided in Sections 2.5.1 to 2.5.9 that follow. An assessment of the of the ATC Surveillance Minimum Altitude Chart (ATC SMAC) is provided in Section 2.5.10.

Aerodrome	Aerodrome Procedure	Procedure / Chart ID
Shannon	RNAV Standard Instrument Departure Chart RWY 06	EINN AD 2.24-5
Shannon	RNAV Standard Instrument Departure Chart RWY 24	EINN AD 2.24-6
Shannon	RNAV Standard Arrival Chart RWY 06	EINN AD 2.24-7
Shannon	RNAV Standard Arrival Chart RWY 24	EINN AD 2.24-8
Shannon	Instrument Approach Chart ILS or LOC RWY 06	EINN AD 2.24-10
Shannon	Instrument Approach Chart VOR RWY 06	EINN AD 2.24-11
Shannon	Instrument Approach Chart ILS CAT I & II or LOC 24	EINN AD 2.24-13
Shannon	Instrument Approach Chart VOR RWY 24	EINN AD 2.24-14
Shannon	Visual Approach Chart – ICAO	EINN AD 2.24-15

Table 2. Instrument and Visual Flight Procedures – Shannon Airport

2.5.1 RNAV Standard Instrument Departure - RWY 06 (EINN AD 2.24-5)

Flights departing from RWY 06 on a bearing towards TOMTO would fly over the proposed wind farm site. The flight procedure states that the Climb Gradient for departures is 9.1% and 3.3% for obstacle clearance.

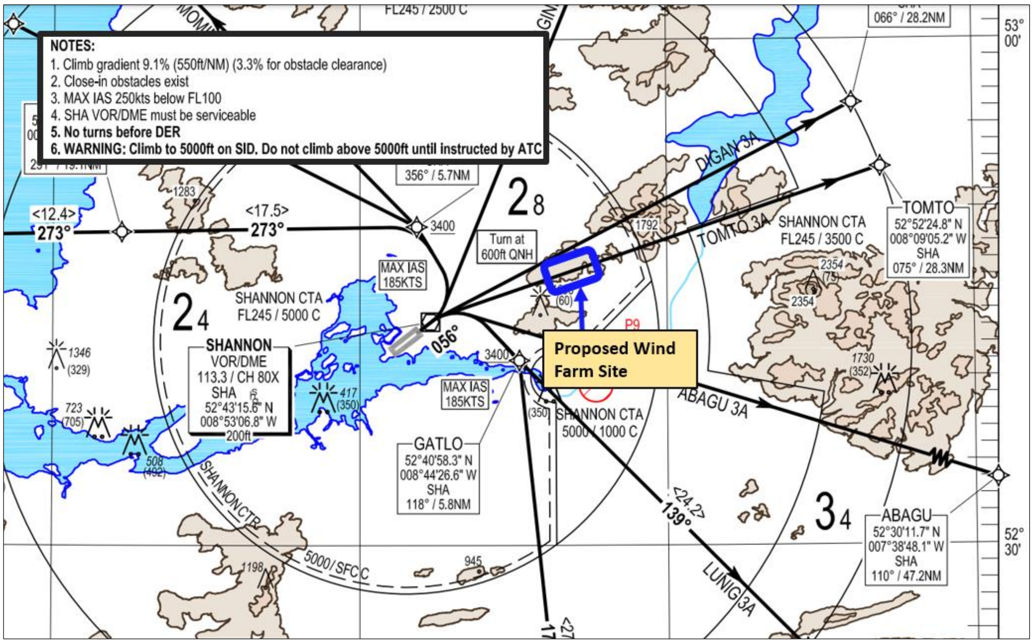


Figure 8. RNAV Standard Instrument Departure Chart (RWY06) - Chart EINN AD 2.24-5

The assessment carried out by Ai Bridges indicated that turbines at the proposed development should not impact the 3.3% Climb Gradient for Obstacle Clearance. Figure 9 shows a representation of the 9.1% and 3.35 Climb Gradients as specified in Flight Procedure EINN AD 2.24-5.

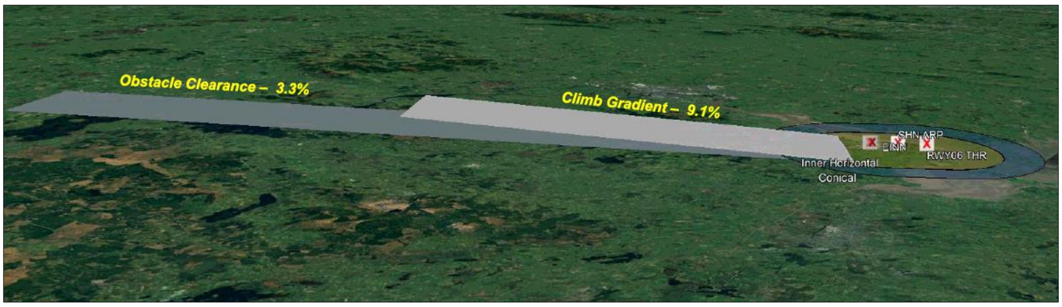


Figure 9. EINN AD 2.24-5 Climb Gradients

Figure 10 below shows a 3D-model which indicated that the proposed turbines would not impact the 3.3% Climb Gradient for flights departing runway RWY06.

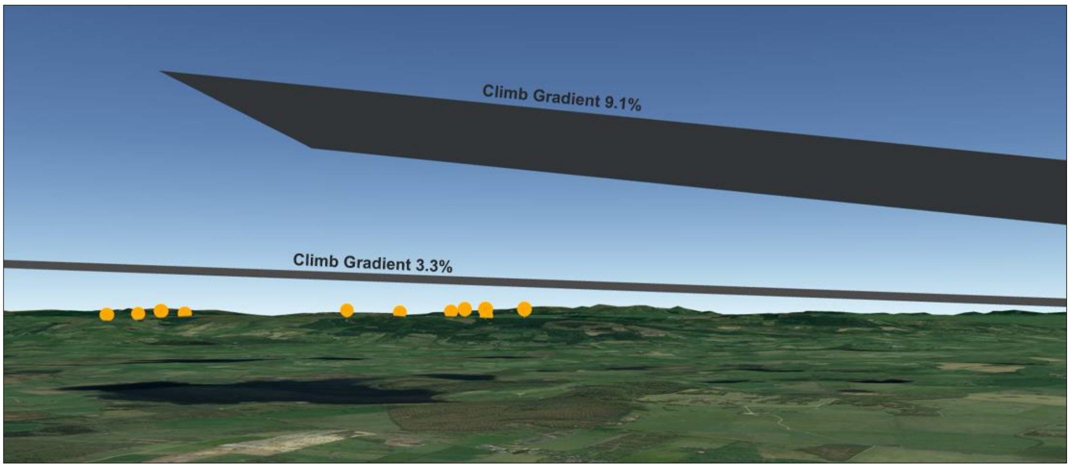
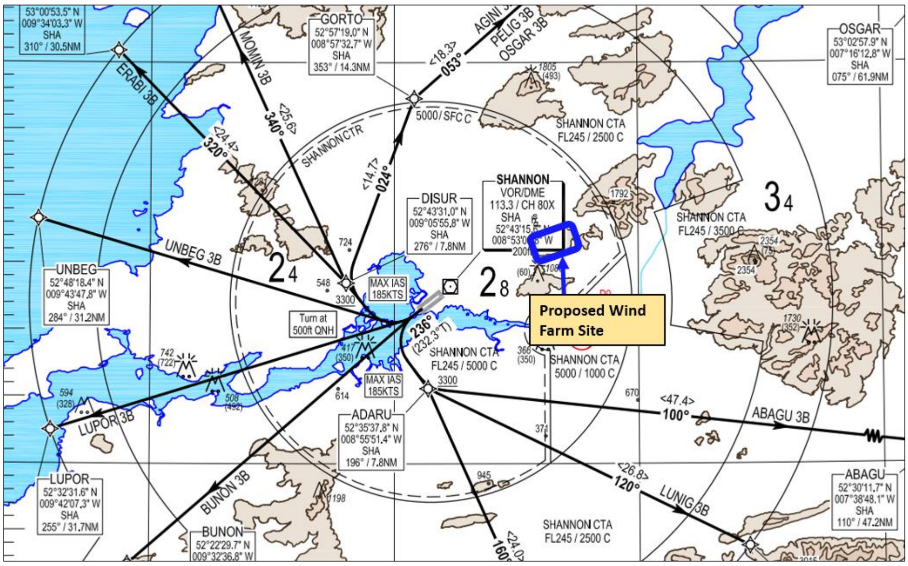


Figure 10. 3D Model indicating that proposed turbines should not impact the 3.3% Climb Gradient

Aviation Impact Review	Mitigation Measure Action	Residual Impact
RNAV Standard Instrument Departure Chart RWY 06	No action	None

2.5.2 RNAV Standard Instrument Departure - RWY 24 (EINN AD 2.24-6)

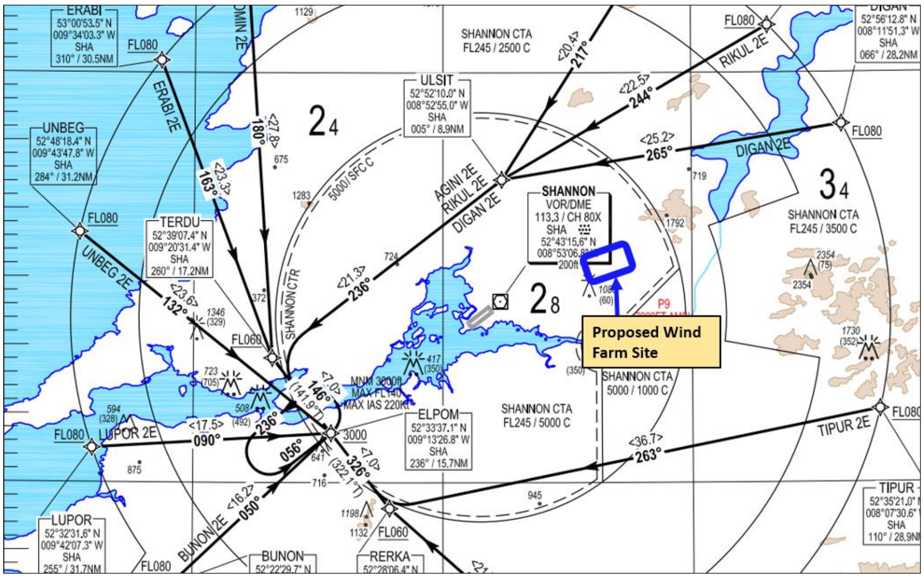
Flights departing from RWY 24 fly take-off to the southwest and do not fly over the proposed wind farm.



Aviation Impact Review	Mitigation Measure Action	Residual Impact
RNAV Standard Instrument Departure Chart RWY 24	No action	None

2.5.3 RNAV Standard Arrival Chart RWY 06 (EINN AD 2.24-7)

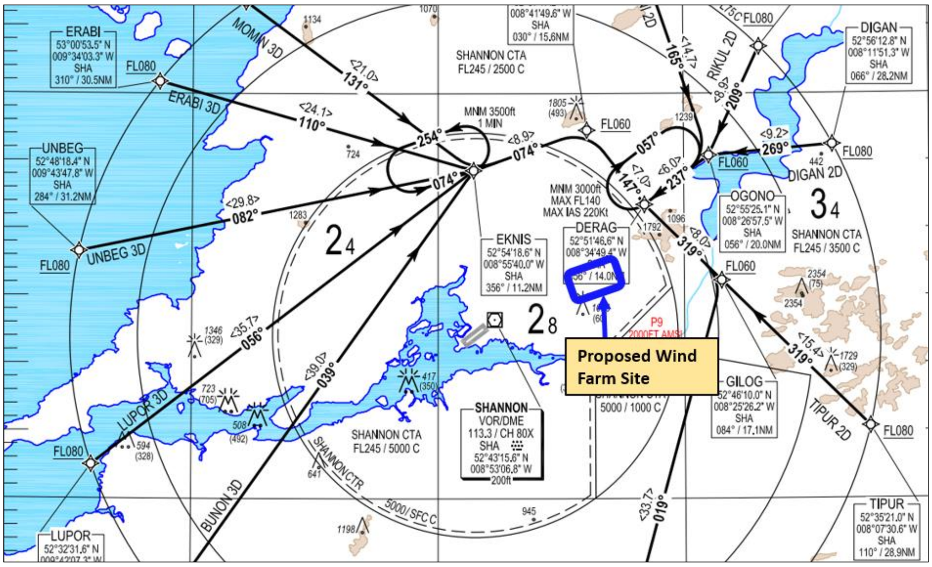
Flight routes for aircraft arriving to RWY 06 do not fly over the proposed wind farm site.



Aviation Impact Review	Mitigation Measure Action	Residual Impact
RNAV Standard Arrival Chart RWY 06	No action	None

2.5.4 RNAV Standard Arrival Chart RWY 24 (EINN AD 2.24-8)

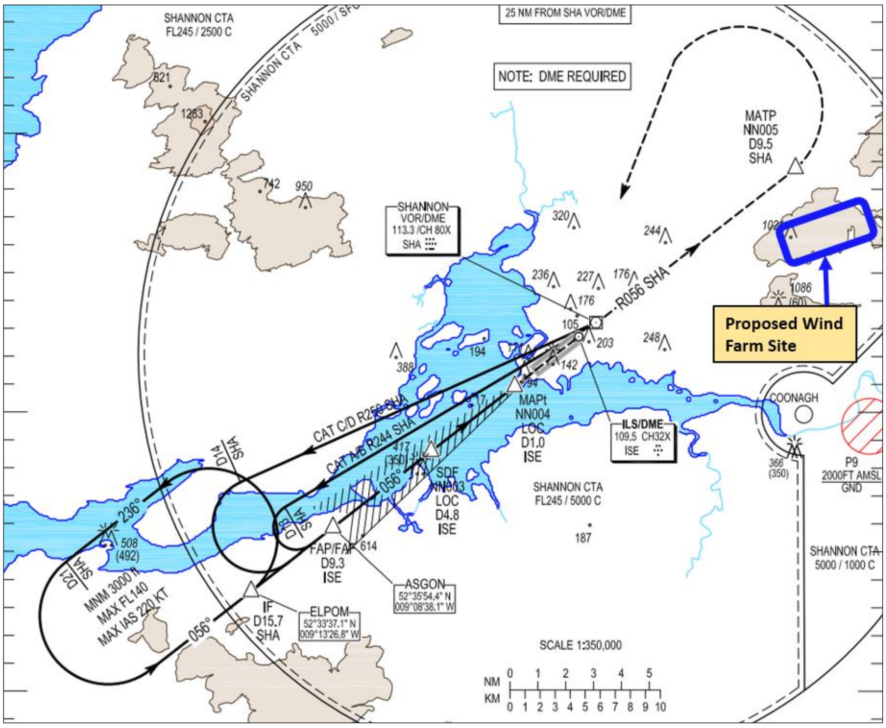
Flight routes for aircraft arriving to RWY 24 do not fly over the proposed wind farm site.



Aviation Impact Review	Mitigation Measure Action	Residual Impact
RNAV Standard Arrival Chart RWY 24	No action	None

2.5.5 Instrument Approach Chart ILS or LOC RWY 06 (EINN AD 2.24-10)

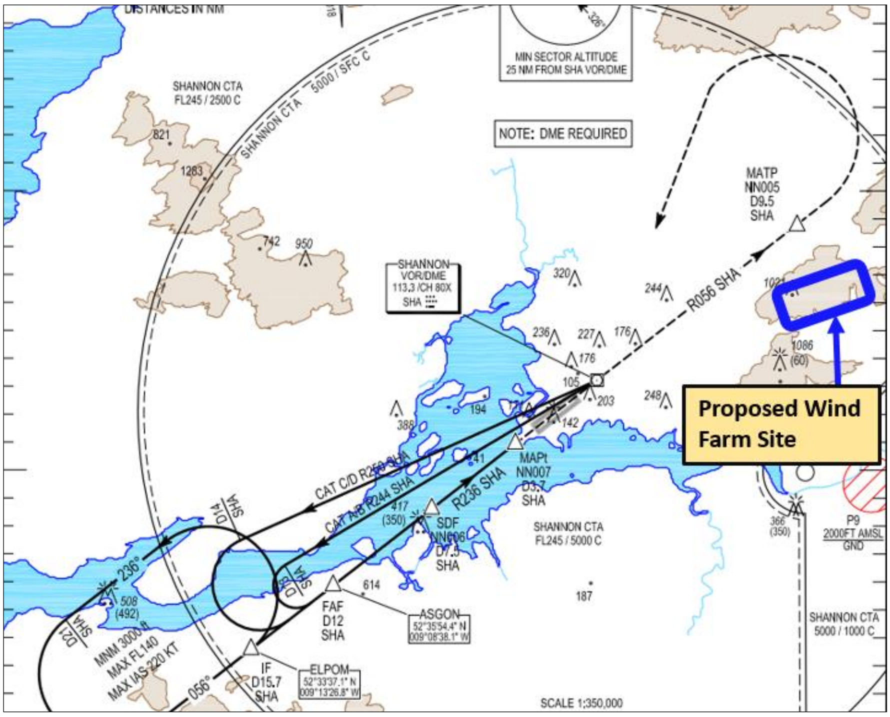
Flight routes for aircraft approaching ILS/ LOC RWY 06 do not fly over the proposed wind farm.



Aviation Impact Review	Mitigation Measure Action	Residual Impact
RNAV Standard Arrival Chart RWY 24	No action	None

2.5.6 Instrument Approach Chart VOR RWY 06 (EINN AD 2.24-11)

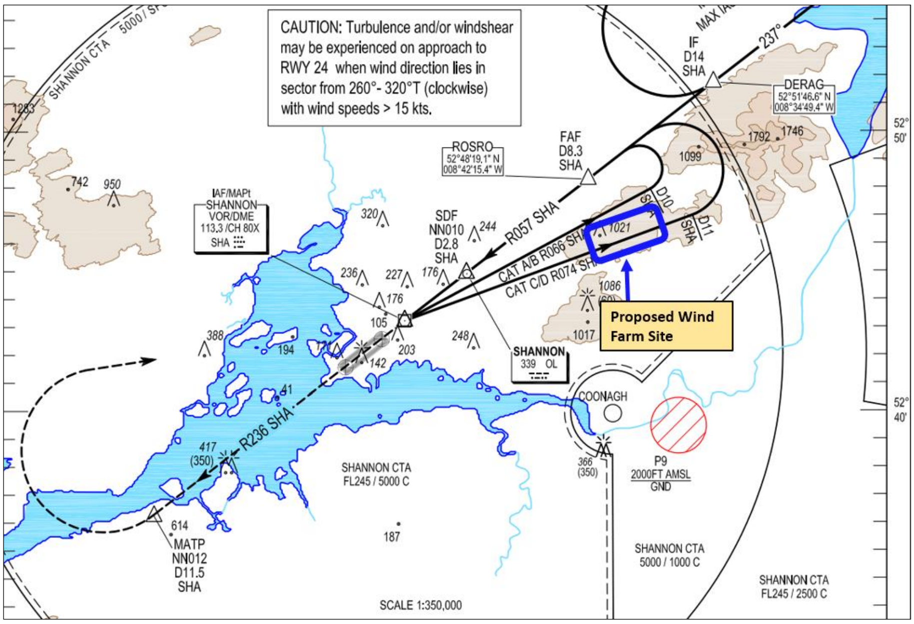
Flight routes for aircraft approaching RWY 06 do not fly over the proposed wind farm.



Aviation Impact Review	Mitigation Measure Action	Residual Impact
Instrument Approach Chart VOR RWY 06	No action	None

2.5.7 Instrument Approach ILS CAT I & II or LOC 24 (EINN AD 2.24-13)

The procedures for this IFP do specify a flight route over the proposed wind farm site as shown in the figure below.



In addition, three of the proposed turbines (T01, T02 and T03) at the proposed development would be located in the Secondary Approach Area of flights arriving into Runway RWY24, as shown in Figures 11 and 12.

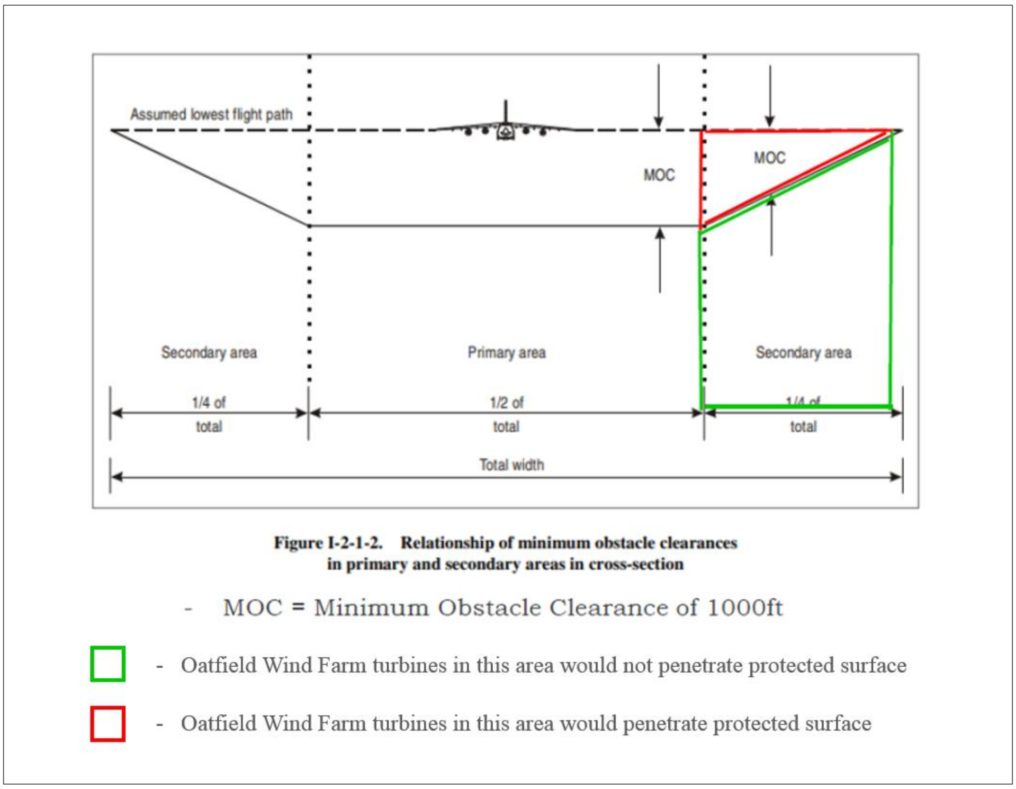


Figure 11. Primary and Secondary Protected Approach Areas - Cross Section View

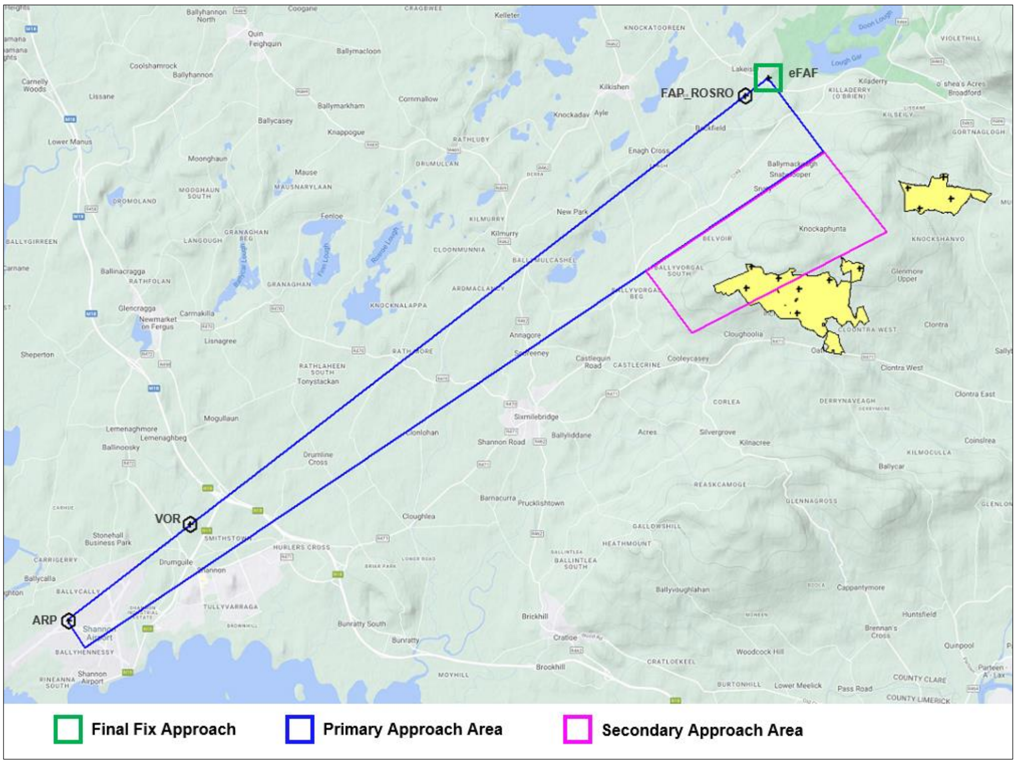


Figure 12. Primary and Secondary Protected Approach Areas - Cross Section View

Although the proposed turbines would be located in the Secondary Approach Area, further investigations would be required to assess the impact the approach procedure as they may be in an area beneath the decent gradient where obstacles need not be considered as illustrated below in Figure 13.

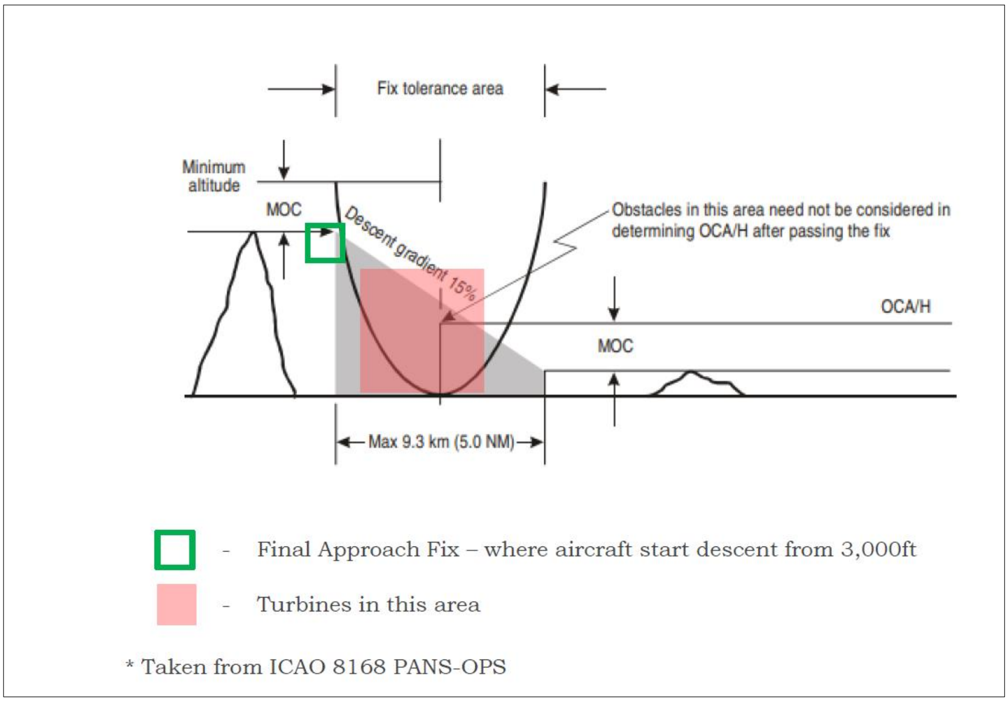
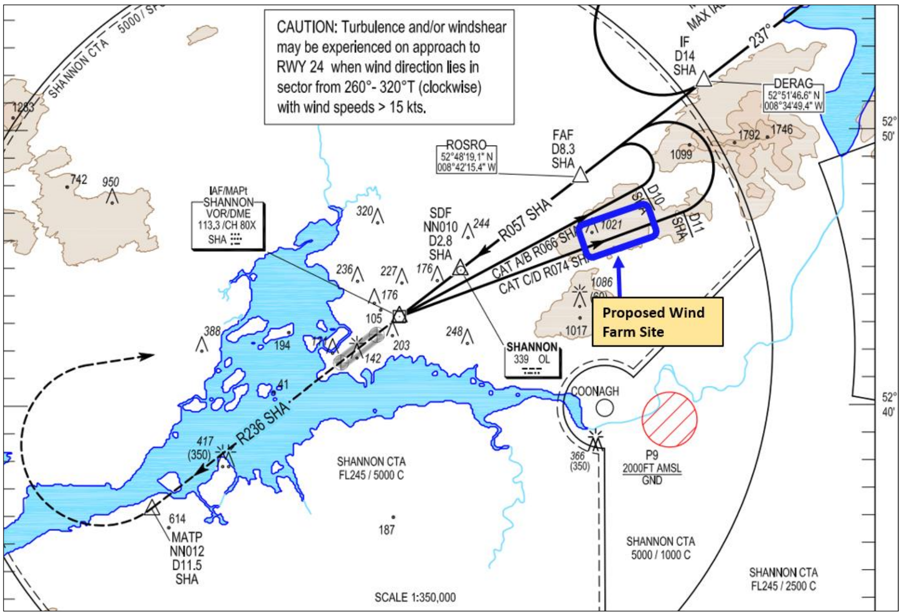


Figure 13. Areas where obstacles need not be considered

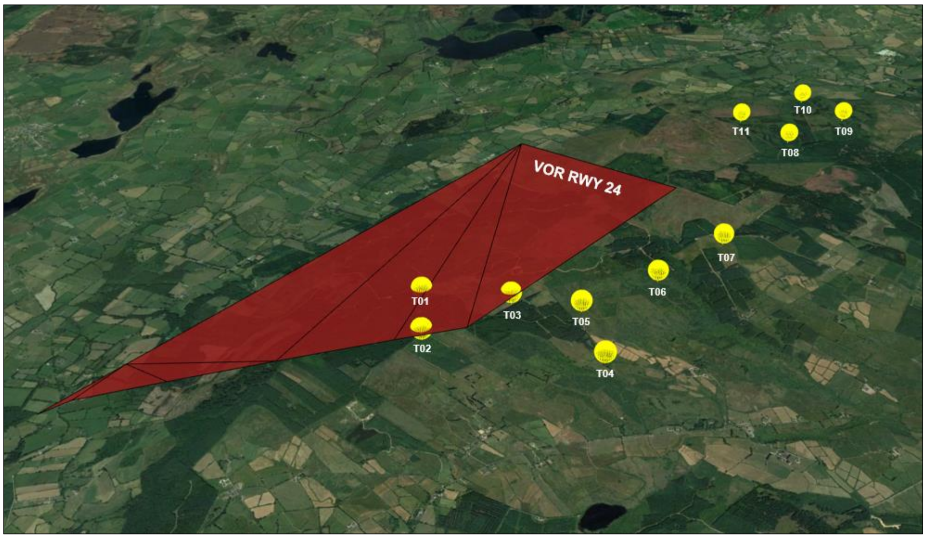
Aviation Impact Review	Mitigation Measure Action	Residual Impact
Instrument Approach Chart ILS CAT I & II or LOC 24	Re-design of the flight procedure. Subject to an IAA review there may be a requirement for a confirmatory study to assess the potential impacts of the proposed turbines.	Subject to Statutory State consultation process review by the IAA.

2.5.8 Instrument Approach Chart VOR RWY 24 (EINN AD 2.24-14)

The procedures for this IFP do specify a flight route over the proposed wind farm site as shown in the figure below.



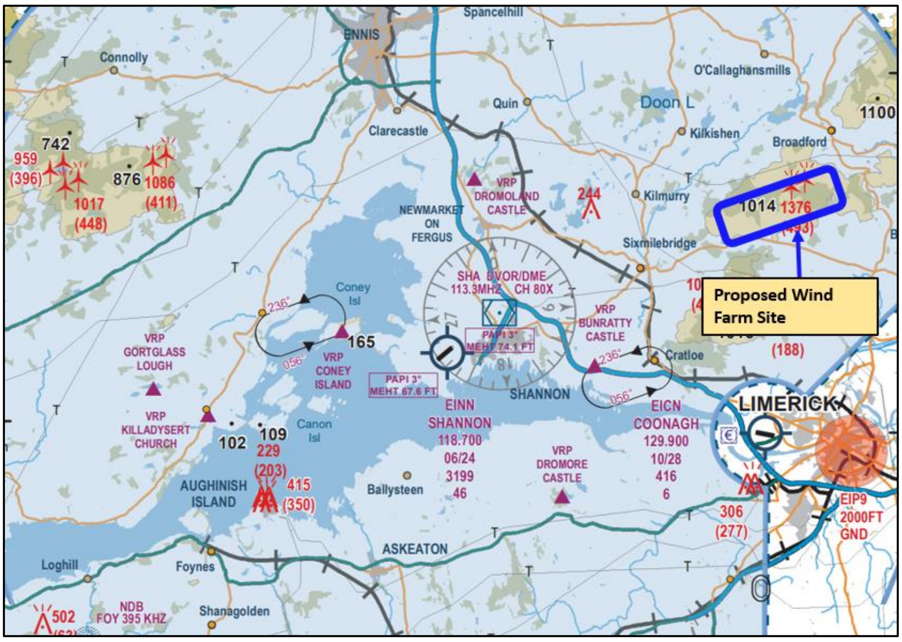
Three of the proposed turbines (T01, T02 and T03) at the proposed development would also be located in the Secondary Approach Area of flights arriving into Runway RWY24 (as shown previously in Figure 11 and Figure 12). In addition, a 3D model of the VOR Constraints Surface indicates that these three turbines also penetrate the VOR Surface as shown below.



Aviation Impact Review	Mitigation Measure Action	Residual Impact
Instrument Approach Chart VOR RWY 24	Re-design of the flight procedure. Subject to an IAA review there may be a requirement for a confirmatory study to assess the potential impacts of the proposed turbines.	Subject to Statutory State consultation process review by the IAA.

2.5.9 Visual Approach Chart (EINN AD 2.24-15)

Should the proposed wind farm at Oatfield be permitted the turbine locations would be submitted to the IAA and all relevant aviation charts, including the visual Approach Chart would be updated accordingly.

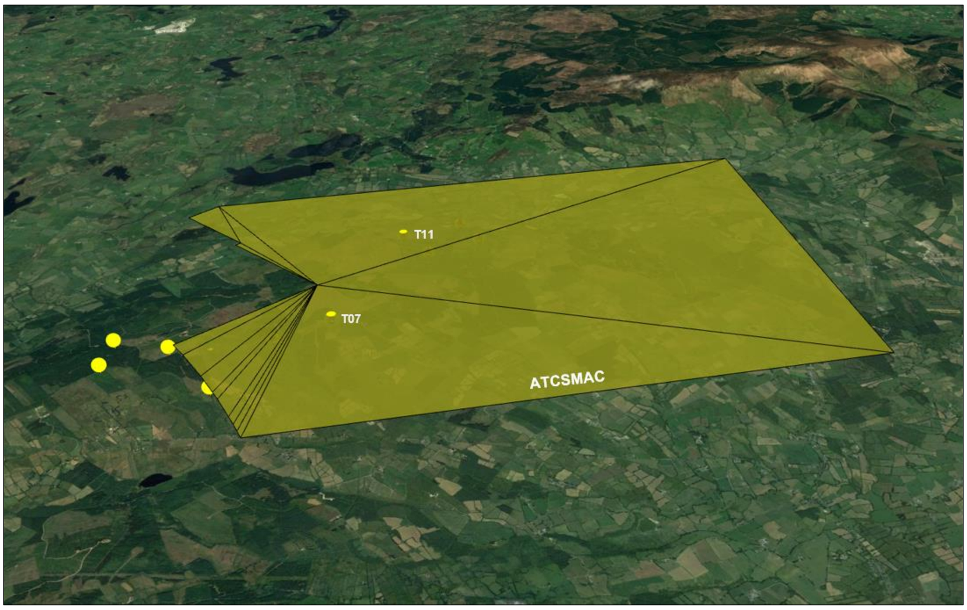


Aviation Impact Review	Mitigation Measure Action	Residual Impact
Visual Approach Chart	No action	None

2.5.10 ATC Surveillance Minimum Altitude Chart (ATC SMAC)

The Air Traffic Control Surveillance Minimum Altitude Chart (ATC-SMAC) is used by Air Traffic Controllers to vector flights for landing into Shannon Airport.

A 3D model of the Air Traffic Control Surveillance Minimum Altitude Chart indicates that two of the proposed turbines (T07 and T11) penetrate the ATC-SMAC surface as shown below. It is highly likely that the IAA-ANSP will require a detailed IFP Safeguarding Assessment by their own approved design specialists to assess the impact due to the proposed development.



Aviation Impact Review	Mitigation Measure Action	Residual Impact
ATC Surveillance Minimum Altitude (ATC-SMAC)	Re-design of the ATC SMAC. Subject to an IAA review there may be a requirement for a confirmatory study to assess the potential impacts of the proposed turbines.	Subject to Statutory State consultation process review by the IAA.

2.6 Permitted Wind Farms in vicinity of Proposed Wind Farm

The Planning References for the permitted Wind Farm(s) in the vicinity of the proposed wind farm are shown below in Table 3. As the Carrownagowan wind farm has been permitted there was no amendments or re-design of Instrument Flight Procedures required.

Wind Farm	Planning Reference	Description
Carrownagowan	Planning Application: 229000 (Clare County Council) https://www.eplanning.ie/ClareCC/AppFileRefDetails/229000/0	Permitted Wind Farm

Table 3. Permitted wind farms in vicinity of proposed wind farm.

On review of the planning application \ permission documents for Carrownagowan Wind Farm the IAA have stated:

> *"I wish to confirm that the IAA ANSP has no objections in regard to the planning process for the proposed Carrownagowan/ Moylussa Clare East Wind Farm."*

Note: The above IAA statement has been extracted from the "*Letter from the Irish Aviation Authority*" in the *RFI Response to Item 3, Carrownagowan Wind Farm (ABP-308799-20)*. This document can be found in Appendix E of this report and is also publically available via the following URL:

https://carrownagowanplanning.ie/wp-content/uploads/2022/02/RFI%20Response%20Item%203.pdf

2.7 Communication and Navigation Systems

The AIP document EIKN AD 2-18/19 provides the information for communication and navigation facilities for Shannon Airport. Table 4 below shows the channel frequencies for the ATS communications Facilities and the Radio Navigation and Landing Aids at the airport.

As the proposed wind farm is approximately 15 km from the Localizers and transmitting antennas, it is very unlikely that turbines at the proposed wind farm will have any impact on these ATS communications and radio navigational aids. Typically, interference to VHF communications systems will only occur when obstacles are in close proximity to the VHF transmitter. e.g. less than 500m.

Aerodrome	ATS communications Facilities Channel Frequency	Radio Navigation and Landing Aids Channel Frequency	Approximate Distance to Localizer and Transmitting Antennas	Impacts of wind farm
Shannon	118MHz –131MHz	339 kHz – 330 MHz	15 km	No impacts

Table 4. Impacts on Communications and Navigation Systems

2.8 Radar Surveillance Sensors

The tables below show the EUROCONTROL Guidelines Assessment Zone arrangement for the two types of aviation radar surveillance systems; Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR).

Zone	Description	Assessment Requirements
Zone 1	0 - 500m	Safeguarding
Zone 2	500m - 15km and in radar line of sight	Detailed Assessment
Zone 3	Further than 15km but within maximum instrumented range and in radar line of sight and in radar line of sight	Simple Assessment
Zone 4	Not in radar line of sight	No Assessment

Table 5. PSR Zone Arrangements

Zone	Description	Assessment Requirements
Zone 1	0 - 500m	Safeguarding
Zone 2	500m - 16km but within maximum instrumented range and in radar line of sight	Detailed Assessment
Zone 4	Further than 16km or not in radar line of sight	No Assessment

Table 6. SSR Zone Arrangements

The EUROCONTROL Guidelines require a 16km safe distance for a "Zone 4 - No Assessment" condition and detailed assessments are required for any proposed wind development within 16km of a secondary surveillance radar.

It should be noted that in the UK, NATS (Air Traffic Control) safeguards SSR to a distance of 10km. The guidelines used by NATS (*CAP 764: Chapter 2: Impact of wind turbines on aviation*) state that:

> *"Wind turbine effects on SSR are traditionally less than those on PSRs but can be caused due to the physical blanking and diffracting effects of the turbine towers, depending on the size of the turbines and the wind farm. These effects are typically only a consideration when the turbines are located very close to the SSR i.e. less than 10 km."*

The nearest radar surveillance sites to the proposed wind farm are the IAA Radar Stations at Shannon Airport (PSR and SSR) and at Woodcock Hill (SSR). Both IAA radar sites are shown relative to the proposed wind farm in Figure 14 below.

Figure 14. IAA Radar Surveillance Sites relative to proposed wind farm.

2.8.1 IAA Radar Surveillance Sensors Assessment

A preliminary radar desktop analysis review was carried out by Ai Bridges and is presented herein. A summary of the radar assessment for the IAA Radar Stations at Shannon Airport and Woodcock Hill are provided below in Section 2.8.1.1 and Section 2.8.1.2 respectively.

2.8.1.1 Shannon Radar Instrument Station Review

The radar surveillance site at Shannon Airport consists of a Thales STAR 2000 primary surveillance radar system (PSR) and a monopulse secondary surveillance radar (MSSR). The PSR and the SSR antennas are co-located on the same structure at Shannon Airport (Figure 15).

Figure 15. Shannon Airport Radar Station

2.8.1.1.2 Shannon PSR Review

Table 7 below shows the (EuroControl & NATS) PSR assessment zone applicable to each of the proposed turbines, which have been based on distance from the PSR at Shannon Airport and whether a radar line-of-sight condition exists. As the table shows, the EUROCONTROL Guidelines indicate that a Simple radar assessment would be required for the PSR at Shannon Airport. The Radar Line-of-Sight Plots for the PSR at Shannon Airport can be found in Appendix G1.

ID	Distance to PSR	In Radar LOS (Y/N)	Radar LOS Assessment (EuroControl Guidelines)	Radar LOS Assessment (NATS Guidelines – UK)
T01	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T02	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T03	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T04	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T05	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T06	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T07	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T08	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T09	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required
T10	> 15 km	N	No Assessment Required	Detailed Assessment Not Required
T11	> 15 km	Y	Simple Assessment Required	Detailed Assessment Not Required

Table 7. EuroControl / UK Safeguarding Guidelines – Shannon PSR

2.8.1.1.1 Shannon SSR Review

Table 8 below shows the (EuroControl & NATS) SSR assessment zone applicable to each of the proposed turbines, which have been based on distance from the SSR at Shannon Airport and whether a radar line-of-sight condition exists. As the table shows, the EUROCONTROL Guidelines indicate that a detailed radar assessment should not be required for the SSR at Shannon Airport.

ID	Distance to SSR	Radar LOS Assessment (EuroControl Guidelines)	Radar LOS Assessment (NATS Guidelines – UK)
T01	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T02	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T03	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T04	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T05	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T06	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T07	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T08	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T09	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T10	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required
T11	> 17 km	Detailed Assessment Not Required	Detailed Assessment Not Required

Table 8. EuroControl / UK Safeguarding Guidelines – Shannon SSR

2.8.1.2 Woodcock Hill Radar Assessment

The radar surveillance site at Woodcock Hill consists of a Thales RSM970 monopulse secondary surveillance radar (MSSR) system housed in the dome-shaped structure shown in the figure below.

Figure 16. Woodcock Hill Radar Station

Table 9 below shows the (EuroControl & NATS) assessment zone applicable to each of the proposed turbines, which have been based on distance from the Radar Station at Woodcock Hill and whether a radar line-of-sight condition exists.

ID	Distance to PSR/SSR	Radar LOS Assessment (EuroControl Guidelines)	Radar LOS Assessment (NATS Guidelines – UK)
T01	5.6 km	Detailed Assessment Required	Detailed Assessment Required
T02	5.2 km	Detailed Assessment Required	Detailed Assessment Required
T03	5.5 km	Detailed Assessment Required	Detailed Assessment Required
T04	4.8 km	Detailed Assessment Required	Detailed Assessment Required
T05	5.3 km	Detailed Assessment Required	Detailed Assessment Required
T06	5.7 km	Detailed Assessment Required	Detailed Assessment Required
T07	6.2 km	Detailed Assessment Required	Detailed Assessment Required
T08	8.0 km	Detailed Assessment Required	Detailed Assessment Required
T09	8.6 km	Detailed Assessment Required	Detailed Assessment Required
T10	8.9 km	Detailed Assessment Required	Detailed Assessment Required
T11	8.3 km	Detailed Assessment Required	Detailed Assessment Required

Table 9. EuroControl / UK Safeguarding Guidelines – Woodcock Hill MSSR

As the table above show, the proposed wind farm is within Assessment Zone 2 as specified by the EUROCONTROL guidelines, which would indicate that a further technical assessment would be required to determine the possible impact on the SSR at Woodcock Hill.

Note: In instances where the IAA require detailed technical assessment, they refer to Section 4.4 of the EuroControl document *"Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors".* A description of the technical assessment requirements as outlined in the EuroControl guidelines has been provided in Appendix F of this report. Some of the possible mitigation measures to offset the potential impact on the Radar System at Woodcock Hill are also listed in Appendix F.

Based on previous consultations with the IAA relating to other third-party wind development projects the IAA stated that they have been evaluating next generation Air Navigation Surveillance Systems ADS-B (satellite-based navigation), which would provide an enhanced form of navigational tracking as adopted by other states.

Aviation Impact Review	**Mitigation Measure Action**	**Residual Impact**
Radar Surveillance Sensors	The proposed development is within 16 km from the SSR Radar Station at Woodcock Hill and following a statutory state consultation review by the IAA, there may be a requirement for a confirmatory study to assess the potential impacts of the proposed turbines.	Subject to Statutory State consultation process review by the IAA.

2.9 Flight Inspection and Calibration

Flight checks are conducted annually to ensure that flight procedures and associated navigational aids are safe and accurate. These flight checks are carried out by an IAA approved Flight Inspection Service Provider (FCSL). The checks are carried out during annual inspections consisting of radial and orbital test flights around Shannon Airport for calibration of instrument landing systems.

The Flight Inspection Service Provider conducts radial and orbital test flights around the Localizer at the airport. At Shannon Airport the orbital flights are conducted at 6 NM (nautical miles), 17 NM from the runway Localizer as shown in the figure below.

It should be noted that planning permission has recently been granted for another wind farm (Carrownagowan) which is located directly underneath the 17 NM Orbital flight route. The permitted turbines at Carrownagowan are also located nearer to the flight check radial flight path (Centreline Approach) than the proposed turbines at Oatfield.

Note: International Standards and Recommended Practices (SARPS) for ILS are published by the ICAO. ILS Localiser and Glide Path lateral coverage sectors are defined in ICAO Annex 10 Chapter 3.1.

2.9.1 Localiser Coverage (ICAO Annex 10 Chapter 3.1.)

The Localiser coverage sector shall extend from the centre of the localizer antenna system to distances of:

- 46.3 km (25 NM) within plus or minus 10 degrees from the front course line;
- 31.5 km (17 NM) between 10 degrees and 35 degrees from the front course line;
- 18.5 km (10 NM) outside of plus or minus 35 degrees from the front course line if coverage is provided.

Figure 17 below shows ILS Localiser lateral coverage sector (as defined in ICAO Annex 10).

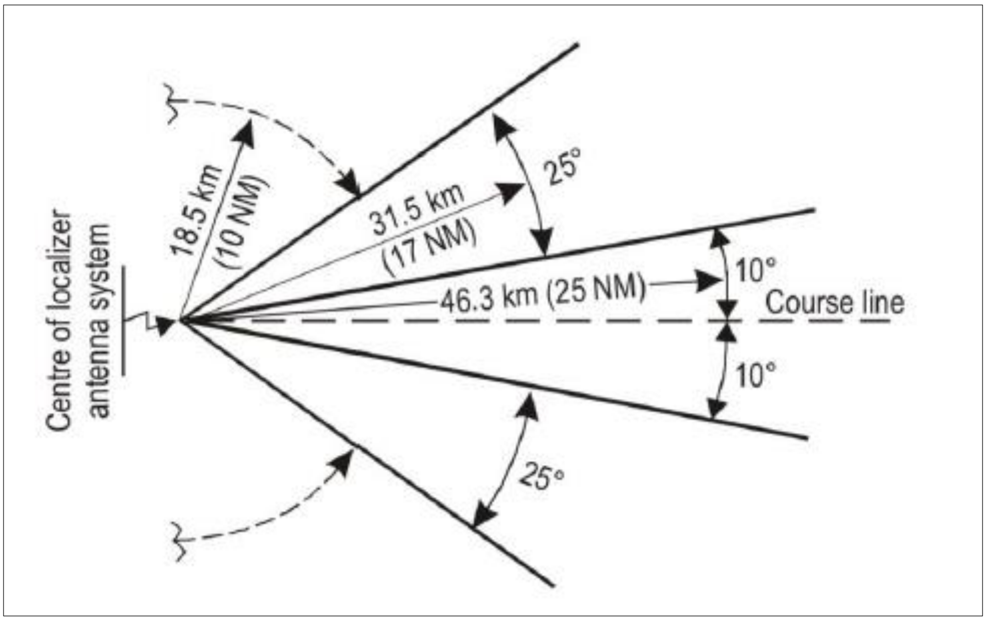


Figure 17. ILS Localiser Lateral Coverage Sector

Figure 18 shows the Runway 24 ILS Localiser lateral coverage sector in relation to the proposed wind farm at Oatfield and the permitted wind farm. Although the proposed turbines are located within the Localiser Lateral Coverage Sector, it should be noted that there are existing/permitted obstacles within the Sector including the wind farm at Carrownagowan.

As the proposed turbines at Oatfield are further from the Centre Approach line that the permitted turbines at Carrownagowan and as the flight procedures should already account for existing terrain (i.e. Moylussa Mountain), it is unlikely that Oatfield will have any significant impacts on the ILS Localiser Flight Inspection/Calibration procedures.

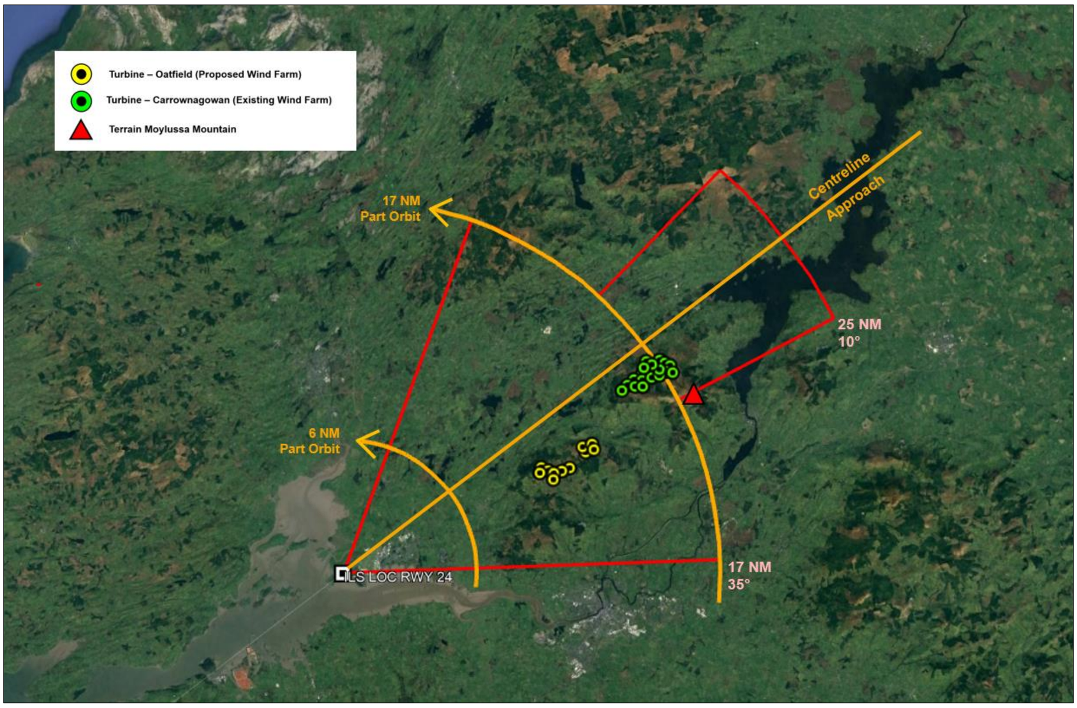


Figure 18. Runway 24 ILS Localiser Lateral Coverage Sector

2.9.2 Glide Path Coverage (ICAO Annex 10 Chapter 3.1.)

ILS Glide Path coverage extends to a range of 10 NM, up to 1.75θ and down to 0.45θ above the horizontal, or to a lower angle, down to 0.3θ as required to safeguard the promulgated Glide Path intercept procedure, where θ is the nominal Glide Path angle.

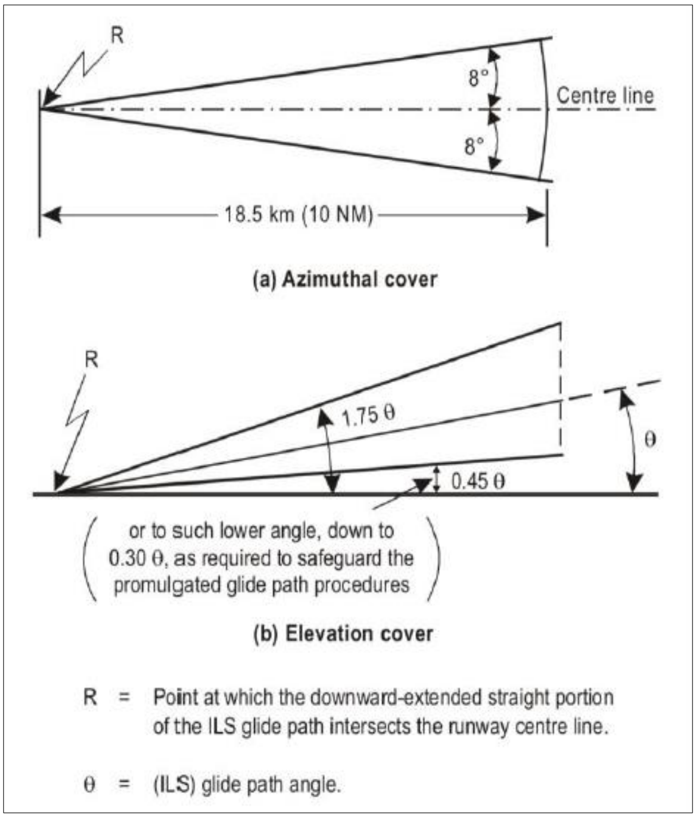


Figure 19. ILS Glide Path Coverage (ICAO Annex 10 Volume I)

Figure 20 below shows the Runway 24 ILS Glide Path lateral coverage sector in relation to the proposed wind farm at Oatfield. As the figure shows all of the proposed turbines are located outside the Glide Path Lateral Coverage Sector.

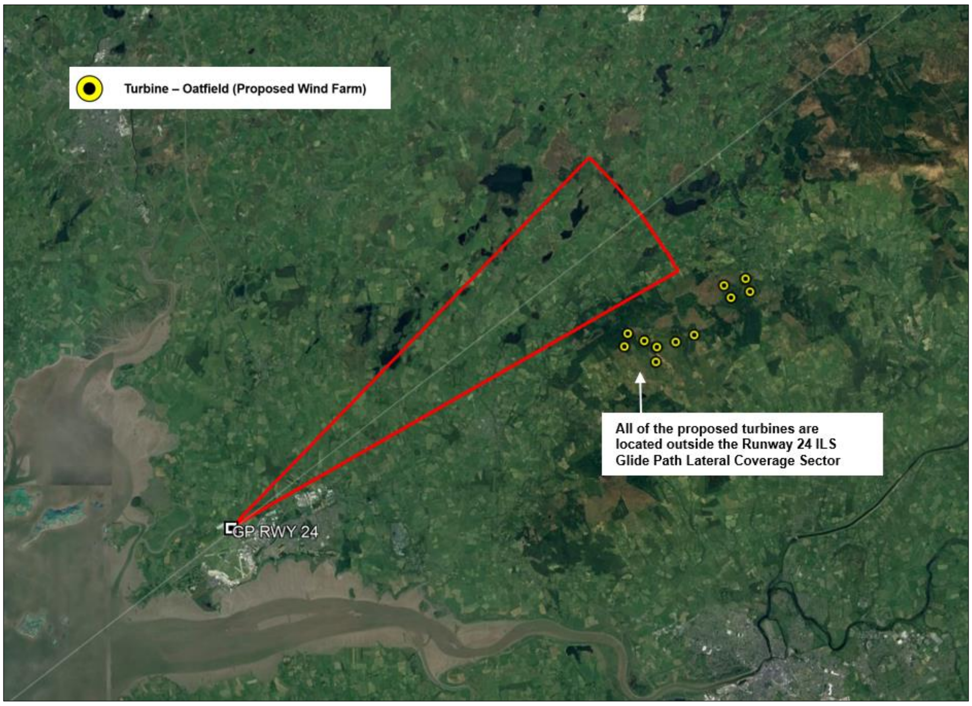


Figure 20. Runway 24 ILS Glide Path Lateral Coverage Sector

2.9.3 Flight Inspection & Calibration - Routes (2023)

FCSL Ltd conducted their 2023 flight checks over two days in June and July. Figure 21 below shows the flight route undertaken by FCSL on the 12th June 2023 and Figure 22 shows the flight route taken on the 28th July 2023. The flight routes show that the flights do not fly over the proposed wind turbines.

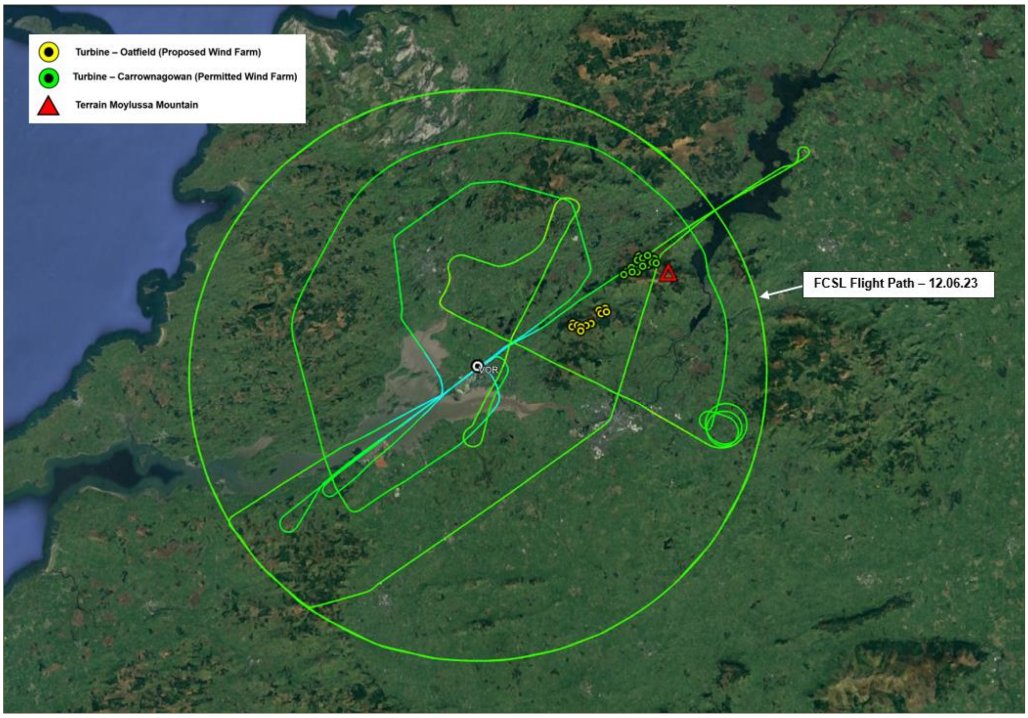


Figure 21. FCSL Flight Route - 12th June 2023

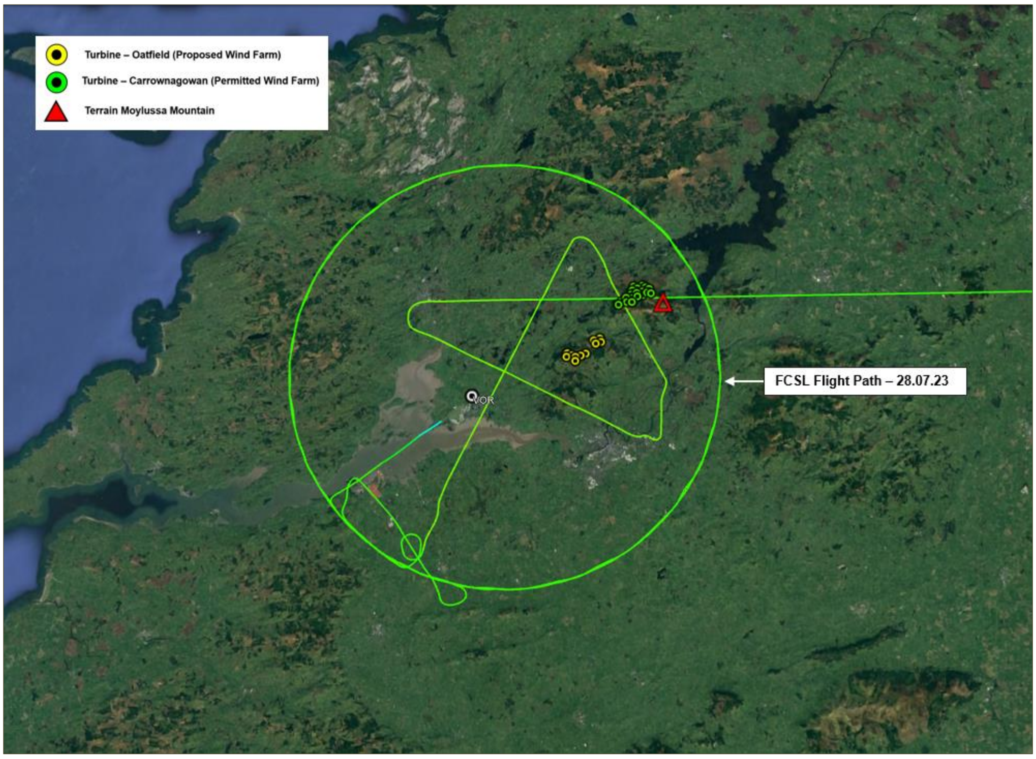


Figure 22. FCSL Flight Route - 28th July 2023

Figure 23 below shows a close-up view of the FCSL aircraft on its radial flight towards Shannon Airport (RWY24). The altitude of the aircraft as it passes to the north of the proposed wind farm is 2625 ft. This distance is over 1000ft higher than the highest of the proposed turbines.

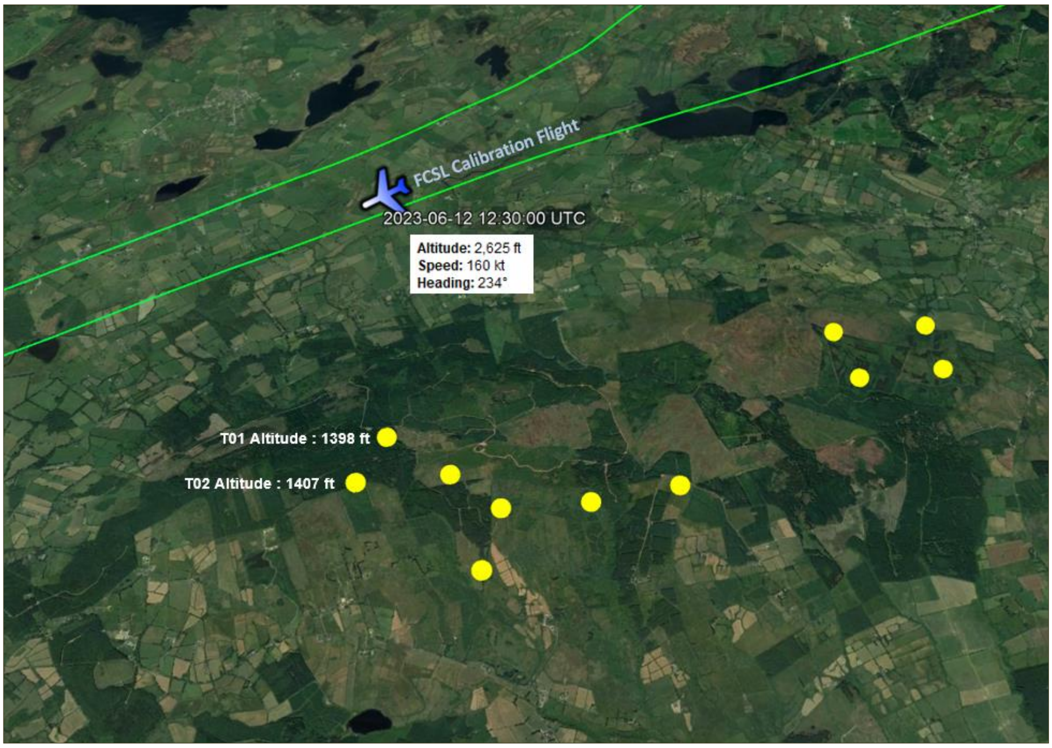


Figure 23. Close-up View of FCSL Flight Route - 12th June 2023

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Flight Inspection and Calibration	No Mitigation Measure Actions are expected. However the IAA / AirNav have requested that their Flight Inspection Service Provider (FCSL) be contacted so that they can assess the proposed development.	None*

** Subject to detailed technical assessment by the IAA approved ILS Calibration service provided FCSL Ltd.*

2.10 Aeronautical Obstacle Warning Light Scheme

In the event of a grant of planning consent the IAA-ANSP would require the lighting of the proposed wind turbines in the interest of aviation safe-guarding as the proposed development may be considered as an en-route obstacle. The developers of the proposed turbines would intend to implement an aeronautical obstacle warning light.

It is recommended that lighting requirements should be in accordance with Chapter Q – Visual Aids for denoting Obstacles; CS ADR.DSN.Q.851 and GM.ADR.DSN.Q.851 (Pages 729/730) of the EASA Easy Access Rules for Aerodromes (Reg (EU) No. 139/2014) where it states that

> *"Applicability: When considered as an obstacle a wind turbine should be marked and/or lighted."*

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Aeronautical Obstacle Warning Light Scheme	It is likely that the IAA would request that the wind farm, if permitted, would be fitted with Aeronautical Obstacle Warning Lights in accordance with industry standards. Subject to further consultation with the IAA.	None

2.11 Irish Air Corps / Department of Defence Safeguarding

The Irish Air Corps Position Paper "*Air Corps Wind Farm / Tall Structures Position Paper*" published on 08th August 2014 (Appendix B), states that the Air Corps are likely to oppose any wind farm / tall structure in the following restricted areas:

i) *Lands underlying military airspace for flying activity. (Areas contained in Danger Areas EI-D1, EI-D5, EI-D6, EI-D13, EI-D14, Restricted Areas EI-R15, EI-R16 within 20 NM of Baldonnel, MOAs 3 and 4 within 20 NM of Baldonnel.*

ii) *Low Flying Training Areas within MOA 4 in the areas of; Blessignton, Edenderry/Allenwood/Rathangan, Kilmeague/Newbridge.*

iii) *Low Flying Training Area West – LFTA WEST.*

iv) *A distance of 5 NM or less from military installations.*

v) *Critical low level flying routes in support of Air Corps operation requirements,* as described in Figure 18 below.

c. The following routes are identified as critical low level routes in support of Air Corps operational requirements and the Air Corps is opposed to the erection of wind farms or tall structures within 3NM of the route centerline which could affect Air Corps' ability to access regional areas.

(a) N/M1
(b) N/M2
(c) N/M3
(d) N/M4
(e) N/M6
(f) N/M7
(g) N/M8
(h) N/M9
(i) N/M11
(j) N25
(k) N17 between Sligo and Knock
(l) N15/N13 between Sligo and Letterkenny
(m) N14 from Lifford to Letterkenny and R245 and R247 from Letterkenny to Fanad Head.

Applications or proposals for structures in these areas of a height greater than 45m above ground level at the site of the object must be referred to Irish Air Corps for assessment of potential impact on flight operations.

Figure 24. Irish Air Corps - Critical Low-Level Routes

The nearest of the Air Corps restricted areas to the proposed wind farm is the M7 Motorway. Figure 25 shows that the nearest of the proposed turbines is 7.8 km from the restricted area around the motorway. As the proposed wind farm is located outside the restricted area, there should be no impacts on Irish Air Corps activities.

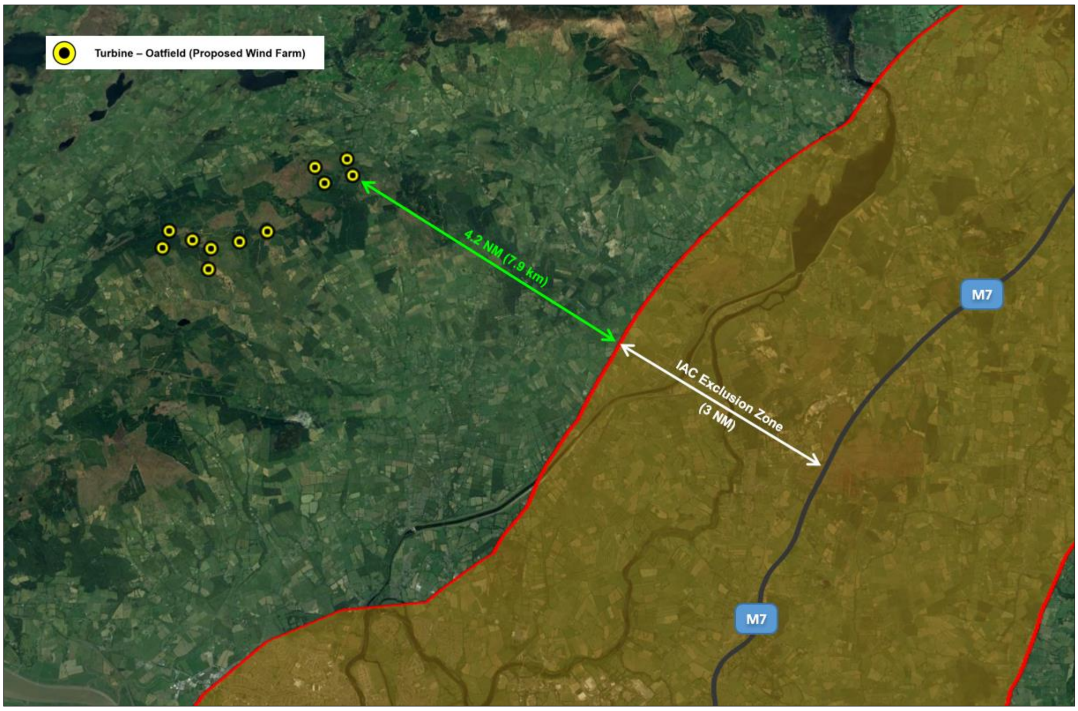


Figure 25. Irish Air Corps Restricted Area - Low Level Flight Route (M7)

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Irish Air Corps / Department of Defence Safeguarding	No action	None

2.12 Garda Air Support Unit (GASU) and Emergency Aeromedical Service (EAS)

The standard concerns that are being raised in recent consultations with the Air Corps also highlight the potential for obstacles that could impact the operations of the Garda Air Support Unit (GASU) and the Emergency Aeromedical Service (EAS). The excerpt below is taken from a response received from the IAC in relation to a third-party wind farm project:

"*Having consulted with the subject matter experts in the Irish Air Corps, the Department of Defence wishes to make the following observations:*

- *The Department of Defence cannot support, based on military advises, the erection of wind farms or other tall structures within 3 NM of roads identified as critical low level routes in support of operational requirements. The erection of obstacles within low-level helicopter routes could affect the Irish Air Corps ability to access regional areas and to fulfil its role.*
- *If this proposed development was to go to the planning stage, the Department of Defence would be obligated to raise the following concerns and advise the planning authorities that the proposed windfarm*

  a) lies wholly within 3 nautical miles of the [Motorway/National Road] which is identified as a critical low level route used by state aircraft on operational taskings. A windfarm or any other tall structures within a low-level route will be an obstacle to state aircraft not operating within the civil rules of the air;

  b) The [Motorway/National Road] low level route requires protection from obstacles for low level state aircraft on operational tasking's such as:

  (i) The Garda Air Support Unit (GASU)
  (ii) The Emergency Aeromedical Service (EAS)"

An assessment of the possible impacts of the proposed wind farm on the Garda Air Support Unit and the Emergency Aeromedical Service operations is provided in Sections 2.11.1 and 2.11.2 that follow.

2.12.1 The Garda Air Support Unit (GASU)

The Garda Air Support Unit is based at Casement Aerodrome, Baldonnel and is typically deployed to incidents in the following cases:

- Immediate threat to life
- Incidents of a criminal, terrorist or other nationally important nature
- Immediate threat of serious public disorder
- Tasks leading to the prevention or detection of crime
- Evidence gathering
- Intelligence gathering
- Photographic tasks
- Traffic Management/Monitoring

The unit consists of one fixed-wing aircraft (a Pilatus Britten-Norman BN 2T-4S Defender 4000) and two helicopters (Eurocopter EC 135 T2).

Figure 26. GASU - Pilatus Britten-Norman BN 2T-4S Defender 4000

Figure 27. GASU - Eurocopter EC135 T2

The proposed wind farm is 7.9 km from the nearest IAC restricted area and is located in a largely rural area. The terrain at the proposed wind farm site consists of forestry and bog. For these reasons, it is highly unlikely that the proposed wind farm development would have any impacts on GASU operations.

In the unlikely event that that a GASU fixed-wing aircraft is flying in the Oatfield area, it should be noted that all modern aircraft are equipped with a range of Global Navigation Satellite Systems (GNSS), e.g. GPS, GLNASS, Galileo, etc. These GNSS systems provide pilots with accurate navigation information including data to avoid obstacles during VFR operations.

Should the proposed wind farm at Oatfield be permitted the turbine locations would be submitted to the IAA and aviation charts and GNSS databases would be updated accordingly.

GASU helicopters would also be fitted with GNSS systems which would clearly identify any potential objects in the operational area (e.g. wind turbines). Also, in good weather conditions, a wind farm at Oatfield could potentially be used as a visual landmark to aid Visual Flight Rules (VFR) navigation which would actually make it easier for pilots to identify their flight position.

If a helicopter is required to land in the Oatfield area, the pilot would seek a Helicopter Landing Site (HLS) that is clear of wires, loose objects and is relatively clear of obstacles. The chosen HLS should have good road access to link up with the local ambulance. A good example of a HLS would be a local football field.

It would be highly unlikely that the wind farm site location would ever be considered as a HLS due to its terrain and road access. A more suitable HLS for any such emergency landings in the general area would be: Sixmilebridge GAA football field or O'Callaghans Mills GAA football field (as marked below in Figure 28).

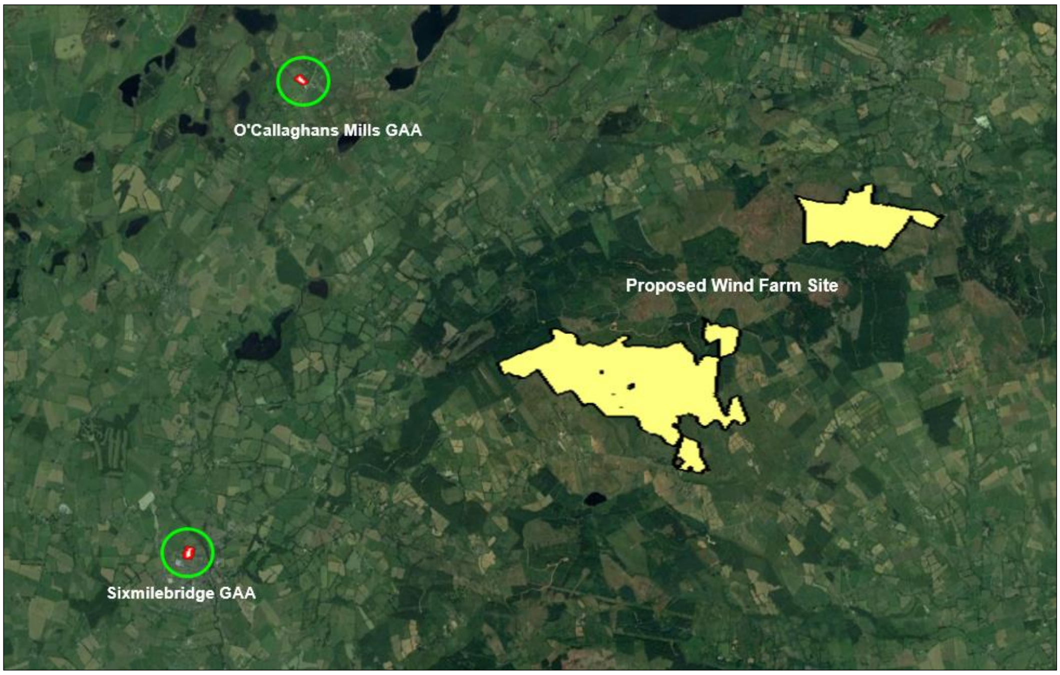


Figure 28. Possible Helicopter Landing Sites

GASU Aircraft	Impact of proposed wind farm - Opinion
Fixed-wing Airplane (Pilatus Britten-Norman BN 2T-4S Defender 4000)	Low – Fixed-wing aircraft are unlikely to be deployed in low level activity in the subject area. In addition, the aircraft would be equipped with modern communications systems and navigational equipment. Should the wind farm be permitted, the turbines would be fitted with aeronautical lighting and would be clearly marked in aviation charts.
Helicopter (Eurocopter EC135 T2)	Low – The aircraft would be equipped with modern communications systems and navigational equipment. Should the wind farm be permitted, the turbines would be fitted with aeronautical lighting and would be clearly marked in aviation charts. Should an emergency landing be required in the subject area, the GAA pitches at Sixmilebridge or O'Callaghans Mills GAA are likely to be used as a HLS.

Table 10. Impact of proposed wind farm on GASU Operations

2.12.2 The Emergency Aeromedical Service (EAS)

This Emergency Aeromedical Service is based in and operates from the Custume Barracks in Athlone. The aircraft utilised by the EAS is an Irish Air Corps Euro-copter 135 and is used for time-critical medical emergencies. Figure 29 below shows the flying times from the EAS base at Athlone.

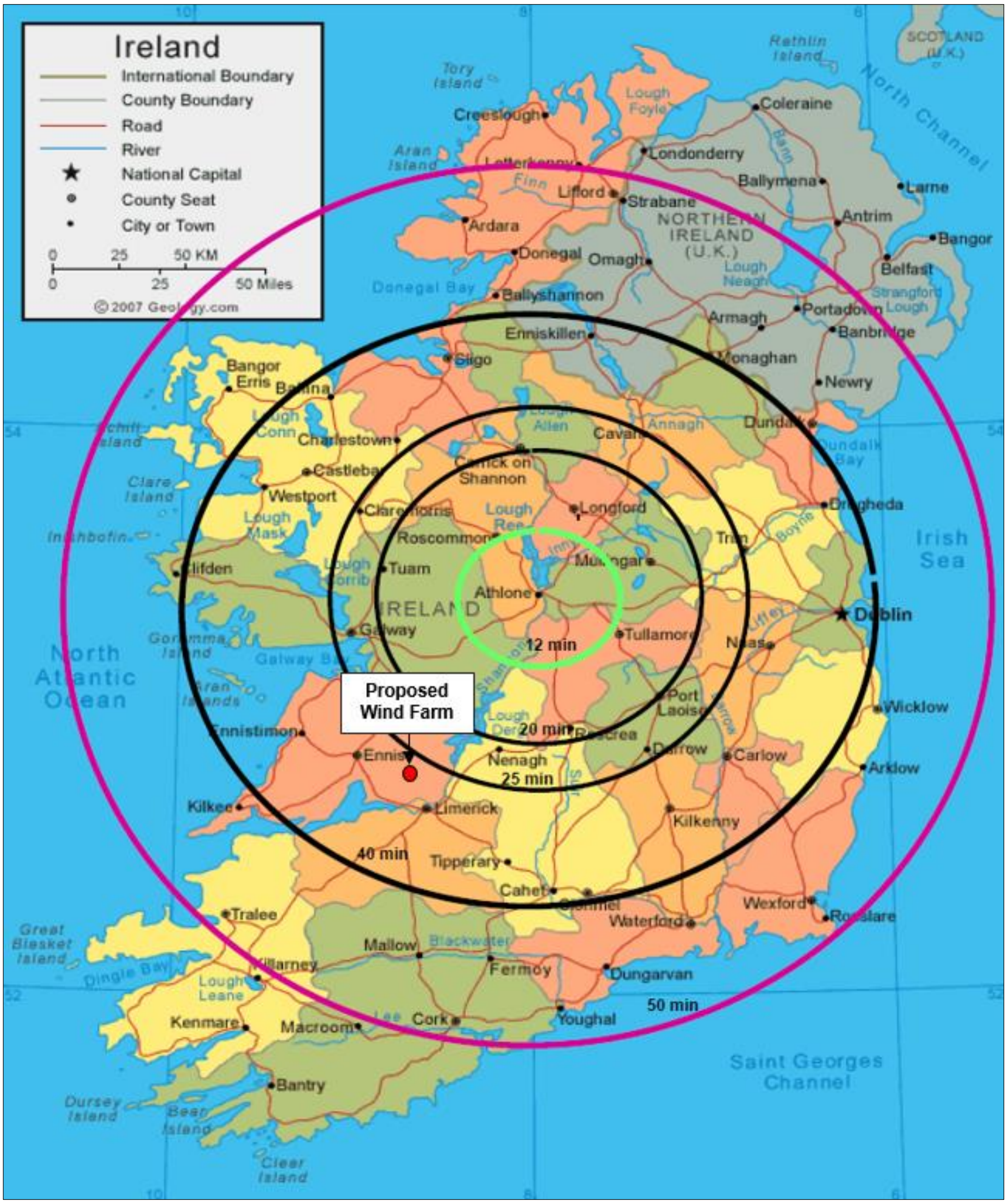


Figure 29. EAS – Flying Times from Athlone

The proposed wind farm is located approximately 5 km northeast of Sixmilebridge and in an area that is relatively sparsely populated. Helicopter landings are highly unlikely to occur in the subject area due to the location’s forested/mountainous terrain.

Also, should the proposed wind farm be permitted the turbine locations would be submitted to the IAA and aviation charts and GNSS databases would be updated accordingly. EAS helicopters would also be fitted with GNSS systems which would clearly identify any potential objects in the operational area (e.g. wind turbines).

In the unlikely event of EAS operations in the general area, the pilot would seek a Helicopter Landing Site (HLS) that is clear of wires, loose objects and is relatively clear of obstacles (e.g. trees). The chosen HLS should also have good road access to link up with the local ambulance service. The GAA Fields at Sixmilebridge or O'Callaghans Mills would be a much more suitable HLS for any such emergency landings in Oatfield area.

EAS Aircraft	Impact of proposed wind farm – Opinion
Helicopter (Eurocopter EC135)	Low – Helicopter landings in the subject area would not occur as the site of the proposed wind farm is sparely populated and is located in forested/mountainous terrain. In addition, the aircraft would be equipped with modern communications systems and navigational equipment. Should the wind farm be permitted, the turbines would be fitted with aeronautical lighting and would be clearly marked in aviation charts.

Table 11. Impact of proposed wind farm on EAS Operations

3. Mitigation Measures

From the findings of this aviation desktop review, mitigation measures are required for the following items:

- Annex 15 Aerodrome Surfaces
- Instrument Flight Procedures
- Radar Surveillance Sensors
- Flight Inspection and Calibration
- Aeronautical Obstacle Warning Light Scheme

3.1 Annex 15 Aerodrome Surfaces – Mitigation Measures

As described in Section 2.2, turbines at the proposed wind farm site would penetrate the ICAO Annex 15 Aerodrome Surfaces. Should the proposed wind farm be permitted, the turbine locations and dimensions should be submitted to the IAA for inclusion in the IAA Electronic Air Navigation Obstacle Dataset. There would be no residual impacts if this mitigation measure is implemented.

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Annex 15 Aerodrome Surfaces	The proposed wind turbines would penetrate the ICAO Annex 15 Aerodrome Surface and should be included in the IAA Obstacle Data Set.	None

3.2 Instrument Flight Procedures – Mitigation Measures

As described in Section 2.5, it is likely that the IAA may require a confirmatory detailed technical assessment to determine if mitigation measures are required for the Instrument Approach Flight Procedures into Runway 24. This detailed technical assessment would be have to be carried out by an IAA approved design specialist to determine the exact impacts of the proposed turbines. If required, a re-design of the affected procedure(s) could be carried out to account for the proposed turbines.

A confirmatory detailed review of the impacts on the Air Traffic Control Surveillance Minimum Altitude Chart (ATC SMAC) is also likely to be required by the IAA which would assess the possible impacts on the ATC SMAC and would include a conceptual design that would be presented to Shannon Air Traffic Control for review and consideration for the safe vectoring of flight operations into Shannon Airport.

A number of design options to reduce the impact of the proposed wind farm to allow Shannon Airport to continue with safe and efficient vectoring operations may include subject to discussion and review with the IAA:

- Raising the Minimum Vectoring Altitude
- Create a new sector to address any issues attributable to the proposed wind turbines.

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Instrument Approach Chart ILS CAT I & II or LOC 24	Confirmatory Study Required.	Confirmatory Study Required.
Instrument Approach Chart VOR RWY 24	Confirmatory Study Required.	Confirmatory Study Required.
ATC Surveillance Minimum Altitude (ATC-SMAC)	Confirmatory Study Required.	Confirmatory Study Required.

3.3 Radar Surveillance Sensors – Mitigation Measures

Due to the proximity of the proposed wind farm to surveillance radar stations, the IAA are likely to request a confirmatory detailed radar assessment by an approved radar design specialist.

There are a number of evidence-based precedents for mitigation measures that have been adopted in UK\Scotland and other EU states over the last decade most notably the case of Newcastle Airport in UK where the existing Thales STAR 200 Radar was upgraded and also the Marshall Project in the UK which involved upgrades and optimizations of over forty Ministry of Defence (MoD) Thales Radar Surveillance Sensors to mitigate for wind farm. While the earlier options for Radar Mitigation Techniques for wind farms adopted in the last decade have been referenced and included in Appendix G there have been considerable advancements in Radar Surveillance Data Processing and Thales have been to the forefront in developing Windfarm Filter algorithms to minimize degradation and clutter impacts of wind farm.

Should the confirmatory radar assessment determine that mitigation measures are required, the mitigation solution may require upgrades and enhancements for the radar systems at Woodcock Hill and Shannon Airport. This would be subject to a conditions-based survey by the manufacturer of the radar surveillance equipment

It should be noted that the radar systems, Thales RSM970 (MSSR) and Thales STAR 2000 (PSR)), used by the IAA at Woodcock Hill and Shannon Airport have sophisticated capabilities to process and handle impacts due to ground obstacles, including wind turbines. It is likely that a conditions survey would be required by the manufacturer to assess what level of upgrades are required to the Radar data processing on both radars to mitigate the effects of wind farm impacts.

In addition, the radar systems have been designed to work in areas with wind farms, and the manufacturer undertakes a continual development cycle to ensure the systems performance is not impacted by wind turbines. Thales have also developed a "*Windfarm Filter*" which can be integrated into existing ATC systems. The Thales wind farm filter is a dedicated algorithm designed to minimize track loss and reduce false alarms above and around wind farms. The radar systems can also be optimized to adjust the radar beams to an appropriate sensitivity to minimize degradation and clutter. Any shadowing from the proposed turbines is likely to be below the published ATC surveillance minimum altitudes and therefore should be operationally tolerable.

Should mitigation measures be required for the proposed wind farm, the existing IAA radars system may require upgrades and enhancements (available from Thales). A detailed conditions survey by the manufacturer would assist in assessing the requirements.

Details regarding the Thales radar systems and capabilities are publicly available and are listed on their website (https://www.thalesgroup.com).

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Radar Surveillance Sensors	The Thales RSM970 Radar Station at Woodcock Hill is within the Assessment zone for assessment. The Thales STAR 2000 Radar Station at Shannon Airport is outside of the Assessment Zone but within instrumented range and may require. Mitigation Measure to include condition-based survey by Thales to determine the Radar upgrade path if required	Confirmatory Radar Assessments and if required Upgrades and Enhancements to the Radar systems at Shannon Airport and Woodcock Hill subject to IAA and Shannon Airport approval.

3.4 Flight Inspection and Calibration – Mitigation Measures

As described in Section 2.9, no mitigation measure actions are expected for Flight Inspection and Calibration procedures; however, the IAA / AirNav Ireland have requested that their Flight Inspection Service Provider (FCSL) be contacted so that they can assess the proposed development.

To assess the proposed wind farm development FCSL may conduct desktop computer simulations. They may also conduct additional Flight Inspections to verify that the proposed wind farm would have no adverse impacts on their Flight Inspection and Calibration procedures.

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Flight Inspection and Calibration	No Mitigation Measure Actions are expected. However the IAA / AirNav have requested that their Flight Inspection Service Provider (FCSL) be contacted so that they can assess the proposed development.	None

3.5 Aeronautical Obstacle Warning Light Scheme – Mitigation Measures

In the event of a grant of planning consent the IAA-ANSP would require the lighting of the proposed wind turbines in the interest of aviation safe-guarding as the proposed development would be considered as an en-route obstacle. The lighting requirements should be in accordance with EASA Easy Access Rules for Aerodromes (Reg (EU) No. 139/2014) which states that:

Applicability: *When considered as an obstacle a wind turbine should be marked and/or lighted.*

Marking: *The rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines should be painted white, or if after a safety assessment, it is determined that other colour will improve safety.*

Lighting: *When lighting is deemed necessary in the case of a wind farm (i.e. a group of two or more wind turbines), the wind farm should be regarded as an extensive object and lights should be installed.*

Further consultations with the IAA would be required to agree the appropriate Aeronautical Obstacle Warning Light Scheme for Oatfield, should the wind farm be permitted.

Aviation Impact Review	Mitigation Measure Action	Residual Impact
Aeronautical Obstacle Warning Light Scheme	It is likely that the IAA would request that the wind farm, if permitted, would be fitted with Aeronautical Obstacle Warning Lights in accordance with industry standards. Subject to further consultation with the IAA.	None

4. Summary

A summary of the aviation review for the proposed wind farm at Oatfield is provided in Table 12 below.

Item	Impact	Summary
Annex 14 - Obstacle Limitation Surfaces (OLS)	None	Turbines at the proposed wind farm site would be located outside the OLS Surfaces for Shannon Airport.
Annex 15 - Aerodrome Surfaces	Notification required.	The proposed wind turbines would penetrate the ICAO Annex 15 Aerodrome Surface and should be included in the IAA Obstacle Data Set.
Building Restricted Areas	None	A review shows that Oatfield is over 9 km from the BRAs at Shannon Airport. At this distance there would be no impacts due to the proposed wind farm.
Minimum Sector Altitudes (MSA)	None	A review of the Minimum Sector Altitudes (MSA) shows that the proposed wind farm is within 25 nautical miles from the VOR/DME at Shannon Airport. The maximum allowable structure in the applicable sector is 2400 ft (AMSL). Turbines at the proposed wind farm would not exceed the 2400 ft threshold, therefore the MSA of the applicable sector will not be affected and there will be no impact on the published MSA altitude figures.
Instrument Flight Procedures	Impacted	A preliminary assessment of the Instrument Flight Procedures (IFP) for Shannon Airport indicates that two of the IFPs are potentially impacted. In addition, the ATCSMAC surface is penetrated by some of the proposed turbines. To confirm the possible impact on the IFPs and ATCSMAC an IAA approved Aviation Design Specialist would be engaged, to undertake a detailed IFP Assessment Mitigation measures to offset any potential concerns raised by the IAA in relation to the proposed turbines are outlined in Section 3of this report.
Communication and Navigation Systems	None	As the proposed wind farm is approximately 15 km from the Localizer and transmitting antenna at Shannon Airport, it is very unlikely that the proposed development will have any impact on these ATS communications and radio navigational aids.
Radar Surveillance Systems Safeguarding	Impacted	According to EUROCONTROL Guidelines, the MSSR at Shannon Airport will not be impacted. The MSSR at Woodcock Hill may need a confirmatory study to assess if potential impacts occur. The PSR at Shannon Airport is outside the 17km assessment range but within the instrumented range of the radar and in partial line of sight. A confirmatory assessment. maybe required by the IAA It should be noted that the radar systems (Thales RSM970 (MSSR) and Thales STAR 2000 (PSR)) used by the IAA at Woodcock Hill and Shannon Airport have sophisticated capabilities to process and handle impacts from wind turbines offering the best mitigation measure path.
Flight Inspection and Calibration	Notification required.	A review of the Flight Inspection Procedures indicate that there will be no impacts due to the proposed wind farm. However the IAA have requested that their Flight Inspection Service Provider (FCSL) be contacted so that they can assess the proposed development.
Aeronautical Obstacle Warning Light Scheme	Observation.	It is likely that the IAA would request that the wind farm, if permitted, would be fitted with Aeronautical Obstacle Warning Lights in accordance with industry standards. Subject to further consultation with the IAA.
Irish Air Corps / DoD Safeguarding	None	The proposed wind farm is located outside the Irish Air Corps Restricted Areas.
Garda Air Support Unit and Emergency Aeromedical Service	None	An assessment of GASU and EAS operations indicate that they are unlikely to be impacted by the proposed wind farm development.

Table 12. Oatfield Wind Farm – Aviation Review Summary

Appendix A – Oatfield Wind Farm Turbine Layout

APPENDIX A - Oatfield Wind Farm Turbine Layout

The co-ordinates of the proposed 11-turbine layout are shown below in Table A1.

Turbine ID	WGS84	
	Latitude	Longitude
T01	52° 46' 16.592"N	8° 42' 8.311"W
T02	52° 46' 3.546"N	8° 42' 14.823"W
T03	52° 46' 9.627"N	8° 41' 36.883"W
T04	52° 45' 47.425"N	8° 41' 21.062"W
T05	52° 46' 2.553"N	8° 41' 12.552"W
T06	52° 46' 8.518"N	8° 40' 36.636"W
T07	52° 46' 16.582"N	8° 40' 1.176"W
T08	52° 46' 59.651"N	8° 38' 50.592"W
T09	52° 47' 6.609"N	8° 38' 14.565"W
T10	52° 47' 21.580"N	8° 38' 22.417"W
T11	52° 47' 13.685"N	8° 39' 3.983"W

Table A1. Turbine Layout

Appendix B – Aviation Stakeholder Consultations

APPENDIX A - Aviation Stakeholder Consultations

The consultations between RSK / Ai Bridges Ltd and the Aviation Stakeholders in relation to the proposed Oatfield wind farm are presented below.

RSK Email to Shannon Airport Group – 13 September 2023

From: *Ayodeji Oyelami <aoyelami@nodwyer.com>*
Sent: *13 September 2023 12:10*
To: *Paul Hennessy <paul.hennessy@snnairportgroup.ie>*
Subject: *[External] Consultation for an EIAR - proposed Oatfield Wind Farm, Oatfield, Co. Clare*

Our Project Ref. 604569

Dear Sir/Madam

Orsted have commissioned RSK Ireland as the Environmental and Planning Consultants to prepare an application for planning permission to An Bord Pleanála for a Strategic Infrastructure Development (SID). The SID is for the proposed Oatfield Wind Farm Project, located in County Clare in the townlands of Oatfield, Crag, Cloontra West, Derryvinnaan, Cloontra, Cloonsheerea, Mountrice, Cloghera, Drumsillagh (Merritt), Drumsillagh (Parker), Kyle and Gortacullin.

The site of the proposed development is located on approximately 985 hectares and comprises approximately 11 turbines, a permanent meteorological mast, an on-site 110 kV substation, along with ancillary civil and electrical infrastructure.

As part of the planning application, RSK Ireland is preparing an Environmental Impact Assessment Report (EIAR). To inform the scope of the EIAR, an EIA Scoping Consultation Report has been prepared for issue to consultees. As a valued consultee, we are writing to provide you with a copy of the EIA Scoping Consultation Document for your comments and feedback.

Additionally, we kindly request any information your agency or organisation may have that would assist us in preparing the EIAR for the proposed Project. If you can offer any information or wish to comment on the EIA Scoping Consultation Report, I would be grateful for your reply by close of business on 13th October 2023.

If you do not have any comments to make or do not have any information relevant to the proposed Project, I would be grateful if you would please indicate same in reply to this email.

Feedback or queries can be sent by email or by post to the contact details below.

Kind regards

Ayodeji Oyelami PhD
Senior Environmental Consultant – Environment & Planning

AirNav Email to RSK – 18 September 2023

From: Cathal MacCriostail <Cathal.MacCriostail@airnav.ie>
Sent: Monday, September 18, 2023 12:38 PM
To: Ayodeji Oyelami <aoyelami@nodwyer.com>
Subject: 230918 Consultation for an EIAR - proposed Oatfield Wind Farm, Oatfield, Co. Clare - AirNav Response
Importance: High

Dear Dr. Ayodeji,

I was forwarded your email by my SAA colleagues and have read the attached EIAR with interest. While primarily the report deals with potential environmental impacts etc, and is well constructed, from a Shannon Airport and Air Navigation Services Provider (ANSP), AirNav Ireland perspective, there are broader considerations to take account of.

This site was previously the topic of discussion with ourselves and SAA in 2018-2019 and I am attaching some of the assessment documents that resulted from our interaction.

I provided the following comments on the reports received:

1. Osprey Aviation Impact Assessment (Attachment 1):
   Section 7: Instrument Flight Operations Analysis
   - Indicates an issue with the secondary containment are for ILS RWY 24: This is not acceptable to the ANSP
   - Para. 7.1.3 SIDs; these have been updated since the report was produced and therefore the argument is not acceptable to the ANSP
   - Recommendations from the FCSL Report included:
     If construction of the Oatfield Wind Farm is to proceed, large cranes exceeding the height of the wind turbines may be used to erect the turbine structures. Depending on the type of cranes to be used, some further computer simulations may be required to assess the effect of cranes on the ILS Localiser and Glide Path guidance signals.
     It is further recommended that a full ILS flight inspection is performed after construction of the wind farm is completed to assess the actual levels of interference caused by the wind turbine structures.
     Comment: on both cases, the activity required puts a cost ion the ANSP in further assessment of IFPs and in flight Inspections.
     As no reference is made as to how this will be achieved, this is not acceptable to the ANSP. In addition, if there are issues identified after construction, this has the potential to introduce additional safety risk for the IAA to manage and is once again not acceptable.

2. Pager Power SSR Technical Assessment:
   Although I am not an expert in this domain, I can comment in my role.
   - I note that examples of Wind Turbines near other airports used, relate to relatively flat topographical environments, whereas in this case the construction of the proposed farm on an elevated site is of issue to me.
   - The conclusion record potential impacts on the SSR service. Even being conservative, this implies a cost on the IAA in mitigating effects and in turn carrying additional risk

3. Pager Power ILS Calibration Flight Impact Assessment:
   I have discussed this with my colleague Fergal Doyle and note that-
   - The proposed mitigations imply that associated costs if these mitigations are implemented fall to the IAA ANSP or the flight calibration company
   - In addition the ANSP will be required to carry additional risk in promulgating information on this wind farm

For these reasons alone this cannot be supported.

The EIAR notes that 11 turbines will have a maximum blade tip height between 179 and 180metres.

When we the ANSP look at these values, we must also include the site elevation which is c. 250m. This gives us an above Mane Sea Level elevation of c. 430m. This value in the case of all turbines, penetrates our Instrument Flight Procedures (IFP) Surfaces for Shannon Airport. This would require a detailed IFP Assessment from a certified IFP designer to establish the effects of these new obstacles and to suggest possible mitigations.

We have a Surveillance Radar on Woodcock Hill, from which AirNav is responsible and is approximately 6km from the proposed wind farm. Being that the AMSL elevation of the completed turbines is higher that the elevation of this radar, we would expect that this could affect the radar's operation and would need detailed examination.

While AirNav also have responsibility for the Navigation Aids at Shannon Airport, I wouldn't expect any great issue in this area. However, as these facilities undergo half-yearly flight inspections, which are flown by a calibration aircraft.

The proposed turbines will impact the conduct of these flights.

When you have had a chance to digest all this, I'd be glad to meet with you (via Teams) if you wish, to discuss further.

Regards,

Cathal

Cathal Mac Criostail
Airspace & Navigation | AirNav Ireland

AirNav Email to Ai Bridges Ltd – 18 September 2023

From: Brendan O'Connor <Brendan.OConnor@airnav.ie>
Sent: Monday, August 28, 2023 2:55 PM
To: David McGrath <dmcgrath@aibridges.ie>
Subject: RE: Oatfield Wind Farm Development, Co Clare

Hi David,

The proposed windfarm development falls within the coverage area of AirNav Ireland operated navigational-aids at Shannon Airport and may have an impact on the flight-calibration profiles flown as part of the associated commissioning and periodic routine flight-checks.

AirNav Ireland requests that you contact our flight calibration contractor FCSL, to assess if any adverse effects to Shannon ILS 24 Commissioning and Routine Flight Check Profiles will occur because of this development.

Please find FCSL contact details attached.

Regards,
Brendan O'Connor

Appendix C – ICAO Annex 15 Area 1 and Area 2 Surfaces

APPENDIX C - ICAO Annex 15 Area 1 and Area 2 Surfaces.

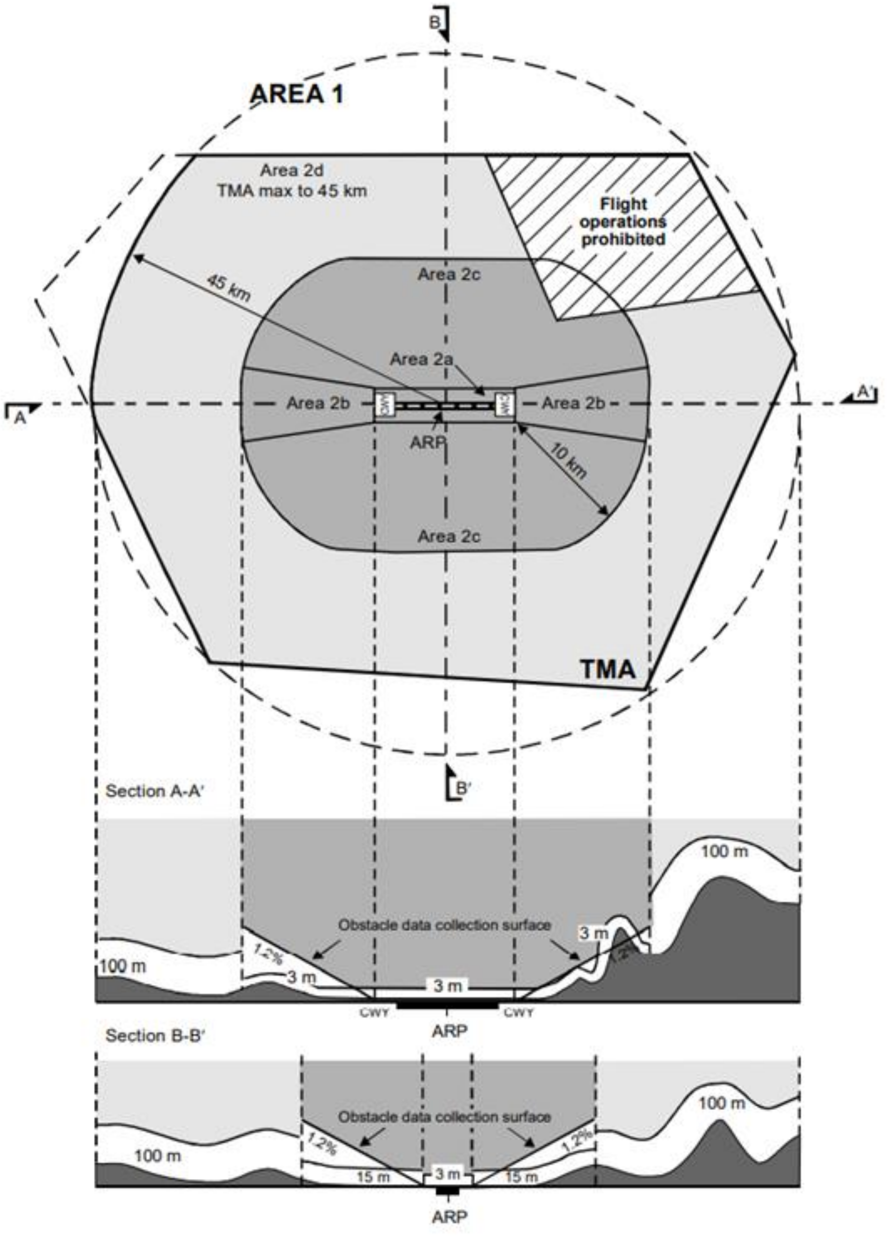


Figure A8-2. Obstacle data collection surfaces — Area 1 and Area 2

Figure C1 - ICAO Annex 15 Area 1 and Area 2 Surfaces.

Appendix D – ICAO Building Restricted Areas

APPENDIX D - ICAO Building Restricted Areas.

Figure D1 below shows an example BRA shape for directional facilities. Table D1 provides harmonized guidance figures for the directional navigational facilities in accordance with Figure D1.

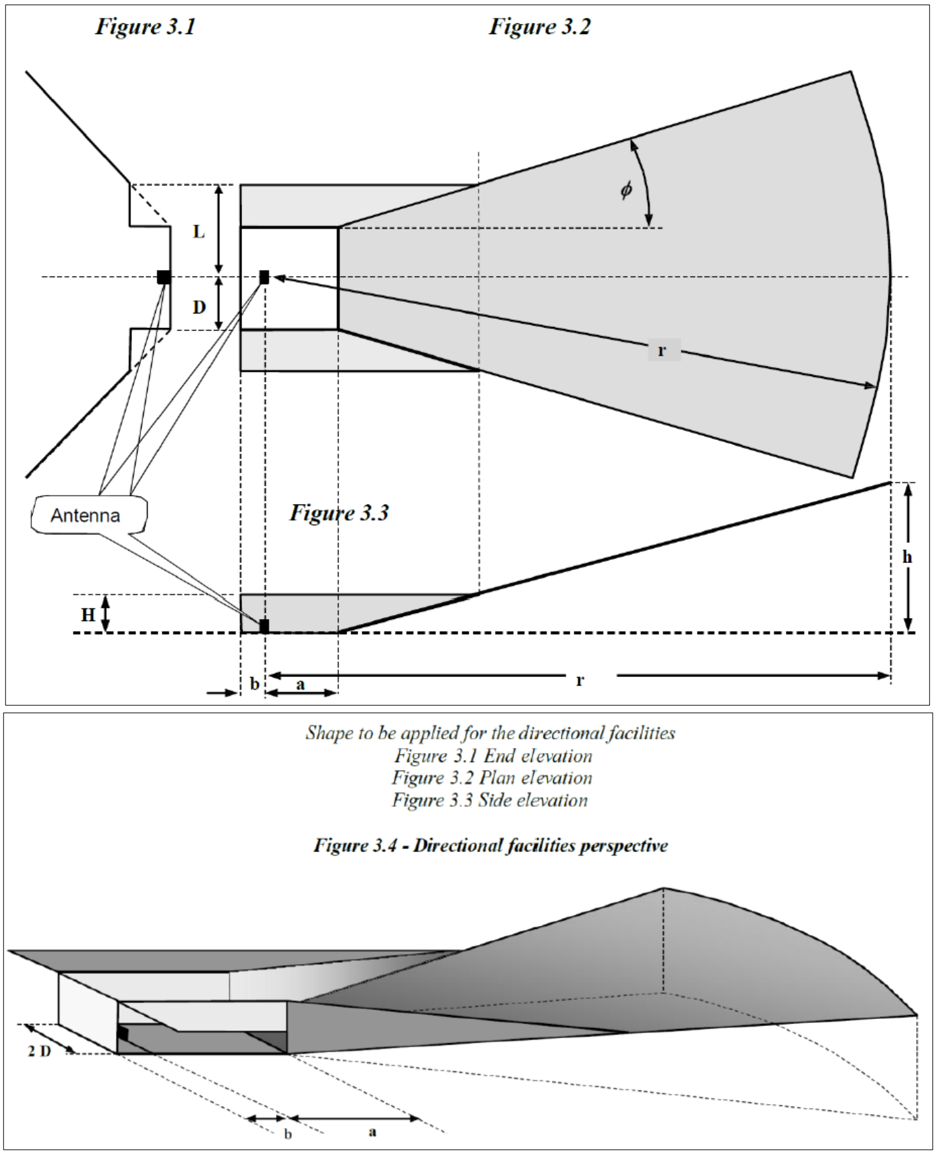


Figure D1 - Example BRA shape for directional facilities (ICAO EUR DOC 015 Figures 3.1-3.4)

*Type of **navigation** facilities*	*A* (m)	*b* (m)	*h*(m)	*r* (m)	*D* (m)	*H* (m)	*L* (m)	*ϕ* (°)
ILS LLZ (medium aperture single frequency)	Distance to threshold	500	70	a+6000	500	10	2300	30
ILS LLZ (medium aperture dual frequency)	Distance to threshold	500	70	a+6000	500	20	1500	20
ILS GP M–Type (dual frequency)	800	50	70	6000	250	5	325	10
MLS AZ	Distance to threshold	20	70	a+6000	600	20	1500	40
MLS EL	300	20	70	6000	200	20	1500	40
DME (directional antennas)	Distance to threshold	20	70	a+6000	600	20	1500	40

Table D1 - Harmonized guidance figures for the directional navigational facilities (ICAO EUR DOC 015 Table 2)

Appendix E – Request for Further Information Response to Item 3 Carrownagowan Wind Farm

Malachy Walsh and Partners
Engineering and Environmental Consultants

Request for Further Information

Response to Item 3

Carrownagowan Wind Farm (ABP-308799-20)

ISSUE FORM	
Project number	19107
Document number	6048
Document revision	A
Document title	Request for Further Information – Response to Item 3
Document status	Final
Document prepared by	Helen Burman-Roy, MWP
Document checked by	Ken Fitzgerald, MWP

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List of appendices

1 INTRODUCTION

Coillte CGA, care of Malachy Walsh and Partners, received a request for further information regarding the Carrownagowan Wind Farm application from An Bord Pleanála in a letter dated 23rd February 2021. This report addresses the further information outlined in Item 3 of the letter.

1.1 CONTRIBUTORS TO THIS REPORT

This report has been completed by Helen Burman-Roy to outline the assessment required and completed to address the submission made by Shannon Airport to An Bord Pleanala in respect of the proposed development.

Cyrrus and FCSL were contracted by MWP on behalf of the applicant to address specific queries raised by Shannon Airport and the Irish Aviation Authority. John Van Hoogstraten of Cyrrus and David Bartlett of FCSL completed the required assessments.

John Van Hoogstraten (MBCI, CBCP, SIIRSM) is the Operations Director of Cyrrus. John has a wealth of aviation experience over 30 years including experience from South Africa and the Middle East. John specialises in aviation support to airports, airport developers, regulators and air navigation service providers to help achieve regulatory compliance and implementation of future systems and procedures in line with ICAO (and State) standards and recommended practices.

David Bartlett is the Director of Flight Calibration Serivces Ltd (FCSL) and specialises in the design, specification, installation, licensing and operation of ground based and satellite navigation aids, Aeronautical Ground Lighting (AGL) and ATC tower facilities as well as ATM planning and regulatory issues.

Cyrrus and FCSL are both on the list of approved contractors from the Irish Aviation Authority (IAA).

The IAA were consulted through the process and issued a letter stating they are satisfied that the issues highlighted can be appropriately managed. Refer to section 2.3 below and **Appendix 4** for the Letter from the Irish Aviation Authority.

1.2 ITEM 3 OF THE FURTHER INFORMATION REQUEST

Item 3 of the request for further information from An Bord Pleanála is as follows:

The submission received from Shannon Airport states the location of the proposed turbines may have implications for instrument flight procedures. The applicant shall review the submission from Shannon Airport and respond accordingly.

2 RESPONSE TO ITEM 3

Shannon Airport, in conjunction with the Irish Aviation Authority, required the following technical assessments to be carried out with regards to the Carrownagowan Wind Farm.

- Assess the effect the proposed wind farm may have on flight inspection procedures and profiles associated with the Shannon Airport Runway 24 Instrument Landing System (ILS).
- Technical Safeguarding Assessment to address the potential impact the proposed development may have on the Shannon Airport Instrument Landing System (ILS) and the Woodcock Hill Monopulse Secondary Surveillance Radar (MSSR).
- An Instrument Flight Procedure (IFP) Opinion is necessary (which may result in a full IFP Assessment being required)

MWP received a list of approved contractors from the Irish Aviation Authority (IAA) for the work and consulted with both Shannon Airport and the IAA on the scope of the assessments. The scope of work required by Shannon Airport and the IAA and completed by Cyrrus and Flight Calibration Services Ltd (FSCL) was as follows;

Flight Calibration Services Ltd (FSCL)
FCSL performed an assessment to establish any adverse effect the proposed wind farm may have on flight inspection procedures and profiles associated with the Shannon Airport Runway 24 Instrument Landing System (ILS).

Cyrrus Limited
Cyrrus was engaged to conduct a Technical Safeguarding Assessment for the proposed Carrownagowan wind farm development. The study addressed the potential impact the proposed development may have on the Shannon Airport Instrument Landing System (ILS) and the Woodcock Hill Monopulse Secondary Surveillance Radar (MSSR). Cyrrus conducted the technical safeguarding assessment on the proposed development under a worst-case scenario.

Cyrrus were also engaged to provide an IFP opinion, ie to review the Instrument Flight Procedures (IFP) to determine if a full assessment is required. Cyrrus deemed a full IFP Assessment was necessary and was thereafter engaged to conduct the full study to assess if any of the turbines infringe the protection surfaces of the IFPs serving Shannon Airport.

2.1 RESULTS OF THE FCSL ASSESSMENT

FCSL notes that flight inspection aircraft flying centreline and part orbit flight profiles associated with the Shannon Airport Runway 24 ILS will remain sufficiently clear of the proposed Carrownagowan Wind Farm site. The proposed Carrownagowan Wind Farm will therefore have no adverse effect on flight inspection procedures and profiles associated with the Runway 24 ILS.

FCSL note that their study does not include an assessment of Runway 24 Localiser guidance signal or any impact the proposed wind farm may have on the integrity of the Runway 24 ILS guidance signals. However, this was part of the Cyrrus technical assessment.

Refer to **Appendix 1** for the FCSL Study: Carrownagowan Wind Farm Impact on ILS Flight Inspection

2.2 RESULTS OF THE CYRRUS ASSESSMENT

2.2.1 Technical Assessment

Cyrrus conducted the technical safeguarding assessment for the proposed development under a worst-case scenario.

The main findings of this study with regard to ILS performance show that:

- The proposed wind farm lies outside all of the Airport Air Navigation Equipment (AANE) Building Restricted Areas (BRA);
- The proposed wind farm will not pose a risk to aircraft approaching or departing from either runway at Shannon Airport;
- No further modelling is deemed necessary.

Detailed radar modelling of the indicative layout against the MSSR at Woodcock Hill shows the following:

- Radar Line of Sight exists between Woodcock Hill MSSR and the towers of turbines T1, T2, T3, T4,T5 and T6;
- Bistatic reflections from these turbines will not result in false targets for Woodcock Hill MSSR;
- Woodcock Hill MSSR shadow regions from the turbines are considered operationally tolerable;
- No mitigation measures are considered necessary for Woodcock Hill MSSR.

<u>**Conclusions**</u>

- Modelling of the proposed windfarm shows that none of the wind turbines will penetrate any of the AANE BRAs.
- The proposed wind farm will not pose a risk to aircraft approaching or departing from either runway at Shannon Airport. No further modelling is deemed necessary.
- Calculations have shown that false targets due to bistatic reflections from the turbine towers will not occur for Woodcock Hill MSSR.
- The volumes of shadow regions from the turbines are relatively small for the MSSR and considered operationally tolerable. No mitigation measures are considered necessary for the Woodcock Hill MSSR.

Refer to **Appendix 2** for the Cyrrus Technical Study: Technical Safeguarding Assessment

2.2.2 IFP Opinion and Assessment

Cyrrus reviewed the Instrument Flight Procedures for Shannon and determined a further study was required. Therefore, a full IFP Assessment was carried out.

The study assessed if the wind farm impacted on IFPs serving the airport. Each IFP has different criteria to consider in assessing any impact. Cyrrus assessed all IFPs and determined that the wind Farm has no impact to the currently published IFPs for Shannon Airport.

Refer to **Appendix 3** for the Cyrrus IFP Safeguarding Assessment

2.3 REVIEW OF RESULTS – STAKEHOLDER MEETING

A stakeholder meeting was held on the 19th of May 2021 to discuss the outcome of the various studies. The following were in attendance;

- Cathal MacCriostail (IAA)
- Paul Hennessy (Shannon Airport)
- David Bartlett (FCSL)
- John Van Hoogstraten (Cyrrus)
- Charles Langley (Coillte)
- Helen Burman-Roy (MWP)

The studies and conclusions were discussed and in follow up correspondence, the IAA issued a letter stating they are satisfied that the issues highlighted can be appropriately managed, if and when planning permission is granted.

Refer to **Appendix 4** for the Letter from the Irish Aviation Authority.

3 CONCLUSION

The reports addressing item 3 of the request for Further Information are all included as Appendices to this report. A concluding statement is provided for each item below.

Flight inspection procedures – check by Flight Calibration Services Ltd	The proposed Carrownagowan Wind Farm will therefore have no adverse effect on flight inspection procedures and profiles associated with the Runway 24 ILS.
Technical assessment	The proposed wind farm lies outside all of the Airport Air Navigation Equipment (AANE) Building Restricted Areas (BRA). The proposed wind farm will not pose a risk to aircraft approaching or departing from either runway at Shannon Airport. No mitigation measures are considered necessary for Woodcock Hill MSSR.
IFP Assessment	Cyrrus assessed all IFPs and determined that the wind Farm has no impact to the currently published IFPs for Shannon Airport.
Overall statement by IAA	MWP received a letter from the IAA concluding that the IAA ANSP 'has no objections in regard to the planning process for the proposed Carrownagowan/Moylussa Clare East Wind Farm'.

Appendix 1

Carrownagowan Wind Farm Impact on ILS Flight Inspection - FCSL

FLIGHT CALIBRATION SERVICES LTD

CARROWNAGOWAN WIND FARM IMPACT ON ILS FLIGHT INSPECTION

Prepared For:	Malachy Walsh and Partners
Author:	John Wilson
Reviewed by:	David Bartlett
Reference:	FCSL 0135
Issue:	1
Date:	12 April 2021

CARROWNAGOWAN WIND FARM

Impact on ILS Flight Inspection

TABLE OF CONTENTS

ABBREVIATIONS

AIP	Aeronautical Information Publication
AMSL	Above Mean Sea Level
ARP	Aerodrome Reference Point
DME	Distance Measuring Equipment
FCSL	Flight Calibration Services Ltd
FIP	Flight Inspection Procedure
GP	Glide Path
GPS	Global Positioning System
ha	hectare
IAA	Irish Aviation Authority
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
ITM	Irish Transverse Mercator
LOC	Localiser
NM	Nautical Miles
WGS	World Geodetic System

1 INTRODUCTION

Carrownagowan Wind Farm is a proposed renewable energy project located in County Clare on the north western slopes of Slieve Bernagh mountain, approximately 15 NM north east of Shannon Airport.

The Irish Aviation Authority (IAA) has requested that an assessment be performed to establish any adverse effect the proposed wind farm may have on flight inspection procedures and profiles associated with the Shannon Airport Runway 24 Instrument Landing System (ILS).

This report provides an assessment of the impact of terrain and obstacles on ILS flight inspection procedures. It does not provide an assessment of any impact the proposed wind farm may have on the integrity of the Runway 24 ILS guidance signals.

2 DETAILS OF PROPOSED WIND FARM

The proposed Carrownagowan Wind Farm comprises 19 wind turbines and associated infrastructure including turbine foundations, access tracks, an electricity substation, control building and meteorological mast located in an area of approximately 750 ha as shown in Figure 2.1 below. Figure 2.2 below shows the location of the wind farm in relation to Shannon Airport.

The proposed wind turbine and meteorological mast coordinates are shown in Table 2.1 below.

The maximum height of the proposed wind turbines (to blade tip) is 169 m (554 ft) above ground level. Ground height at the highest turbine (T4) is 326 m (1,069 ft) AMSL (see Figure 2.1 below).

The proposed meteorological mast will have a maximum height of 100 m above ground level.

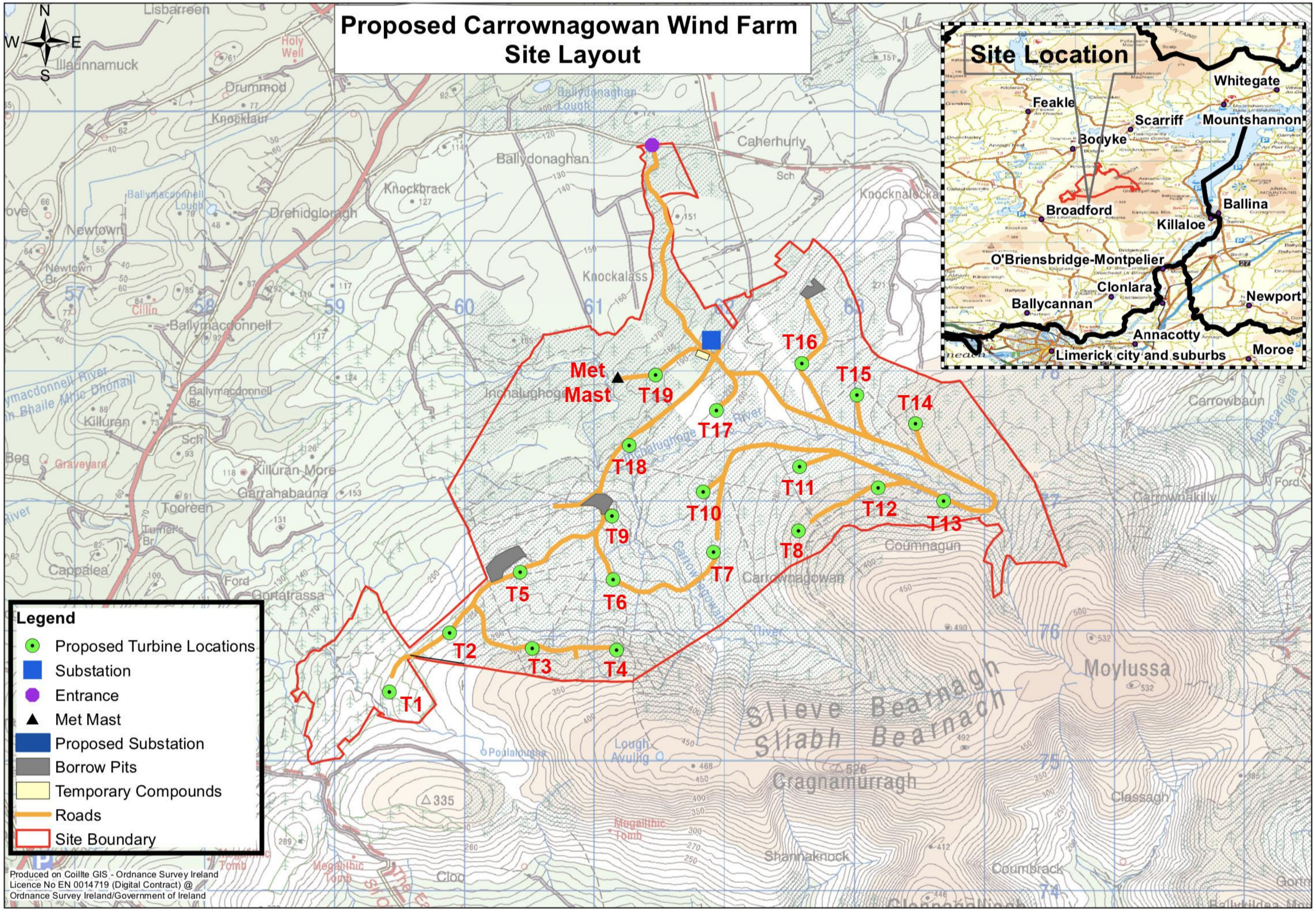


Figure 2.1 - Proposed Carrownagowan Wind Farm Site Layout

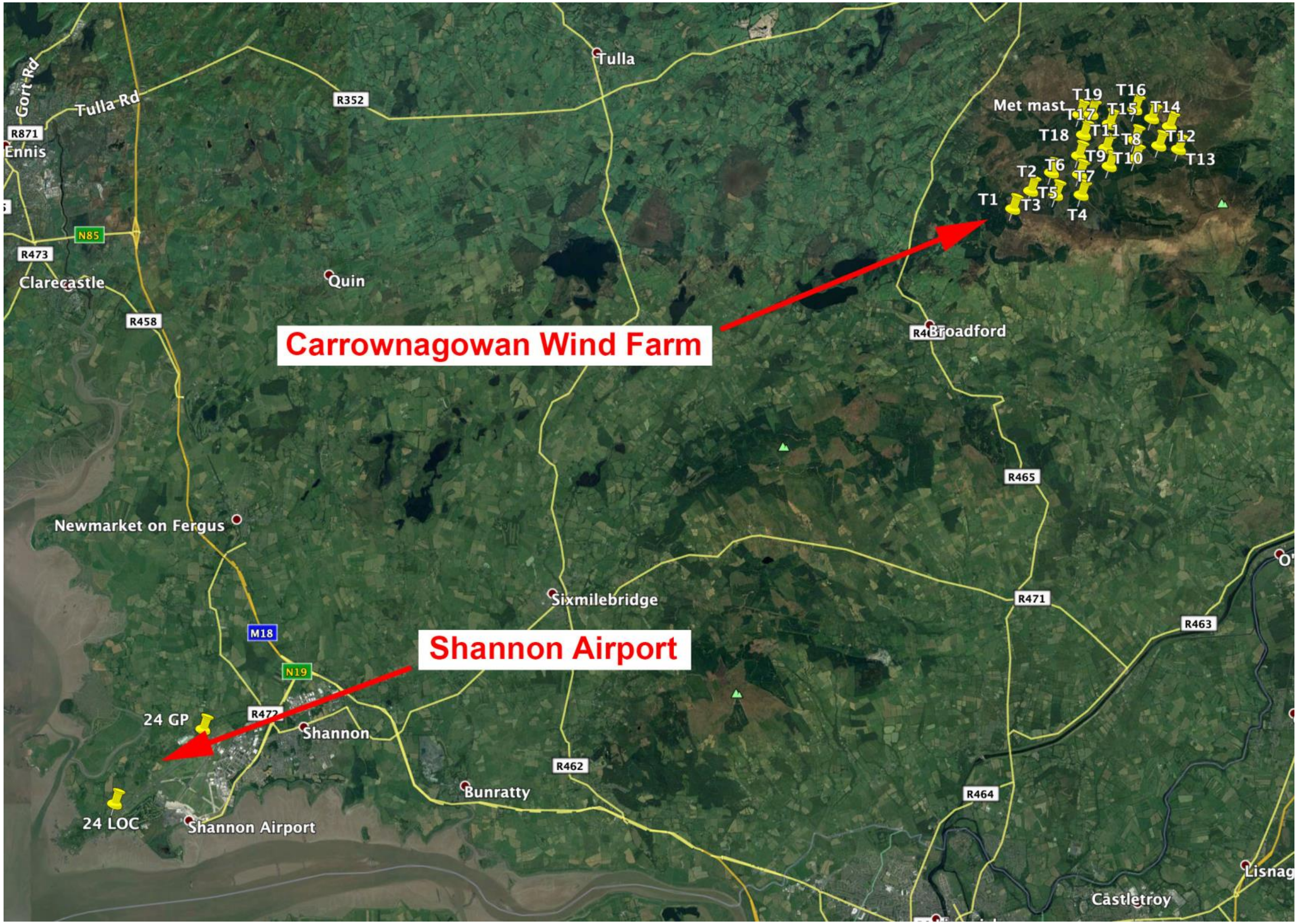


Figure 2.2 – Location of Proposed Carrownagowan Wind Farm and Shannon Airport

Turbine	ITM Coordinates		WGS-84 Coordinates		Ground Level AMSL (m)
	X	Y	Latitude	Longitude	
1	559385	675575	52.829598	-8.602697	245.56
2	559850	676030	52.833722	-8.595853	246.72
3	560484	675908	52.832672	-8.586430	300.12
4	561137	675897	52.832621	-8.576738	326.39
5	560394	676494	52.837932	-8.587836	243.44
6	561109	676437	52.837472	-8.577218	247.31
7	561881	676649	52.839432	-8.565785	244.75
8	562533	676815	52.840970	-8.556128	313.24
9	561098	676928	52.841884	-8.577440	225.49
10	561800	677115	52.843615	-8.567042	237.93
11	562539	677308	52.845401	-8.556095	277.48
12	563149	677146	52.843987	-8.547022	310.89
13	563650	677042	52.843086	-8.539574	314.38
14	563431	677641	52.848455	-8.542892	311.15
15	562982	677858	52.850375	-8.549582	278.45
16	562556	678103	52.852547	-8.555934	250.22
17	561903	677741	52.849248	-8.565586	220.58
18	561234	677472	52.846783	-8.575486	194.97
19	561435	678011	52.851641	-8.572566	188.93
Met mast	561144	677998	52.851503	-8.576884	172.65

Table 2.1 - Proposed Turbine and Meteorological Mast Coordinates

3 ILS INFORMATION

3.1 ILS Site Information

The Runway 24 ILS provides radionavigation information to aircraft in the initial and final approach phases of flight towards Runway 24 within 25 NM of Shannon Airport. The ILS ground installation comprises:

- Localiser equipment (providing lateral guidance to the runway centreline) located on the extended runway centreline approximately 300 m from the stop end of Runway 24.
- Glide Path equipment (providing vertical guidance to a 3.0° glide path) located approximately 130 m offset from runway centreline and backset 360 m from Runway 24 threshold.
- Distance Measuring Equipment (DME) transponder (providing distance to runway threshold information). The DME antenna is mounted on the Glide Path mast.

ILS Localiser, Glide Path and DME antenna coordinates are shown in the extract from AIP Ireland shown in Figure 3.1 below.

3.2 ILS Coverage Information

International Standards and Recommended Practices (SARPS) for ILS are published by the International Civil Aviation Organization (ICAO). ICAO Annex 10 Chapter 3.1 defines ILS Localiser and Glide Path lateral coverage sectors as described below.

3.2.1 Localiser Coverage

The Localiser coverage sector shall extend from the centre of the localiser antenna system to distances of:

- 46.3 km (25 NM) within plus or minus 10 degrees from the front course line;
- 31.5 km (17 NM) between 10 degrees and 35 degrees from the front course line;
- 18.5 km (10 NM) outside of plus or minus 35 degrees from the front course line if coverage is provided.

Figure 3.2 below shows ILS Localiser lateral coverage sector as defined in ICAO Annex 10.

Figure 3.3 below shows the Runway 24 ILS Localiser lateral coverage sector in relation to the proposed Carrownagowan Wind Farm.

3.2.2 Glide Path Coverage

The Glide Path equipment shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation in sectors of 8 degrees in azimuth on each side of the centre line of the ILS glide path, to a distance of at least 18.5 km (10 NM).

Figure 3.4 below shows ILS Glide Path coverage as defined in ICAO Annex 10.

Figure 3.5 below shows the Runway 24 ILS Glide Path lateral coverage sector in relation to the proposed Carrownagowan Wind Farm.

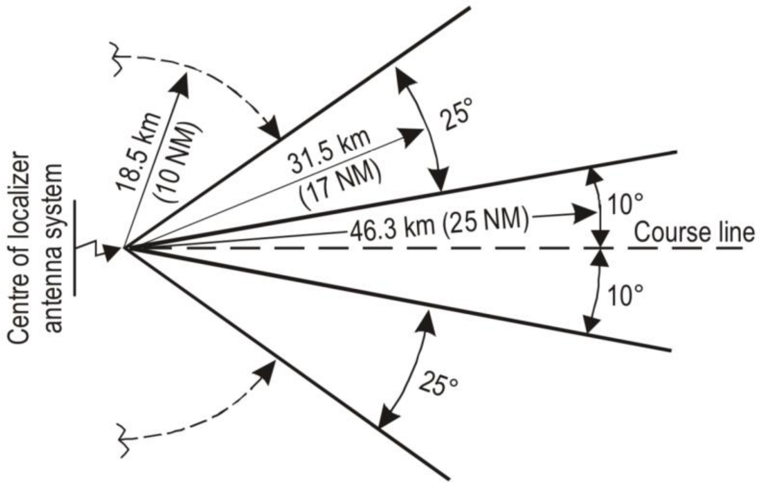
3.2.3 DME Coverage

The DME equipment shall provide aircraft with distance to threshold information throughout the Localiser coverage sector as defined in 3.2.1 above.

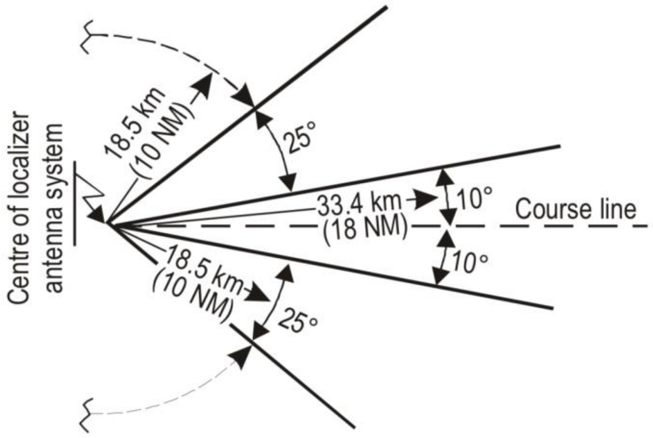
AIP IRELAND **EINN AD 2 - 9**
10 SEP 2020

Type of aid, MAG VAR, Type of supported OP (for VOR/ILS/ MLS/GNSS/ SBAS and GBAS, give declination)	ID	Frequency	Hours of operation	Position of transmitting antenna coordinates	Elevation of DME transmitting antenna or SBAS: ellipsoid height of LTP/FTP	Service Volume Radius from the GBAS Reference Point	Remarks
1	2	3	4	5	6	7	8
ILS DME RWY 06	ISE	CH32X (109.5 MHz)	H24	524147.2N 0085623.1W	100ft		DME Zero ranged to THR 06. DME zero range is displaced from DME antenna by 445M.
ILS LOC RWY 24 CAT II 4º W 2017	ISW	110.95MHz	H24	524129.4N 0085649.6W *			Coverage restricted to 35° either side of the course line. Signals received outside coverage sector, (including back beam radiation), should be ignored. No LOC coverage below 3000ft MSL AT 25 NM EINN *Data whose accuracy has not been quality assured.
ILS GP RWY 24		330.65MHz	H24	524232.1N 0085447.7W			GP Angle 3° RDH 59ft
LO RWY 24	OL	339 kHz	H24	524456.4N 0084926.0W			Designated Operational Coverage 15NM
OM RWY 24	2 Dashes per sec	75 MHz	H24	524455.5N 0084927.0W			
MM RWY 24	Dots and Dashes	75 MHz	H24	524254.8N 0085347.9W			
ILS DME RWY 24	ISW	CH46Y (110.95 MHz)	H24	524232.1N 0085447.7W	100ft		DME Zero ranged to THR 24. DME zero range is displaced from DME antenna by 391M.

Figure 3.1 - AIP Ireland



When topographical features dictate or operational requirements and alternative navigation facilities permit, the following coverage may be provided:



Note.— If coverage as prescribed in Chapter 3, 3.1.3.3.1 is required outside the plus or minus 35-degree sector, this is provided to 18.5 km (10 NM), as indicated by the broken arc above.

Figure 3.2 - ILS Localiser Lateral Coverage Sector

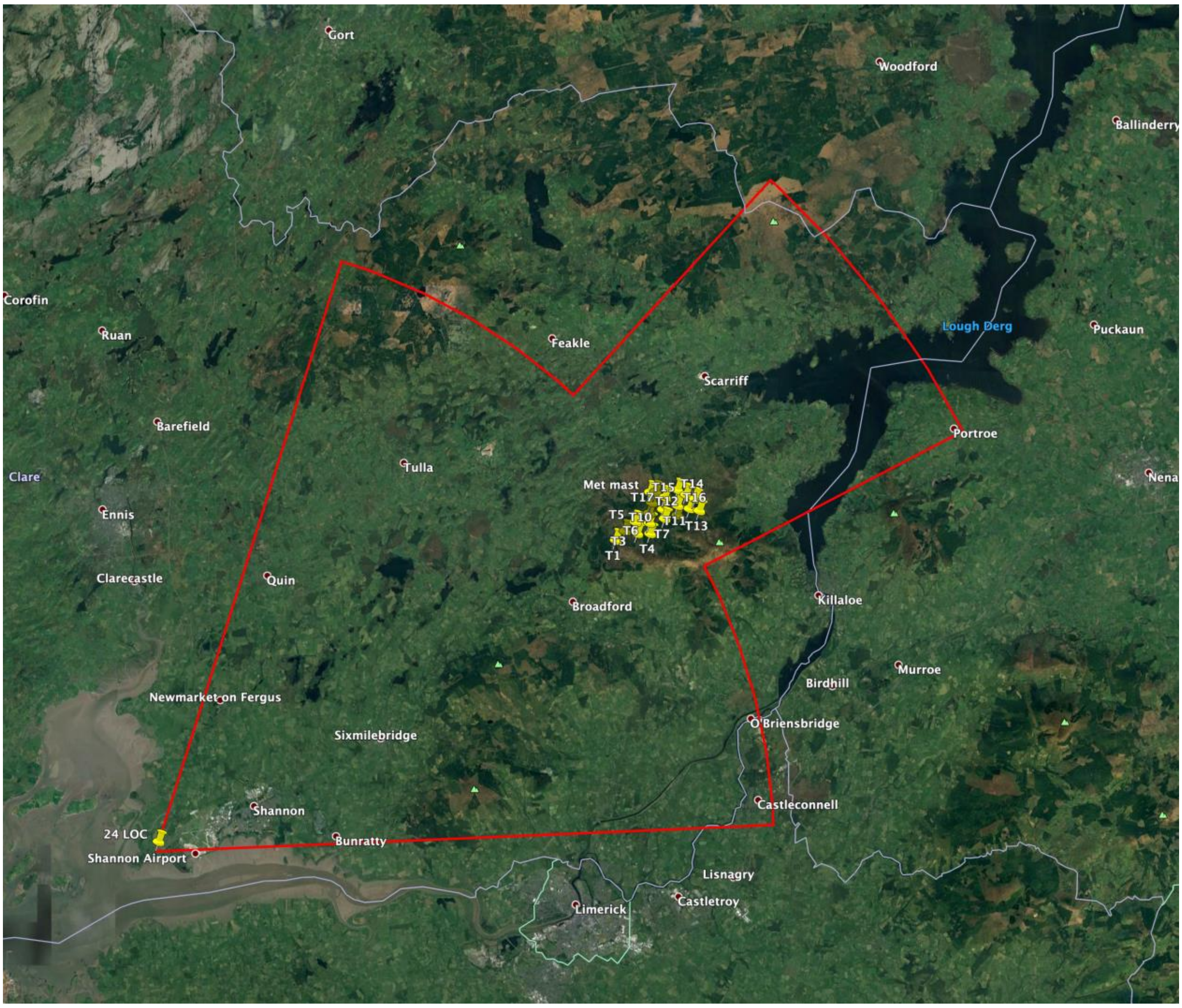


Figure 3.3 - Runway 24 ILS Localiser Lateral Coverage Sector

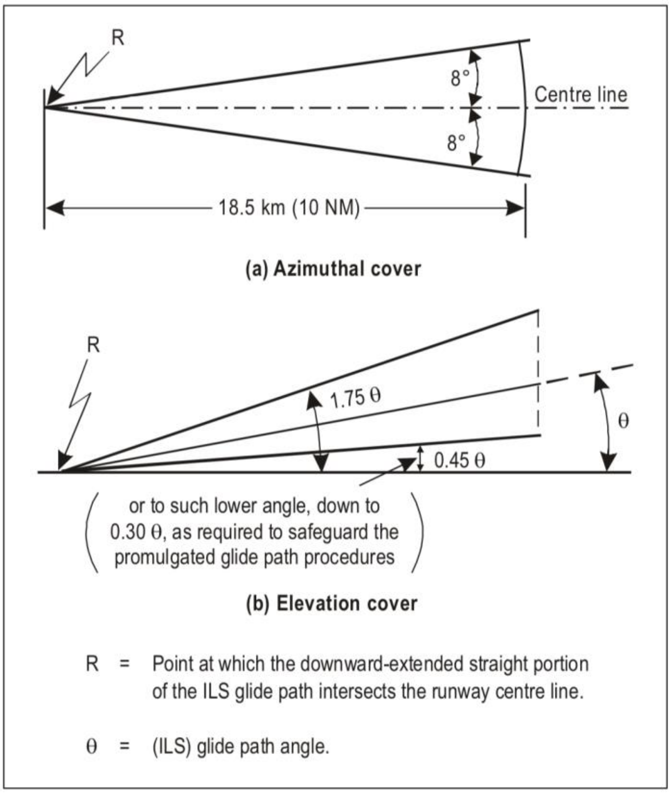


Figure 3.4 - ILS Glide Path Coverage

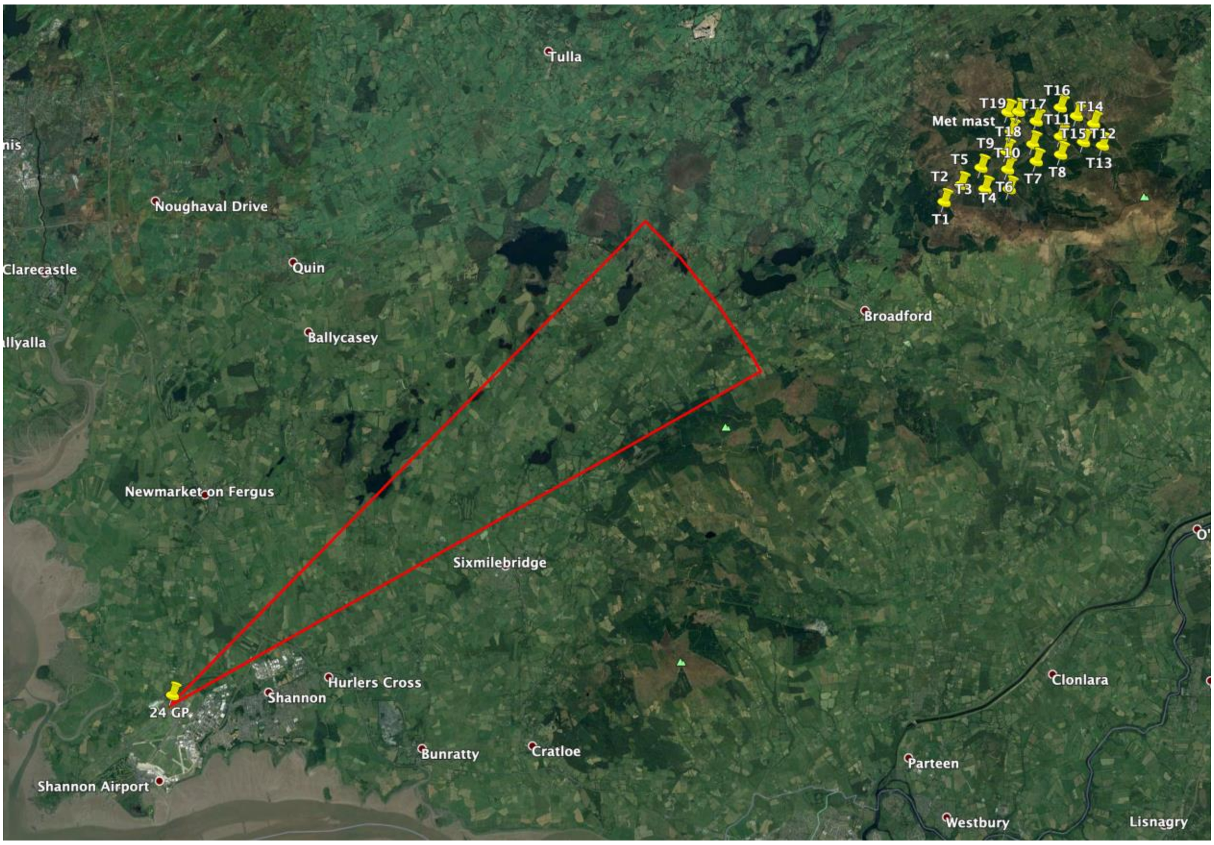


Figure 3.5 - Runway 24 ILS Glide Path Lateral Coverage Sector

4 ICAO ILS FLIGHT INSPECTION RECOMMENDATIONS

International Standards and Recommended Practices (SARPS) for ILS are published by the International Civil Aviation Organization (ICAO). Guidance material on factory, ground and flight testing of ILS installations is published in ICAO Doc 8071 Volume I. The purpose of ICAO Doc 8071 Volume I is to provide general guidance on the extent of testing and inspection normally carried out to ensure that radio navigation systems meet the SARPS published by ICAO.

To verify guidance signal accuracy within the ILS coverage volume, ICAO Doc 8071 recommends that a normal centreline approach should be flown, using the glide path, where available. For a Category II and III Localisers, the aircraft should cross the threshold at approximately the normal design height of the glide path and continue downward to normal touchdown point.

To verify that the ILS Localiser and Glide Path guidance signals provide the correct information to the user throughout the area of operational use, coverage checks should be performed. At periodic inspections, it is necessary to check coverage only at 31.5 km (17 NM) and 35 degrees either side of the course, unless use is made of the localiser outside of this area. Arc (part orbit) profiles may be flown at distances closer than this, provided an arc profile is flown at the same distance and altitude during the commissioning inspection to establish reference values.

5 FCSL FLIGHT INSPECTION PROCEDURES

FCSL have developed company procedures for commissioning and routine flight inspection of ILS Localiser and Glide Path facilities. Customer flight inspection requirements are initially captured on a Client Facility Data Sheet (Form 101). Form 101 records the technical details of the navigation aid to be flight checked and the specified interval between flight checks. For the Runway 24 ILS, the interval between flight checks is 180 days.

In the case of the Runway 24 ILS, the ILS is flight checked in accordance with FCSL Flight Inspection Procedure (FIP) FIP 23 (ILS Flight Inspections GPS Southern Ireland).

FIP 23 specifies that approach and part orbit profiles are flown as defined in FCSL Form 102 (Flight Profile Chart). Figures 5.1 and 5.2 below show the flight profiles to be flown during ILS flight inspection.

The start points, heights and distances for each flight profile are decided by the FCSL Flight Inspector in conjunction with the pilots to ensure correct and sufficient data is recorded while taking into account local terrain and obstacle clearance requirements.

FCSL FIP 23 states that flight inspection pilots will not fly within 1,000 ft of the ground in IMC (unless on centreline and edge approaches) and commissioning flights should be carried out in sight of the surface at all times. FIP 23 also states that Inspection Pilots will not fly within 1,000 ft of the highest obstacle within 5 NM either side of track in IMC.

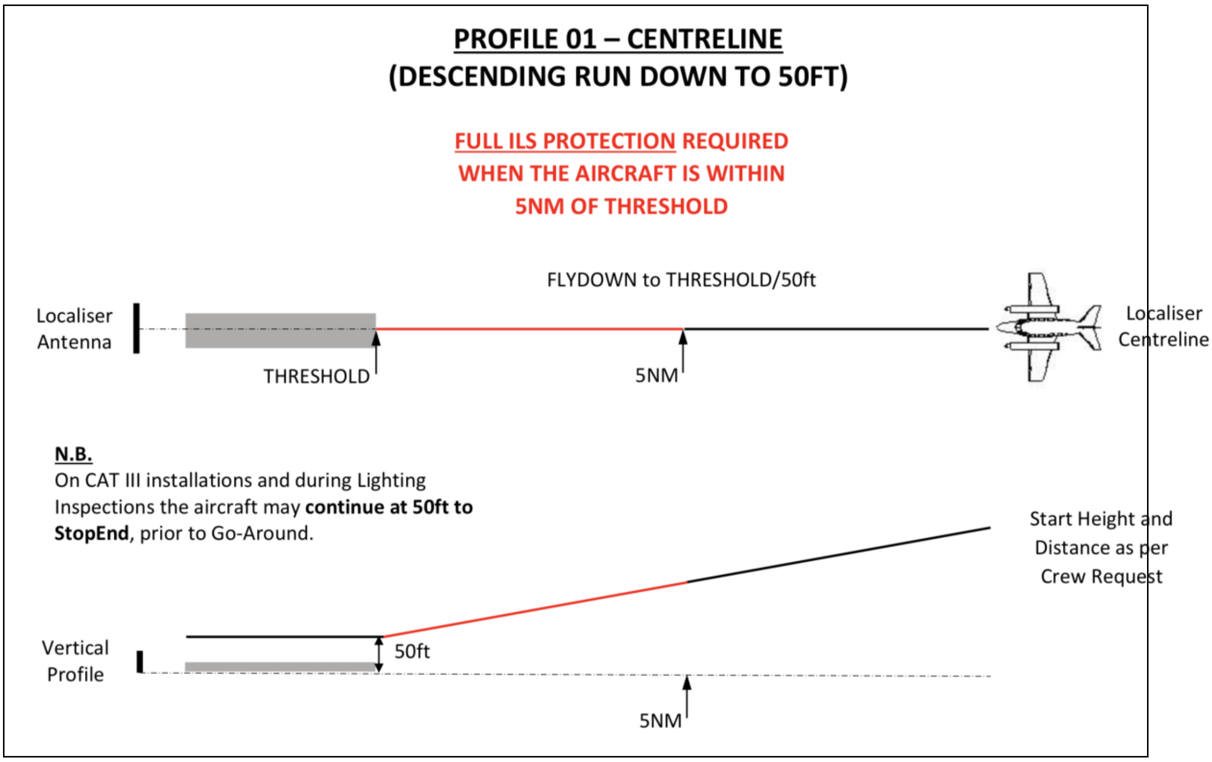


Figure 5.1 - Centreline Approach Flight Profile

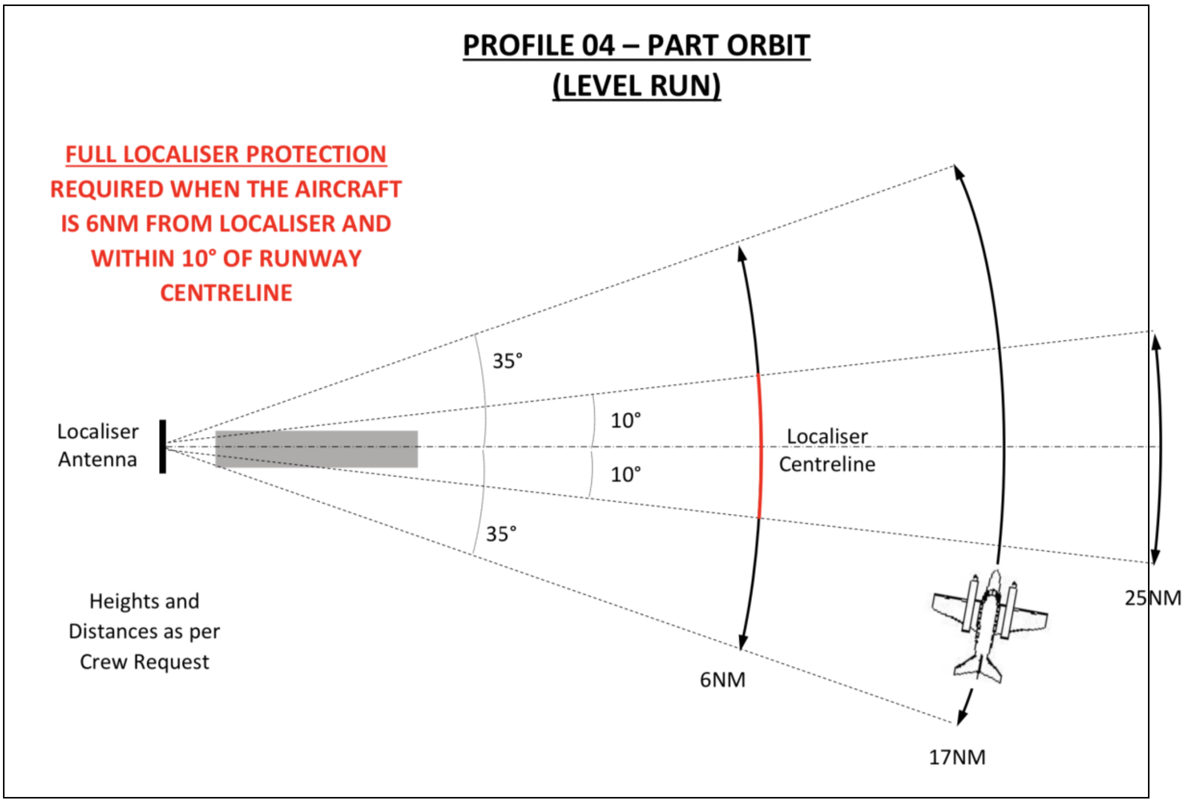


Figure 5.2 – Part Orbit Flight Profile

6 IMPACT ASSESSMENT

6.1 ILS Centreline Approach Flight Profile

For ILS centreline approach flight profiles, heights and distances are decided by the FCSL Flight Inspector in conjunction with the pilots to ensure correct and sufficient data is recorded while taking into account local terrain and obstacle clearance requirements.

For the seven most recent routine Runway 24 ILS flight inspections conducted by FCSL, centreline approaches were flown from a range of 25 NM.

6.1.1 Horizontal Obstacle Clearances

For a centreline approach profile, the flight inspection aircraft will be approximately 0.7 NM laterally from the nearest wind turbine (T19) at a point on the extended runway centreline closest to the wind farm. This distance is less than the minimum clearance required from any object, as defined in FIP 23.

6.1.2 Vertical Obstacle Clearances

For a centreline approach on a 3.0° glide path, the flight inspection aircraft will pass overhead and close to the proposed Carrownagowan Wind Farm site. The flight inspection aircraft vertical clearance above the highest turbine (T4) can be estimated as follows (see Figure 6.1):

Horizontal distance from 24 Glide Path antenna (on boresight) to Turbine T4

= 26,379 m

Assume ground height at 24 Glide Path Antenna = ARP height = 46 ft = 14 m

Clearance (h) above highest turbine (T4)

$= (26{,}379\ m \times \tan 3.0°) - (326\ m - 14\ m) - 169\ m = 901\ m = 2{,}956\ ft$

This height exceeds the minimum clearance required above terrain and obstacles in IMC.

6.2 ILS Part Orbit Flight Profile

For ILS part orbit flight profiles, heights and distances are decided by the FCSL Flight Inspector in conjunction with the pilots to ensure correct and sufficient data is recorded while taking into account local terrain and obstacle clearance requirements.

For the six most recent routine Runway 24 ILS flight inspections conducted by FCSL, part orbits were flown at a range of 6 NM from the Localiser antenna and a height of 1,500 ft AMSL.

The track of the 6 NM part orbit profile is shown in Figure 6.2 below. Figure 6.3 below shows the terrain elevation profile for the 17 NM part orbit.

6.2.1 Horizontal Obstacle Clearances

For a 6 NM part orbit flight profile, the flight inspection aircraft will be at least 9.5 NM from the nearest wind turbine at a point on the part orbit track closest to the wind farm site.

For a 17 NM part orbit flight profile, the flight inspection aircraft will pass directly overhead the proposed wind farm.

6.2.2 Vertical Obstacle Clearances

In accordance with FCSL FIP 23, pilots must not fly within 1,000 ft of the ground in IMC. The 17 NM part orbit flight must therefore be flown at a height of at least 1,000 ft above the highest obstacle to be encountered.

Figure 6.3 shows that a flight inspection aircraft flying a 17 NM part orbit will pass overhead and close to the summit of Moylussa mountain (1,745 ft). The 17 NM part orbit must therefore be flown at a height of at least 2,745 ft AMSL to remain at least 1,000 ft clear of the summit of Moylussa mountain.

The maximum height of the highest wind turbine (T4) can be estimated as:

Ground height + maximum turbine height = 326 m + 169 m = 495 m (1,624 ft).

For an orbit height of 2,745 ft AMSL, a flight inspection aircraft will therefore have a clearance of 1,121 ft above the highest wind turbine. This height exceeds the minimum clearance required above terrain and obstacles in IMC.

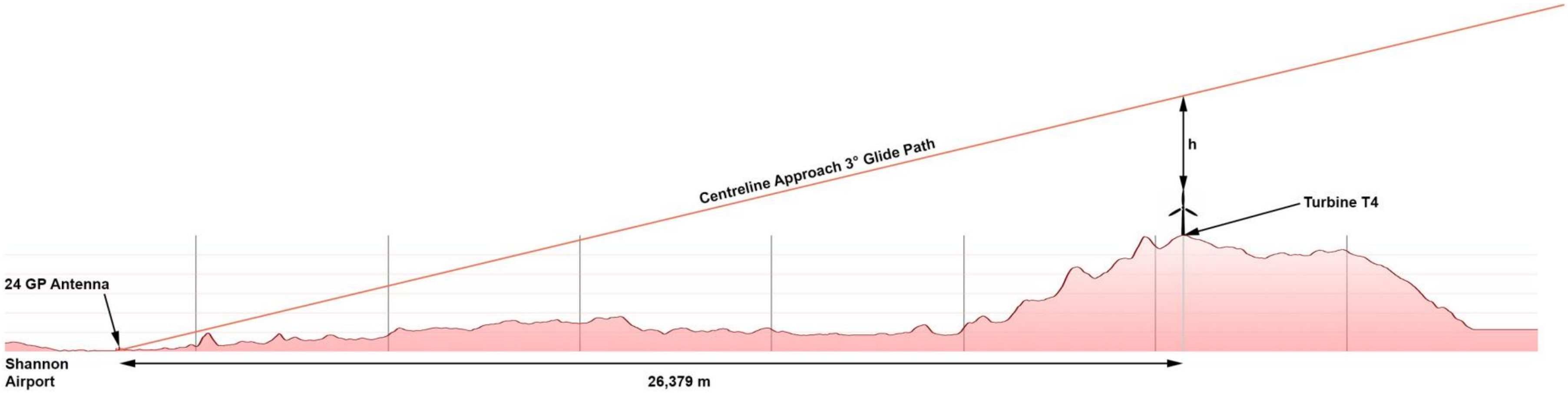


Figure 6.1 – ILS Centreline Approach Profile

(Not to scale)

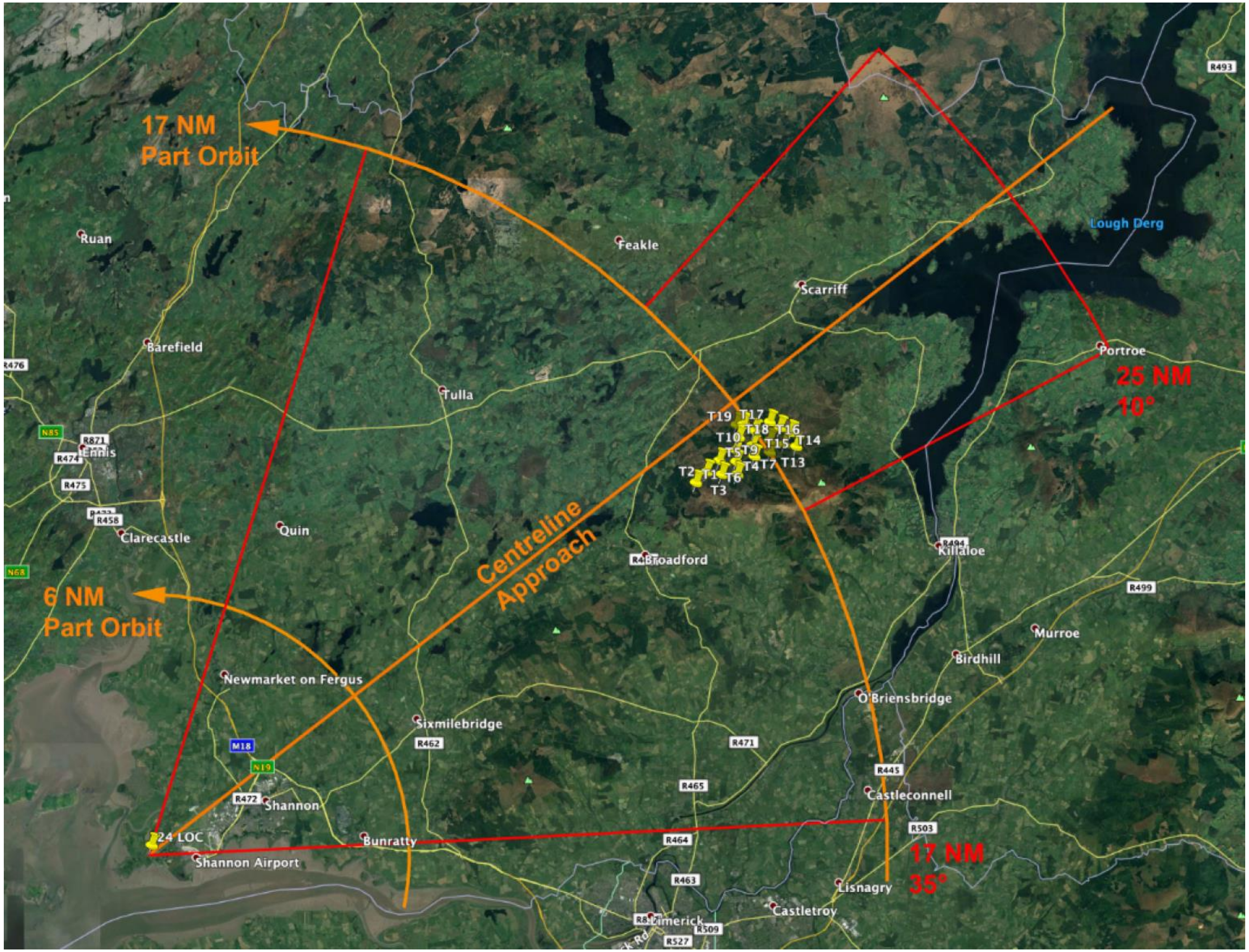


Figure 6.2 – ILS Centreline Approach and Part Orbit Tracks

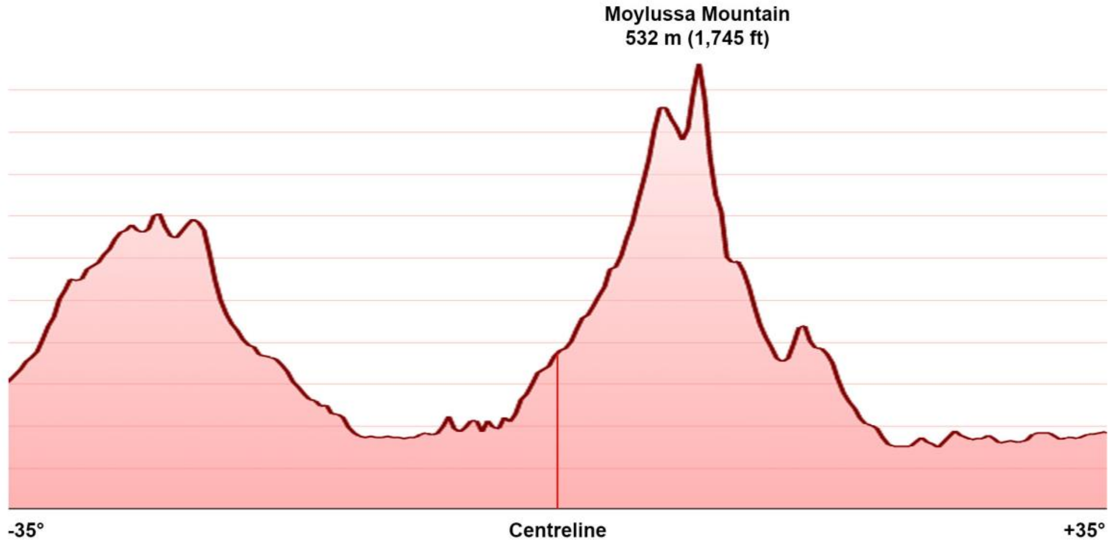


Figure 6.3 – 17 NM Part Orbit Terrain Elevation Profile

7 CONCLUSIONS AND RECOMMENDATIONS

The assessment presented in Section 6 above has shown that a flight inspection aircraft flying centreline and part orbit flight profiles associated with the Shannon Airport Runway 24 ILS will remain sufficiently clear of the proposed Carrownagowan Wind Farm site.

The proposed Carrownagowan Wind Farm will therefore have no adverse effect on flight inspection procedures and profiles associated with the Runway 24 ILS.

As the proposed wind turbines are within 2.4° azimuth and 0.9° elevation of Localiser antenna boresight, there is potential for the proposed wind farm to cause interference to the Runway 24 Localiser guidance signal at ranges of between 15 NM and 25 NM from the Localiser antenna. It is recommended that computer simulations be performed to assess the levels of potential interference to the Runway 24 ILS Localiser guidance signal.

This report provides an assessment of the impact of terrain and obstacles on ILS flight inspection procedures. It does not provide an assessment of any impact the proposed wind farm may have on the integrity of the ILS guidance signals.

Appendix 2

Technical Safeguarding Assessment - Cyrrus

Technical Safeguarding Assessment

Carrownagowan Wind Farm

Malachy Walsh and Partners

08 April 2021

CL-5614-RPT-003 V1.0

www.cyrrus.co.uk

info@cyrrus.co.uk

Executive Summary

Cyrrus Limited has been engaged by Malachy Walsh and Partners (the Client) to conduct a Technical Safeguarding Assessment for a proposed wind farm development near Shannon Airport.

This study addresses the potential impact the proposed development will have on the Shannon Airport Instrument Landing System (ILS) and the Woodcock Hill Monopulse Secondary Surveillance Radar (MSSR).

Cyrrus has conducted the technical safeguarding assessment on the proposed development under a worst-case scenario.

The main findings of this study with regard to ILS performance show that:

- The proposed wind farm lies outside all of the Airport Air Navigation Equipment (AANE) Building Restricted Areas (BRA);
- The proposed wind farm will not pose a risk to aircraft approaching or departing from either runway at Shannon Airport;
- No further modelling is deemed necessary.

Detailed radar modelling of the indicative layout against the MSSR at Woodcock Hill shows the following:

- Radar Line of Sight exists between Woodcock Hill MSSR and the towers of turbines T1, T2, T3, T4, T5 and T6;
- Bistatic reflections from these turbines will not result in false targets for Woodcock Hill MSSR;
- Woodcock Hill MSSR shadow regions from the turbines are considered operationally tolerable;
- No mitigation measures are considered necessary for Woodcock Hill MSSR.

Abbreviations

AANE	Airport Air Navigation Equipment
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AMSL	Above Mean Sea Level
ATCO	Air Traffic Control Officer
BRA	Building Restricted Area
DME	Distance Measuring Equipment
DTM	Digital Terrain Model
DVOR	Doppler VHF Omni-Directional Range
GIS	Geographic Information System
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
MSSR	Monopulse Secondary Surveillance Radar
NDB	Non-Directional Beacon
PD	Probability of Detection
PSR	Primary Surveillance Radar
RCS	Radar Cross Section
RLoS	Radar Line of Sight
VHF	Very High Frequency
VPD	Vertical Polar Diagram

References

[1] ICAO, “EUR DOC 015 "European Guidance Material on Managing Building Restricted Areas", Third Edition,” 2015.

[2] EUROCONTROL, “Guidelines for Assessing the Potential Impact of Wind Turbines on Surveillance Sensors, EUROCONTROL-GUID-0130 Edition Number 1.2,” 2014.

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1. Introduction

1.1. Overview

1.1.1. Malachy Walsh and Partners is proposing to construct a new onshore wind farm located in County Clare in the Republic of Ireland.

1.1.2. The proposed development, Carrownagowan Wind Farm, is planned to comprise 19 wind turbines with a maximum tip heigh of up to 169m Above Ground Level (AGL) and lies approximately 26km east of Shannon Airport and between 13.75km and 18.12 km northeast of Woodcock Hill Monopulse Secondary Surveillance Radar (MSSR).

1.2. Technical Safeguarding Assessment

1.2.1. Cyrrus has been engaged by the client to address the possible impact the Carrownagowan Wind Farm may have on the Woodcock Hill MSSR facility. The Radar Line of Sight (RLoS) assessment will determine the degree of visibility of the proposed turbines to the radar.

1.2.2. An assessment is also conducted against the ILS for Runways 06 and 24 as well as the Non-directional Beacon (NDB) and VHF Omni-directional Range (VOR) facilities at Shannon Airport.

1.2.3. Obstacles that are illuminated by signals from Airport Air Navigation Equipment (AANE) can cause disturbance to the signal and hence have an impact on the system's integrity.

1.2.4. Technical safeguarding of the equipment ensures that any potential disturbance of the guidance beams is identified and assessed to ensure the system's continued safety.

2. Evaluation Tools Used

2.1. Software

- ICS Telecom EV V15.5.3 x64;
- Global Mapper Geographic Information System (GIS) Software v21.1.1;
- ZWCAD+ 2015 SP2 Professional.

2.2. Terrain Data

- ATDI 25m Digital Terrain Model (DTM), 2015, ETRS89 projection.

2.3. Data Provided by Client

- EINN_06_ILS_19-03-19 A.pdf
- EINN_06_ILS_31-03-20_A.pdf
- EINN_24_ILS_01-10-20_R(1).pdf
- EINN_24_ILS_31-03-20_A(1).pdf
- 1. IAA.pdf
- 9. Shannon Airport Authority.pdf
- Turbine Heights.pdf;
- 19107-5021-A.pdf – Typical Turbine, Foundation and Hardstand Details.

2.4. Other Data

- EI_AD_2_EINN_EN - Shannon Airport details in Irish Aeronautical Information Publication (AIP), effective date 10 SEP 2020.

3. Development

3.1. Location

3.1.1. The indicative 19 turbine layout used for the modelling is shown in Figure 1.

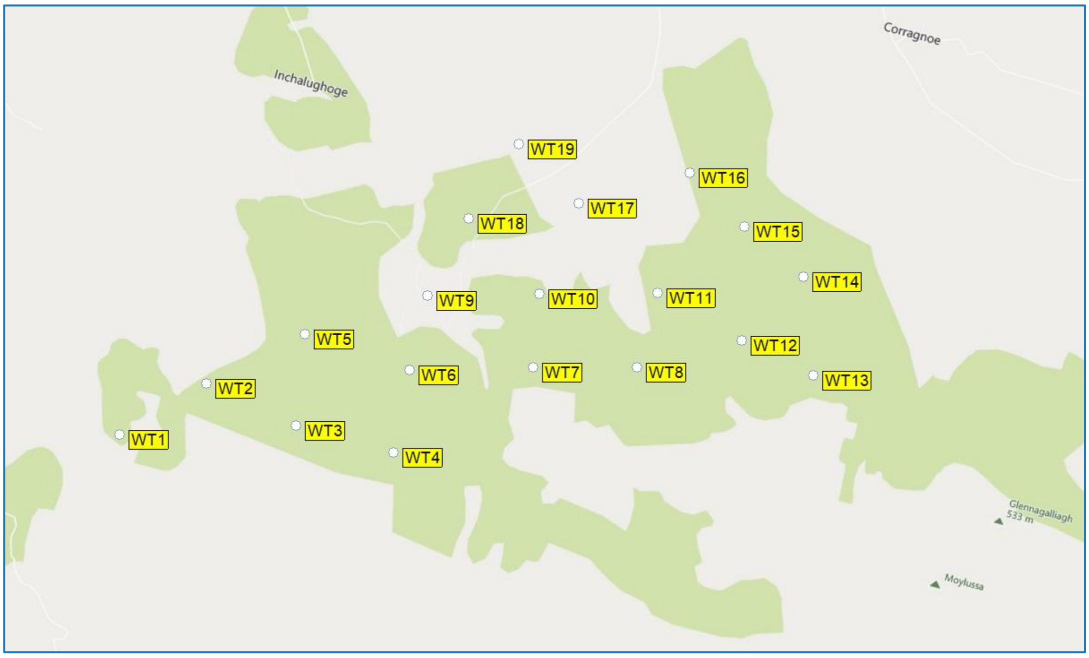


Figure 1: Indicative turbine layout

3.2. Turbine Data

3.2.1. Each turbine has a planned tip height of 169m AGL and a rotor diameter of 136m. Turbine blade length is thus 68m and hub height is 101m AGL.

3.2.2. The locations of the 19 proposed turbines were supplied by the Client as Irish Transverse Mercator (ITM) Eastings and Northings. These coordinates have been converted to ETRS89 decimal degrees and are presented in Table 2.

Turbine	ETRS89 Latitude	ETRS89 Longitude
WT1	52.82959768 N	8.6026967 W
WT2	52.83372169 N	8.59585281 W
WT3	52.8326721 N	8.5864296 W
WT4	52.83262071 N	8.57673811 W
WT5	52.83793201 N	8.58783625 W
WT6	52.8374718 N	8.57721795 W
WT7	52.83943225 N	8.56578534 W
WT8	52.84096986 N	8.55612752 W
WT9	52.84188374 N	8.57743973 W

Turbine	ETRS89 Latitude	ETRS89 Longitude
WT10	52.84361458 N	8.56704208 W
WT11	52.845401 N	8.55609507 W
WT12	52.84398713 N	8.547022 W
WT13	52.84308648 N	8.53957385 W
WT14	52.84845504 N	8.54289164 W
WT15	52.85037462 N	8.54958165 W
WT16	52.85254706 N	8.55593399 W
WT17	52.84924789 N	8.56558634 W
WT18	52.8467826 N	8.57548577 W
WT19	52.85164114 N	8.5725658 W

Table 1: Turbine coordinates

4. ILS Analysis

4.1. General

4.1.1. Prior to the construction of new developments on or near an airport, it is important to consider the potential resultant effect on the performance of the Airport Air Navigation Equipment (AANE).

4.1.2. For example, the ILS provides both lateral and vertical guidance by means of radio signals to enable aircraft to approach and land without visual reference to the ground in times of poor visibility. By using this system, approach and landing may be carried out either automatically or by suitable instrument guidance to the pilot. To ensure the safety and integrity of such systems, it is necessary to provide a high level of safeguarding of the system performance.

4.1.3. Cyrrus can provide the airport operator with data and recommendations, but the final decision on the response to a proposed development must remain the responsibility of the airport operator once all factors affecting such a decision have been considered.

4.2. Site Location

4.2.1. The closest turbine within the proposed Windfarm lies approximately 26km from the Aerodrome Reference Point. The locations of the nineteen wind turbines relative to Shannon Airport are shown in Figure 2.

Figure 2 - Proposed Windfarm with respect to Shannon Airport

4.3. Building restricted areas

4.3.1. The minimum safeguarded areas for the AANE under consideration at Shannon Airport are defined by the International Civil Aviation Organisation (ICAO) in the document ICAO EUR DOC 015 [1].

4.3.2. Figure 3 and Figure 4 show an example of the Building Restricted Area (BRA) shape for directional facilities such as ILS Localisers, Glidepaths and Distance Measuring Equipment (DME), as depicted in ICAO EUR DOC 015 Figures 3.1, 3.2, 3.3 and 3.4.

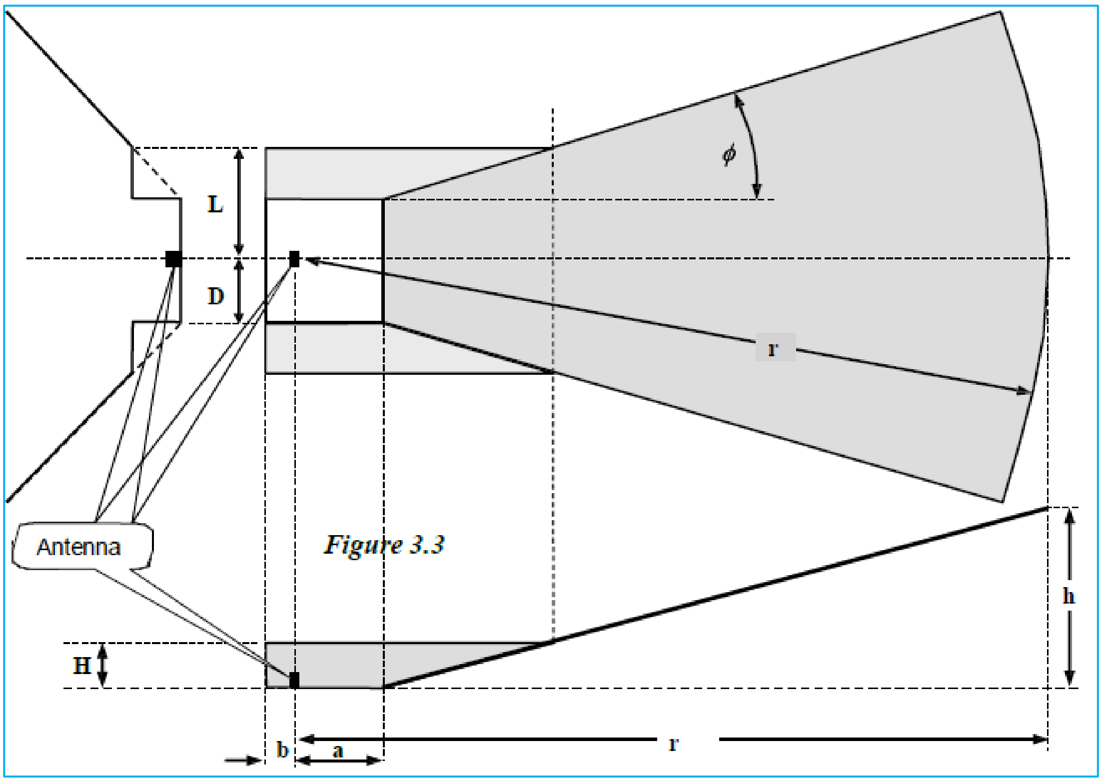


Figure 3 - BRA shape for directional facilities

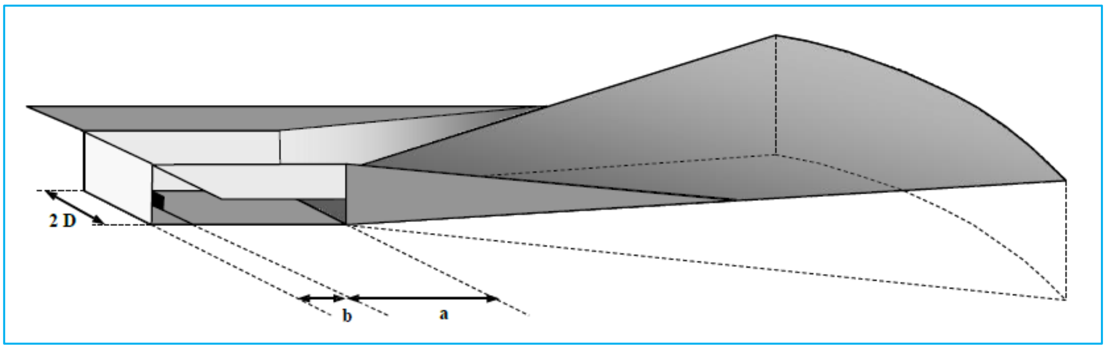


Figure 4 - BRA shape for directional facilities (side profile)

4.3.3. Figure 5 indicates the applicable dimensions to be applied in order to generate safeguarded zones for the various directional navigation facilities. The purpose of these safeguarded areas is to identify developments with the potential for causing unacceptable interference to navigation facilities. Developments that infringe a safeguarded area must undergo technical assessments to determine the degree of interference, if any, and whether the interference will be acceptable to the Airport operator.

Type of navigation facilities	*A* *(m)*	*b* *(m)*	*h(m)*	*r* *(m)*	*D* *(m)*	*H* *(m)*	*L* *(m)*	*ϕ* *(°)*
ILS LLZ *(medium aperture single frequency)*	Distance to threshold	500	70	a+6000	500	10	2300	30
ILS LLZ *(medium aperture dual frequency)*	Distance to threshold	500	70	a+6000	500	20	1500	20
ILS GP M–Type (dual frequency)	800	50	70	6000	250	5	325	10
MLS AZ	Distance to threshold	20	70	a+6000	600	20	1500	40
MLS EL	300	20	70	6000	200	20	1500	40
DME (directional antennas)	Distance to threshold	20	70	a+6000	600	20	1500	40

Figure 5 - Dimensions of safeguarded areas for directional navaids

4.4. Navaids under consideration at Shannon Airport

4.4.1. The AANE under consideration at Shannon Airport consists of ILS Localisers and Glidepaths serving Runways 06 and 24, ILS DME facilities co-located with each Glidepath, and a Doppler VHF Omnidirectional Range (VOR) and co-located DME facility as well as a Non-Directional Beacon (NDB).

4.4.2. The ILS, DME, NDB and DVOR/DME safeguarded areas at Shannon Airport are shown in Figure 6.

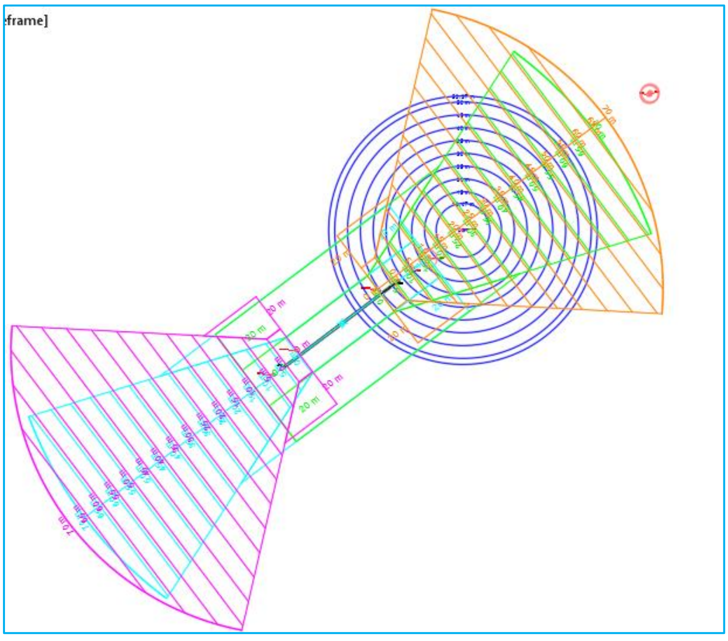


Figure 6 - AANE safeguarded areas at Shannon Airport

4.4.3. The ILS, DME, NDB and DVOR/DME safeguarded areas at Shannon Airport relative to the wind turbines are illustrated in Figure 7 and Table 2.

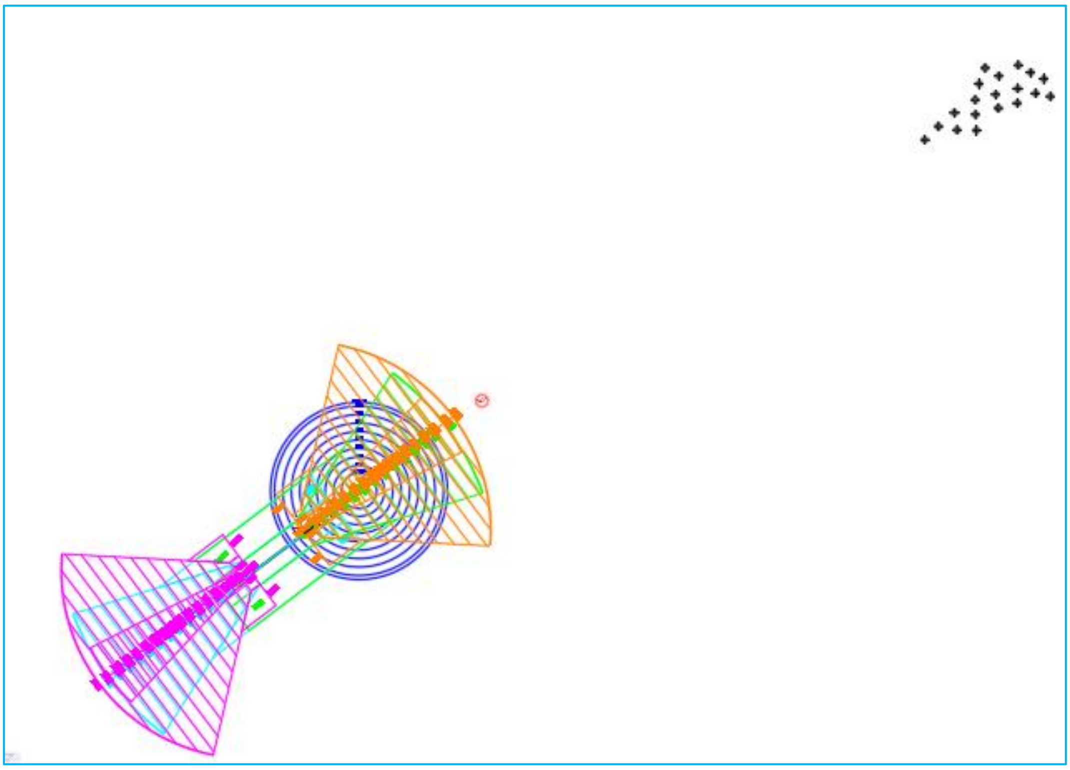


Figure 7 - AANE safeguarded areas with respect to wind turbines

Area Colour	Description
Magenta	Glidepath/DME 06
Orange	Glidepath/DME 24
Cyan	Localiser 06
Green	Localiser 24
Blue	DVOR/DME

Table 2 - Safeguarded Areas Colour Reference

4.4.4. None of the AANE safeguarded areas are infringed by the proposed windfarm development.

4.4.5. Since the proposed nineteen wind turbines lie comfortably outside of all AANE safeguarded areas, modelling of the ILS performance is not required.

4.4.6. The proposed windfarm will not pose a risk to aircraft approaching or departing from either Runway at Shannon Airport. Therefore, no further investigation is deemed necessary.

5. Radar Assessment

5.1. Potential Impact of Wind Turbines on MSSR

5.1.1. An MSSR is an 'active' system. It operates by the radar transmitting a coded pulse sequence which is received and decoded by suitably equipped aircraft. The aircraft responds with a coded pulse sequence on a different frequency which is received by the MSSR. The radar detects the range and azimuth of an aircraft based upon the difference in time between the transmission of pulses to the aircraft and the receipt of energy from the aircraft. Additional information in the coded reply allows the identification of a particular aircraft and its height. Other data may also be made available dependant on the mode of operation.

5.1.2. MSSR is immune to direct reflections (monostatic back scatter) from large objects such as wind turbines, because the transmitted and received frequencies differ and the message structure is different for transmit and receive paths.

5.1.3. Bistatic reflection is where the signal transmitted by the radar is 'forward' reflected to an aircraft, and the aircraft reply is also reflected back to the radar. The effect of this is best understood by considering the following diagrams.

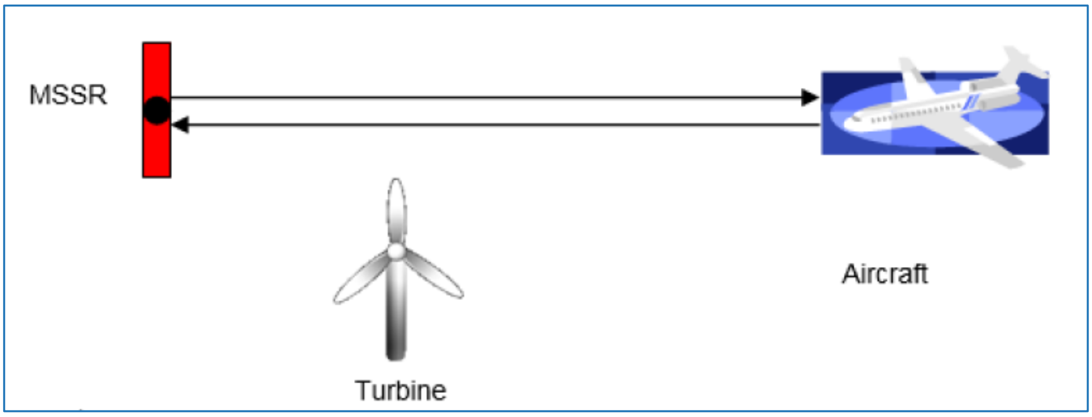


Figure 8: Direct interrogation and reply pulses

5.1.4. In Figure 8, the MSSR transmits an interrogation pulse sequence and the aircraft, on receiving the interrogation sequence, replies with a coded pulse sequence. The time delay between interrogation and receipt of reply is proportional to the distance of the aircraft from the radar. The bearing of the aircraft is the physical bearing of the radar antenna.

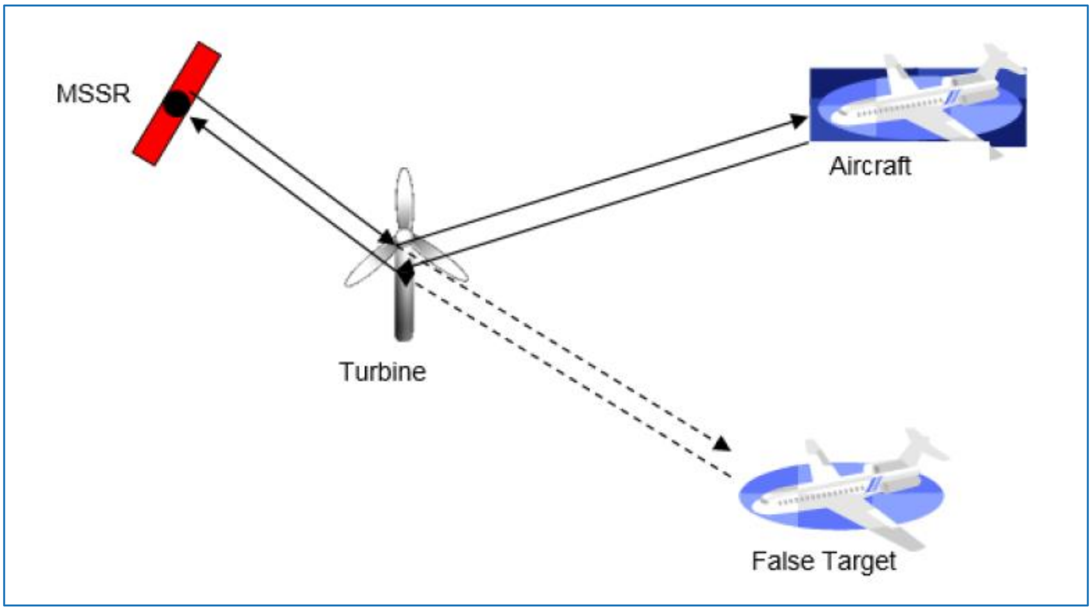


Figure 9: Reflected interrogation and reply pulse

5.1.5. In Figure 9, the MSSR beam illuminates a wind turbine which reflects the interrogation to an aircraft on a different bearing. The aircraft transponder replies, and this is received by the radar via the turbine. The radar processes this as a false target on the bearing of the wind turbine and at a distance proportional to the path length, which is slightly longer than the direct path length.

5.1.6. Objects can produce a radar shadow in the area behind the object. As a wind turbine is narrow compared to the radar beam width, assuming the turbine is more than 2 km away from the radar, the shadow will be relatively small, and will reduce with increasing distance behind the turbine. Shadowing effects are likely to be insignificant but, due to diffraction of the beam around the turbine power, small azimuth angular errors may be introduced. Aircraft targets in this area can potentially be subject to track jitter causing the returns to meander from side to side. This can only occur when the turbine is in the direct RLoS between the radar and the aircraft target.

5.2. Woodcock Hill Radar

5.2.1. The radar at Woodcock Hill is a Thales RSM 970 S MSSR and is housed in a polycarbonate radome.

Image © 2019 Google © 2018 Europa Technologies

Figure 10: Woodcock Hill MSSR

5.2.2. The ETRS89 coordinates for the radar are: 52.72104722 N, 8.707438889 W.

5.2.3. The MSSR antenna height is 10m AGL.

5.2.4. The location of Woodcock Hill MSSR is shown in Figure 11.

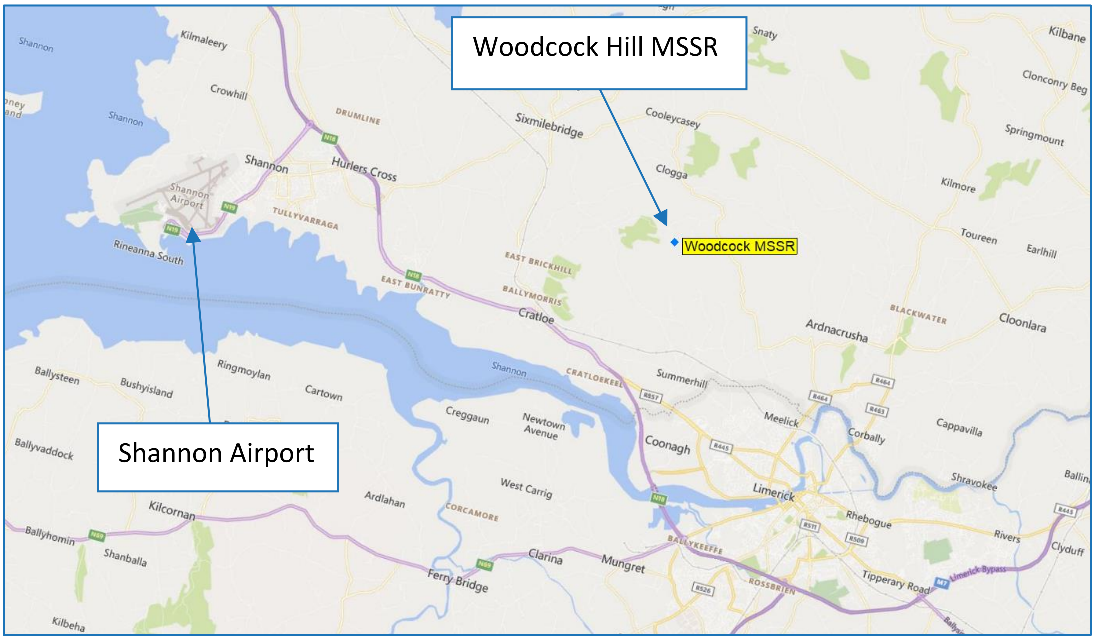


Figure 11: Location of Woodcock MSSR

5.2.5. The relative locations of the proposed turbines and the Woodcock Hill MSSR are shown in Figure 12.

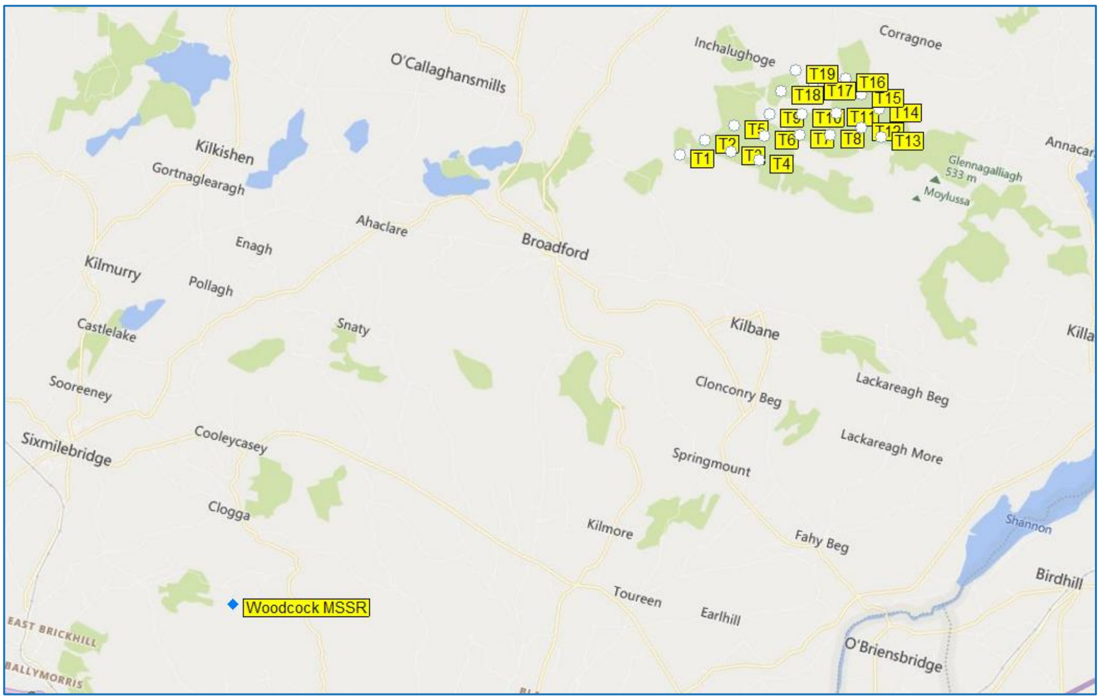


Figure 12: Location of MSSR and proposed turbines

5.2.6. The proposed turbines lie between 13.75km and 18.12km from the Woodcock Hill MSSR.

5.3. Radar Line of Sight Modelling

5.3.1. RLoS is determined from a radar propagation model (ATDI ICS telecom EV) using 3D DTM data with a 25m horizontal resolution. Radar data is entered into the model and RLoS from the radar site to each turbine is then calculated.

5.3.2. Note that by using DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, RLoS assessments are worst-case results.

5.3.3. In the case of MSSR, adverse effects are generated by the turbine towers, so for the scope of this study, RLoS is calculated for the maximum hub height of the turbines, i.e. 101m AGL.

5.3.4. The magenta shading in Figure 13 illustrates the RLoS coverage from Woodcock Hill MSSR to the turbines with a maximum hub height of 101m AGL.

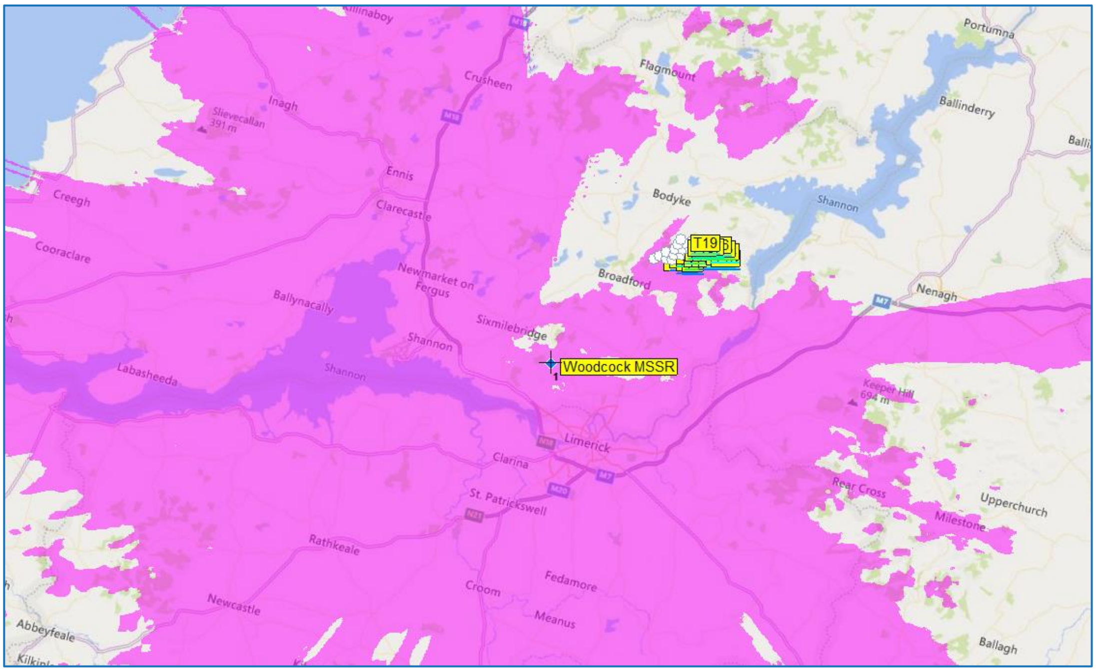


Figure 13: Woodcock MSSR RLoS to 101m AGL

5.3.5. RLoS exists between the MSSR and several turbine towers in the indicative layout. The zoomed view of the Carrownagowan Wind Farm in Figure 14 shows that RLoS exists between the Woodcock Hill MSSR and the towers of turbines T1, T2, T3, T4, T5 and T6.

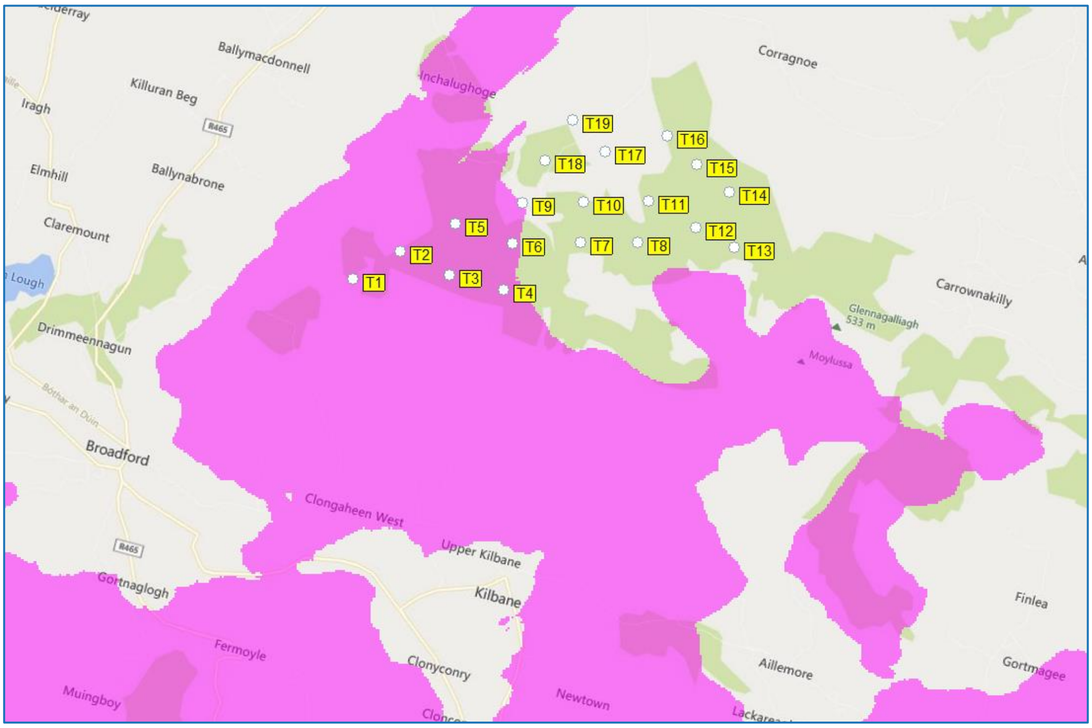


Figure 14: Woodcock MSSR RLoS to 101m AGL – zoomed

5.4. Woodcock Hill MSSR Path Loss

5.4.1. Using the radar propagation model the actual path loss between Woodcock Hill MSSR and the tops of the Carrownagowan turbine towers can be determined.

5.4.2. An illustration of the path loss profile between Woodcock Hill MSSR and turbine T1 is shown in Figure 15.

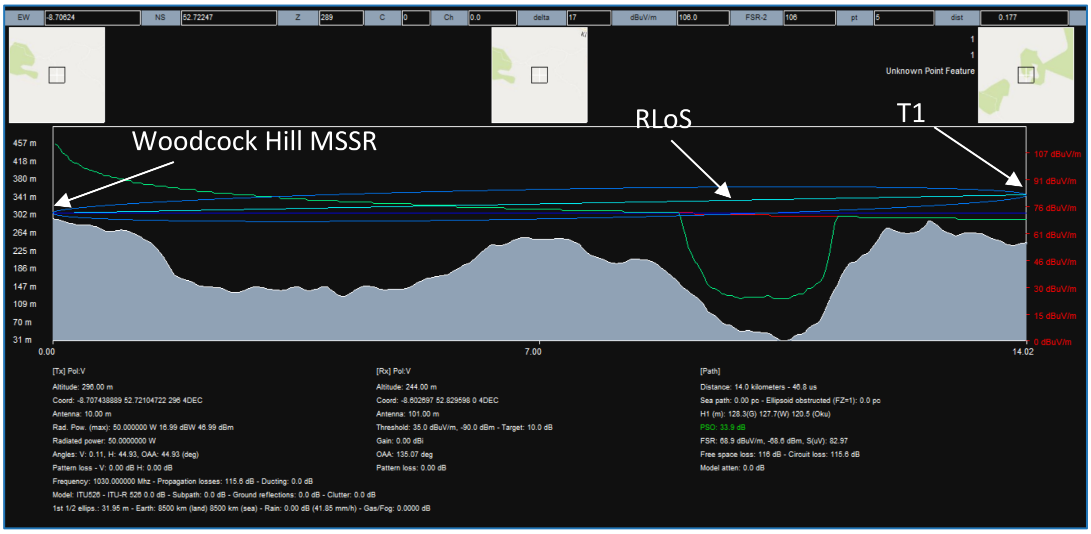


Figure 15: Path loss profile between Woodcock Hill MSSR and top of turbine tower T1

5.4.3. All of the path profiles between Woodcock Hill MSSR and the 19 Carrownagowan turbines are shown in Annex A of this report.

5.4.4. As explained in Section 5.1, multipath, or bistatic, reflections from turbine towers can potentially cause 'ghost' targets on MSSR. This occurs when an aircraft replies through a signal reflected from an obstruction; the radar attributes the response to the original signal and outputs a false target in the direction of the obstruction, which can lead to Air Traffic Controller Officers (ATCO) deconflicting real traffic from targets that do not physically exist.

5.4.5. The likelihood of bistatic reflections can be determined by knowing the MSSR transmitter power, antenna gain, path loss to the turbine tower, Radar Cross Section (RCS) gain and aircraft receiver sensitivity.

5.4.6. The amount of signal reflected by a turbine tower is a function of the tower's RCS. A typical RCS value for a 100m steel tower of 8m diameter is 3,000,000m^2. However, a 0.5° taper of the tower can reduce this figure from millions to hundreds of square metres.

5.4.7. EUROCONTROL Guidelines [2] recommend an RCS value of $10^{3.5}m^2$ or 35dBm^2 for a turbine tower which equates to an RCS gain of 57dB at the MSSR uplink frequency of 1030MHz.

5.4.8. The following calculation can be used to determine the power of a radar signal reflected by a wind turbine tower:

	Tx Power	dBm
+	Antenna Gain	dB
-	Path Loss	dB
+	RCS Gain	dB (35dBm^2 ~ +57dB)
=	Reflected Power	dBm

5.4.9. Free Space Path Loss can be used to calculate the maximum distance from the reflecting obstacle an aircraft can be in order for the reflected signal to trigger a response from the aircraft transponder.

5.4.10. The maximum range at which a reflection can trigger a response is proportional to the reflected power of the signal. From the above calculation it can be seen that reflected power is greatest when the path loss between the MSSR and a turbine is the least.

5.4.11. Using the radar propagation model the actual path loss between the MSSR and the tops of the Carrownagowan turbine towers can be determined.

5.4.12. The path loss results between Woodcock Hill MSSR and the tops of the 19 Carrownagowan turbine towers are shown in Table 3.

Turbine	Path Loss dB
T1	115.6
T2	116
T3	116.2
T4	116.4
T5	116.4
T6	116.6
T7	165
T8	157.2
T9	134.7
T10	152.5
T11	160.2
T12	157.8
T13	161.6
T14	161.7
T15	155.7
T16	144.2
T17	148.1
T18	146.6

Turbine	Path Loss dB
T19	150.5

Table 3: Woodcock Hill MSSR path loss results

5.4.13. From Table 3 it can be seen that the worst-case or smallest path loss is 115.6 dB to turbine T1.

5.4.14. The Tx Power for a Thales RSM 970 S MSSR is 60.35 dBm at the antenna input. The MSSR antenna gain varies with elevation angle, with peak gain of 27dB at an elevation of between 8° and 9° above the horizontal, as shown in Figure 16.

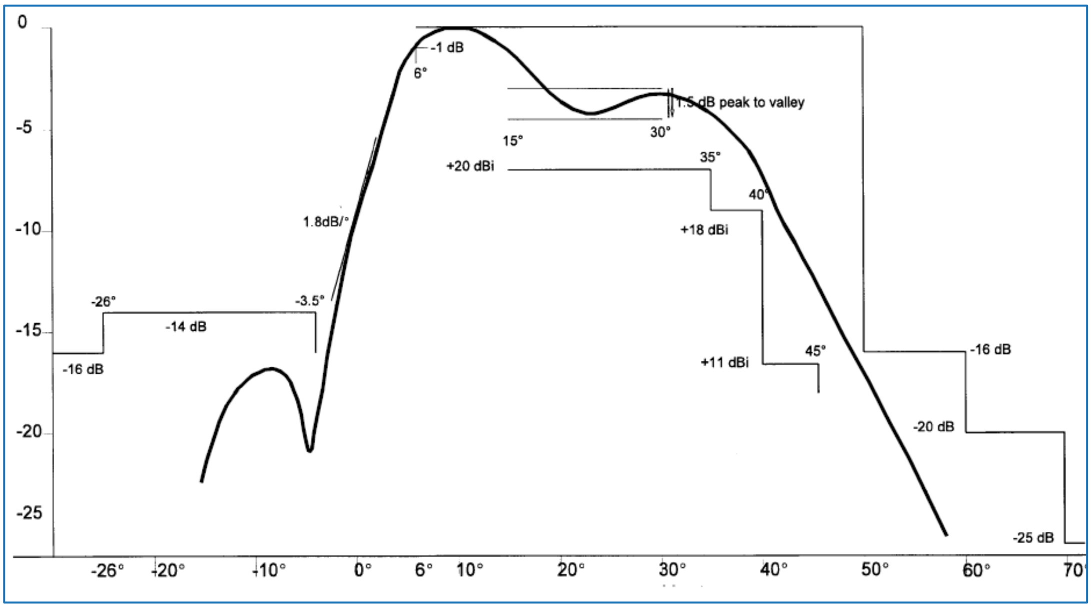


Figure 16: Thales RSM 970 S VPD

5.4.15. The vertical angle from the MSSR to the hub of turbine T1 is 0.11°. If a mechanical tilt of 0° is assumed, this means a reduction in gain of -9dB at this elevation.

5.4.16. Using these values results in a reflected power of 19.665 dBm from turbine T1.

5.4.17. If an aircraft receiver sensitivity of -77dBm is assumed, the reflected signal will not trigger a response if the Free Space Path Loss from the turbine to the aircraft is more than 77+19.665=96.665 dB.

5.4.18. The Free Space Path Length for an MSSR frequency of 1030MHz and path loss of 96.665 dBm is 1579.1m. This means that aircraft beyond this distance from the turbine will not detect a reflected signal. Reflected signals from other Carrownagowan turbines will only be detected at ranges less than 1579m.

5.4.19. Annex D of the EUROCONTROL Guidelines states that an airborne transponder will be insensitive for 35µs following reception of a radar interrogation. Thus, an aircraft closer than 5250m (half of the distance corresponding to 35µs) to the source of a reflected interrogation will not reply to reflected interrogations because the path length between the direct and reflected signals will always be smaller than 35µs.

5.4.20. Aircraft will not respond to reflected MSSR interrogations as they will only be detected when the aircraft is within 5250m of the turbines.

5.4.21. An array of turbines can create a radar shadow in the space beyond it from the radar. The EUROCONTROL Guidelines provides a means of calculating the dimensions of this shadow region.

$$Dwr = Dtw/[\lambda.\frac{Dtw}{S^2}\left(1-\sqrt{PL}\right)^2 - 1]$$

- *Dwr* = depth of the shadow region.
- *Dtw* = distance of turbines (13.75-18.12km)
- λ = wavelength (0.29m)
- S = diameter of support structures (6m)
- PL = acceptable power loss (0.5/3dB as per guidelines)

5.4.22. The depth of the shadow region beyond each of the Carrownagowan turbines will vary between 1572m and 1617m for Woodcock Hill MSSR.

5.4.23. The EUROCONTROL Guidelines also provide equations for calculating the width and height of the shadow regions. For Woodcock MSSR the shadow regions will vary between 44m and 45m wide and will vary in height between 941 ft and 1440 ft Above Mean Sea Level (AMSL).

5.4.24. The volumes of the Woodcock MSSR shadow regions beyond the proposed turbines are considered sufficiently small to be operationally tolerable.

6. Conclusions

6.1. Modelling of the proposed windfarm shows that none of the wind turbines will penetrate any of the AANE BRAs.

6.2. The proposed wind farm will not pose a risk to aircraft approaching or departing from either runway at Shannon Airport. No further modelling is deemed necessary.

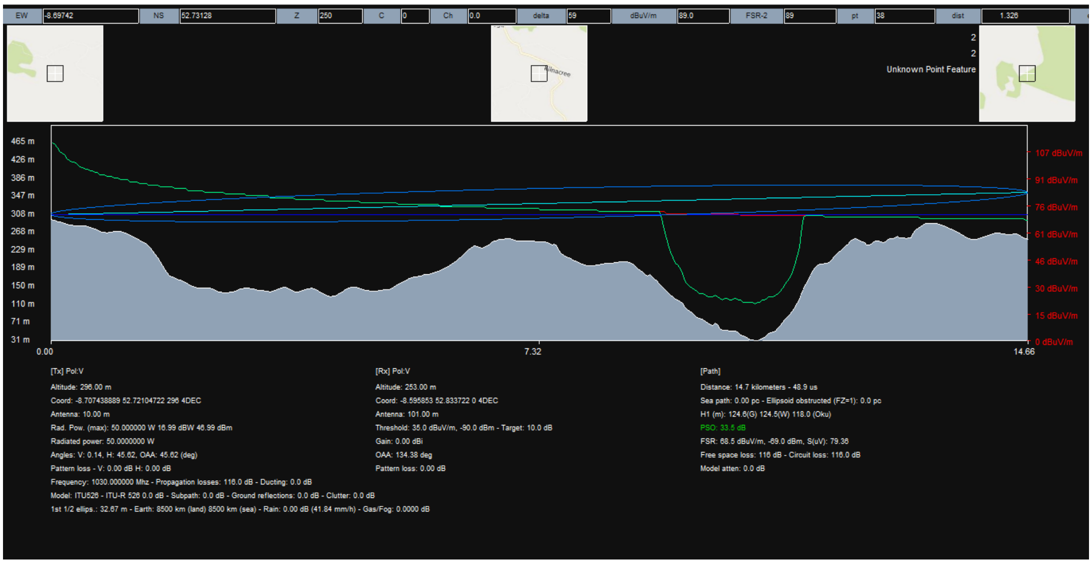
6.3. Calculations have shown that false targets due to bistatic reflections from the turbine towers will not occur for Woodcock Hill MSSR.

6.4. The volumes of shadow regions from the turbines are relatively small for the MSSR and considered operationally tolerable. No mitigation measures are considered necessary for the Woodcock Hill MSSR.

A. Annex A – Woodcock Hill MSSR Path Profiles

A.1. Turbine T1

A.2. Turbine T2



A.3. Turbine T3

A.4. Turbine T4

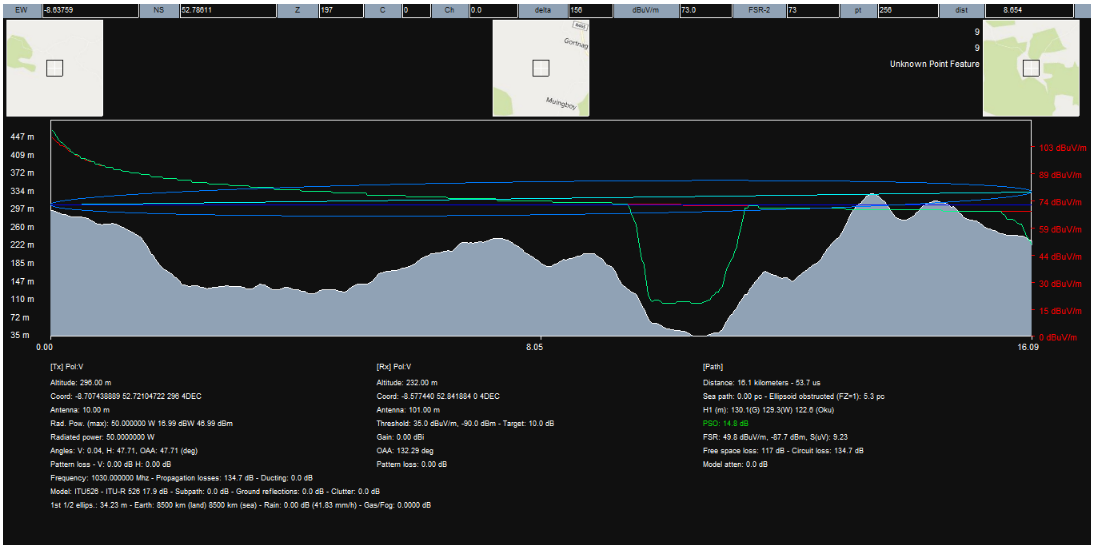
A.5. Turbine T5

A.6. Turbine T6

A.7. Turbine T7

A.8. Turbine T8

A.9. Turbine T9

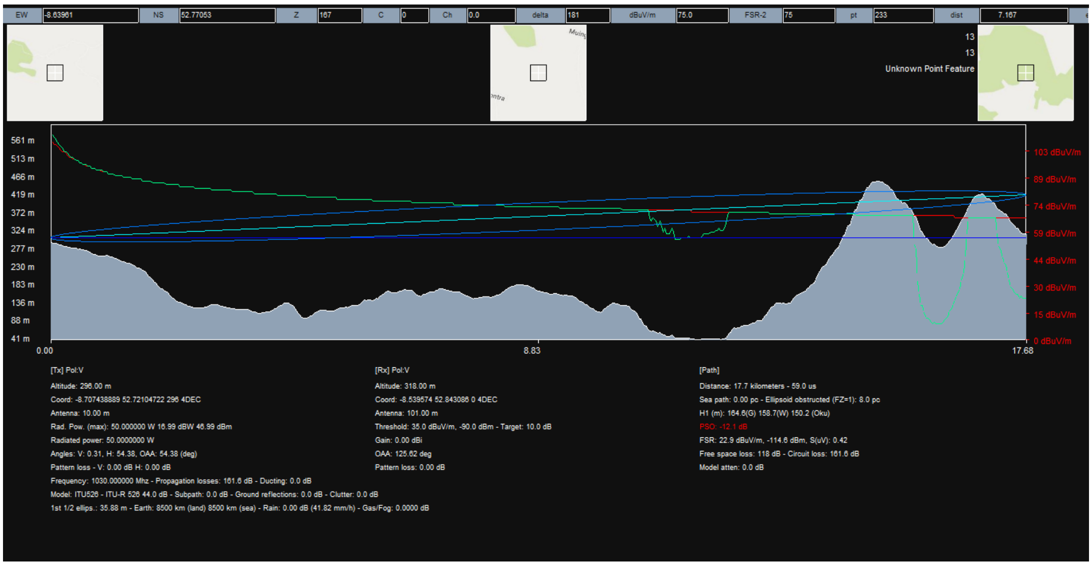


A.10. Turbine T10

A.11. Turbine T11

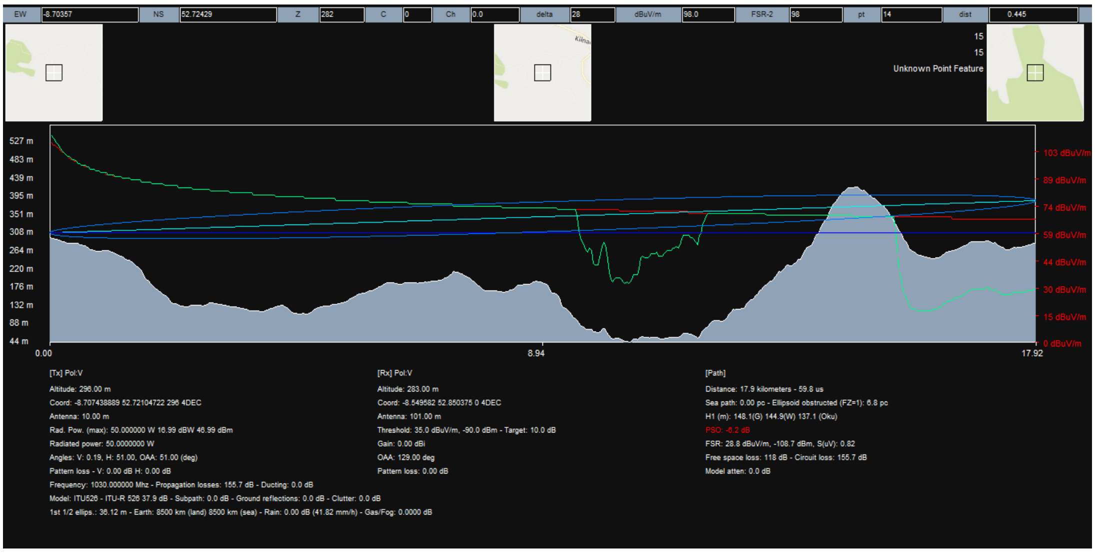
A.12. Turbine T12

A.13. Turbine T13

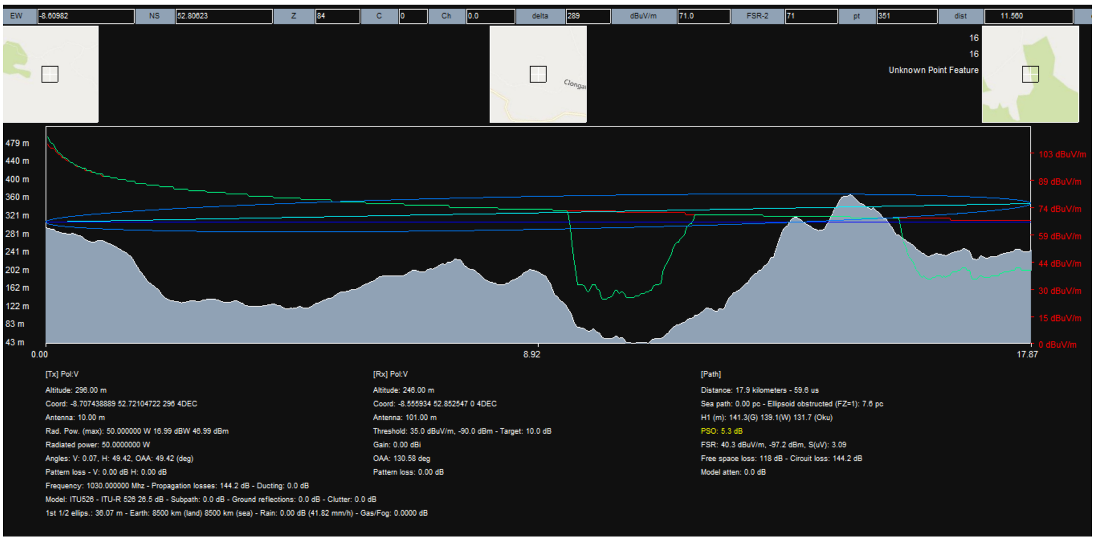


A.14. Turbine T14

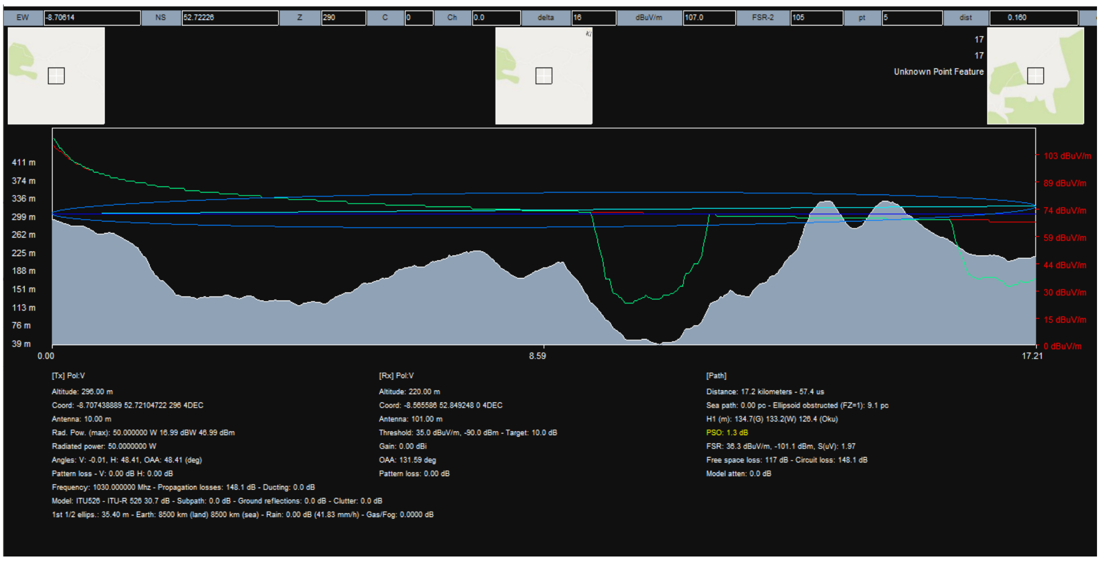
A.15. Turbine T15



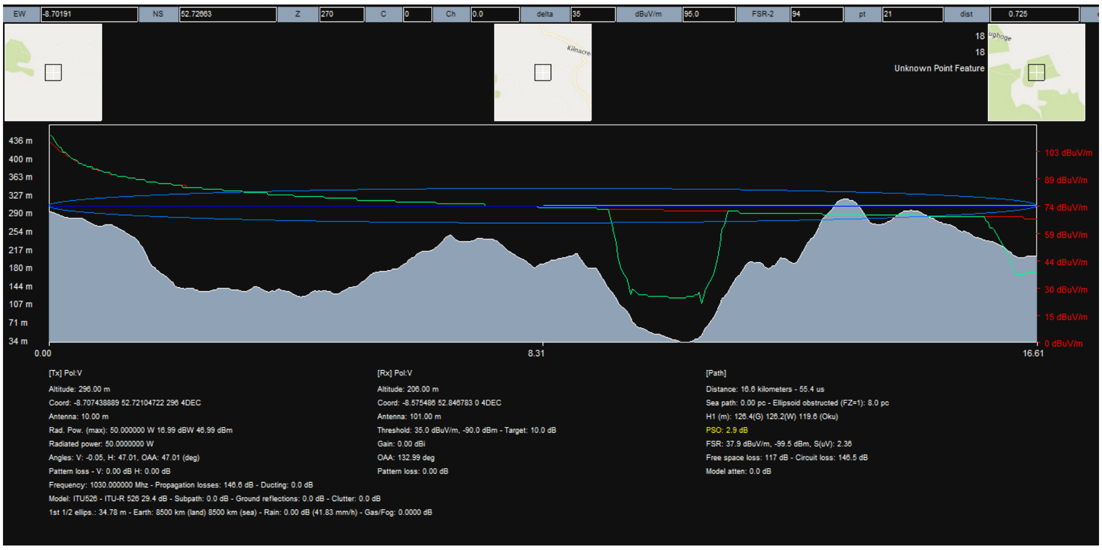
A.16. Turbine T16



A.17. Turbine T17



A.18. Turbine T18



A.19. Turbine T19

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Appendix 3

IFP Safeguarding Assessment - Cyrrus

IFP Safeguarding Assessment

Carrownagowan Wind Farm

Shannon Airport

28 April 2021

CL-5614-RPT-005 V1.0

www.cyrrus.co.uk

info@cyrrus.co.uk

ISO 9001 CERTIFIED
UKAS
British Assessment Bureau

Executive Summary

Malachy Walsh and Partners (The Client) have requested an Instrument Flight Procedures (IFP) Safeguarding Assessment to determine the potential impact of a proposed wind farm development near Shannon Airport.

The location is approximately 14 NM to the North East of the Aerodrome Reference Point (ARP), as shown in Figure 1.

The purpose of the assessment is to assess if any of the turbines associated with the wind farm infringe the protection surfaces of the IFPs serving the Airport. Each IFP type has a different set of criteria that needs to be considered with any penetration potentially impacting the minimum altitude an aircraft may descend to when conducting an approach to land or climb to on a departure.

These IFPs are particularly important during adverse weather conditions when flight visibility is reduced as they provide the pilot with assurances that there are no obstacles on the defined flight path. Whilst on the descent, the aircraft reaches a Decision Point at which the pilot must have the required visual references[1], if these references are not visually acquired the pilot must initiate a missed approach; this portion of flight is also protected and is assessed.

The windfarm has no impact to the currently published IFPs for Shannon Airport.

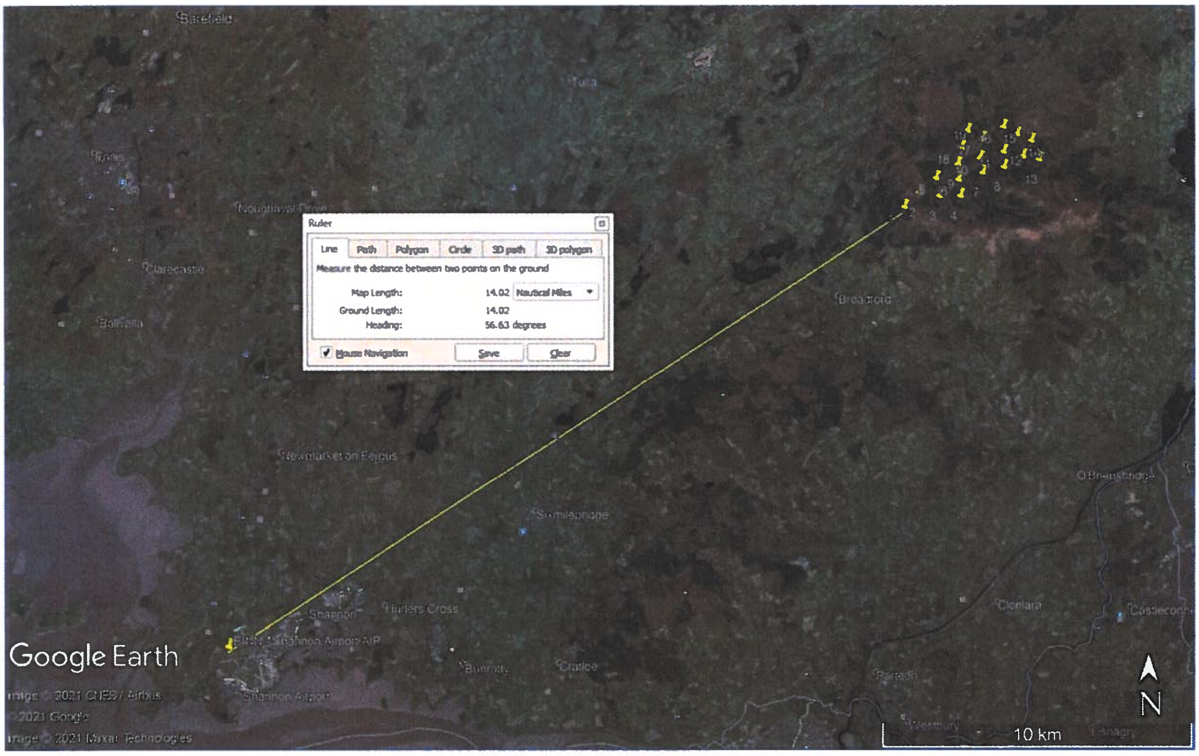

Figure 1: Position and Location of Crane relative to the RWY 16 Centreline

[1] Required visual reference means that section of the visual aids or of the approach area which should have been in view for sufficient time for the pilot to have made an assessment of the aircraft position and rate of change of position, in relation to the desired flight path.

Abbreviations

AGL	Above Ground Level
AIP	Aeronautical Information Publication
AIRAC	Aeronautical Information Regulation and Control
AMSL	Above Mean Sea Level
APD	Approved Procedure Designer
APR	Aerodrome Reference Point
APV	Approach with Vertical Guidance
ARP	Aerodrome Reference Point
ATC	Air Traffic Control
ATCSMAC	Air Traffic Control Surveillance Minimum Altitude Chart
ATT	Along-Track Tolerance
BARO	Barometric
CAT	Category
DER	Departure End of Runway
DME	Distance Measuring Equipment
ETP	Earliest Turning Point
FAP	Final Approach Point
FAS	Final Approach Segment
FAWP	Final Approach Waypoint
FHP	Fictitious Heliport Point
FT	Feet
GARP	GNSS Azimuth Reference Point
HL	Height Loss
IAS	Indicated Airspeed
IAWP	Initial Approach Waypoint
IFP	Instrument Flight Procedure
ILS	Instrument Landing System
ISA	International Standard Atmosphere
km	Kilometres
LNAV	Lateral Navigation
LNAV/VNAV	Lateral/Vertical Navigation
LOC	Localiser
LPV	Localiser Performance with Vertical Guidance
m	Metres
MACG	Missed Approach Climb Gradient
MOC	Minimum Obstacle Clearance (Altitude)
MOCA	Minimum Obstacle Clearance Altitude
MSA	Minimum Sector Altitudes
NDB	Non-Directional Beacon
NM	Nautical Mile
OA	Obstacle Assessment

OAS	Obstacle Assessment Surfaces
OCA	Obstacle Clearance Altitude
OCH	Obstacle Clearance Height
PANS-OPS	Procedures for Air Navigation Services Aircraft Operations
PDG	Procedure Design Gradient
RDH	Reference Datum Height
RNAV	Area Navigation
RNP	Required Navigation Performance
RPT	Report
RWY	Runway
SBAS	Satellite Based Augmentation System
SID	Standard Instrument Departure
SOC	Start of Climb
TAA	Terminal Arrival Altitude
TAS	True Airspeed
THR	Threshold
VOR	VHF Omni-directional Radio Range
VPA	Vertical Path Angle
XTT	Cross-Track Tolerance
DTM	Digital Terrain Model
DVOR	DME/VOR
TP	Turning Point

References

[1] ICAO DOC 8168 - Procedures for Air Navigation Services, Aircraft Operations, Vol II, Seventh Ed, Amendment 9, (5/11/20).

[2] ASAM 017 - Guidance Material on Instrument Flight Procedure Design. Issue 5 (02/11/20)

Contents

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1. Introduction

1.1. Information Received

It is essential, for both efficiency and safety, that all personnel involved in the control and management of aircraft operations have the same information and work from a common database. Relevant information is published in an Aeronautical Information Publication (AIP) and the Irish State promulgates its data in the Ireland AIP. Aeronautical information is constantly changing, and updates are notified every 28-days through the Aeronautical Information Regulation and Control (AIRAC) notification system.

Changes made to airspace structures, navigation aids, instrument flight procedures including departures (SIDs), arrivals (STARs) and instrument approach procedures (IAPs) and airport infrastructure particularly the runway, taxiway and manoeuvring areas are notified by the individual airports to the Irish Aviation Authority (IAA) which will then promulgate approved changes in the AIP.

The assessment undertaken by Cyrrus has been based upon the latest promulgated aeronautical information for Sligo contained in the Ireland AIP, reference EISG AD Section 2.

The following data was received for the assessment:

- Irish AIP – AIRAC 03/2021 effective 25 March 2021.

In order to conduct the assessment, Cyrrus relies on the Client to provide accurate data, this is duplicated in this report for validation. The data received that was used for this assessment, is contained in the email as listed below. The respective information was extracted and applied as indicated in Table 1.

- Email titled "RE Carrownagowan Wind Farm.pdf"

Table 1 provides the base co-ordinates of the Turbines, the co-ordinates were provided in Irish Transverse Mercator and converted to World Geodetic System 84 (WGS84) using the ordinates survey's GridInQuestII conversion tool.

Turbine No	Easting (ITM)	Northing (ITM)	Lat (WGS84 d.d)	Long (WGS84 d.d)	Ground Level (m AMSL)	Max Tip Elevation (m AMSL)
1	559385	675575	52.829598	-8.602697	245.56	414.56
2	559850	676030	52.833722	-8.595853	246.72	415.72
3	560484	675908	52.832672	-8.586430	300.12	469.12
4	561137	675897	52.832621	-8.576738	326.39	495.39
5	560394	676494	52.837932	-8.587836	243.44	412.44
6	561109	676437	52.837472	-8.577218	247.31	416.31
7	561881	676649	52.839432	-8.565785	244.75	413.75
8	562533	676815	52.840970	-8.556128	313.24	482.24
9	561098	676928	52.841884	-8.577440	225.49	394.49
10	561800	677115	52.843615	-8.567042	237.93	406.93

Turbine No	Easting (ITM)	Northing (ITM)	Lat (WGS84 d.d)	Long (WGS84 d.d)	Ground Level (m AMSL)	Max Tip Elevation (m AMSL)
11	562539	677308	52.845401	-8.556095	277.48	446.48
12	563149	677146	52.843987	-8.547022	310.89	479.89
13	563650	677042	52.843086	-8.539574	314.38	483.38
14	563431	677641	52.848455	-8.542892	311.15	480.15
15	562982	677858	52.850375	-8.549582	278.45	447.45
16	562556	678103	52.852547	-8.555934	250.22	419.22
17	561903	677741	52.849248	-8.565586	220.58	389.58
18	561234	677472	52.846783	-8.575486	194.97	363.97
19	561435	678011	52.851641	-8.572566	188.93	357.93

Table 1: Extracted and Converted Wind Farm data

1.2. Notes

Table 2 indicates the baseline criteria used for this assessment.

Criteria	Comments
Height	In metres (m)
Bearings	True bearings
Speed	Knots (kts)
Temperature	International Standard Atmosphere (ISA) +15 used for all speed conversions from Indicated Air Speed (IAS) to True Air Speed (TAS)
Aircraft categories	A, B, C, D
Mountainous terrain	No
Buffer for trees and unknown structures not defined in CAP1732 surveyed areas (see Section 1.6)	N/A
Wind	ICAO standard wind.

Table 2: Criteria

1.3. Bearings

All bearings in the relevant tables for each segment are geodetically calculated from two Latitude / Longitude positions. These bearings are "real world" bearings and form the basis for the magnetic bearings (radials etc.) that are on the eventual chart.

1.4. Geodesic Datum

The Geodesic datum is used to re-project data onto a flat surface. The parameters for the geodesic datum are set out in Table 3.

Name	Ireland WGS84 UTM29
Reference Latitude	00°00'00.00"N
Reference Longitude	009°00'00.00"W
Reference X	500000.0000
Reference Y	0.0000
Semi Major Axis [a]	6378137 m
Eccentricity [e]	0.0818191908426215
Scaling Factor	0.9996
Projection	Transverse Mercator

Table 3: Geodesic Datum

1.5. Discrepancies

None.

1.6. Assumptions

The ground elevations provided have no integrity, therefore it is assumed that the provided information is accurate and verified, it is noted that a maximum elevation difference of approximately 7m was observed between the provided data and Ordnance Survey Ireland 10m DTM.

In the absence of the working Turbine blade length, a rotor diameter of 169m was used.

2. IFP Safeguarding Assessment

An IFP Safeguarding assessment was completed against the applicable procedures for RWY 06 / RWY 24 at Shannon Airport.

Due to the position of the windfarm the RNAV Standard Instrument Departure chart for RWY 24 was not assessed.

The visual Approach Chart was not considered.

Due to the technical nature of the information, this report is a distillation of the IFP modelling and subsequent assessment of the obstacles, the full data set is available if required[2]. The purpose of this report is to identify what procedures were assessed and whether there is an impact, in the event of an impact, potential mitigation is provided[3]. Where an impact was identified, only the assessment of the respective segment for said procedure, is provided.

Table 4 provides an impact summary of all the IFPs that were assessed.

Assessed Procedure	RWY	Impact	Comments
MSA	Both	No	Nil
ILS or LOC	06	No	Nil
VOR		No	Nil
RNAV STARs		No	Nil
RNAV SIDs		No	Nil
ILS CAT I & II or LOC	24	No	Nil
VOR		No	Nil
RNAV STARs		No	Nil
RNAV SIDs		No	Nil

Table 4: Impact Summary of Assessed Procedures

2.1. Minimum Sector Altitude (MSA)

The turbines fall into sector 1 (056°M to 146°M) and sector 2 (146°M to 056°M), of the MSA.

Homing Facility Position	
ID	DVOR SHA
Latitude	52°43'15.60"N
Longitude	008°53'06.80"W
Parameters	
Magnetic Variation	4.0000°W
Outer Radius	25 nm
MOC	300 m

2 Please note that the full data set can run into an excess of 20 pages per procedure and can only be decoded by those familiar with the output generation from the IFP Software and trained IFP Designers.
3 Mitigation for the IFPs is for the Airport to decide upon as these may have a direct impact on their operations.

Sector 1	
From	056° M
To	146° M
Calculated Minimum	2700 ft
Number of Checked Obstacles	19
Sector 2	
From	146° M
To	056° M
Calculated Minimum	2700 ft
Number of Checked Obstacles	19

Table 5: 5614 - MSA - VOR/DME SHA - General

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	300.0	2609.6
13	52°50'35.11"N	008°32'22.47"W	483.4	300.0	2570.2
8	52°50'27.49"N	008°33'22.06"W	482.2	300.0	2566.5
14	52°50'54.44"N	008°32'34.41"W	480.2	300.0	2559.6
12	52°50'38.35"N	008°32'49.28"W	479.9	300.0	2558.7
3	52°49'57.62"N	008°35'11.15"W	469.1	300.0	2523.4
15	52°51'01.35"N	008°32'58.49"W	447.5	300.0	2452.3
11	52°50'43.44"N	008°33'21.94"W	446.5	300.0	2449.1
16	52°51'09.17"N	008°33'21.36"W	419.2	300.0	2359.7
6	52°50'14.90"N	008°34'37.98"W	416.3	300.0	2350.1

Table 6: 5614 - MSA - VOR/DME SHA - Checked Obstacles - 056° M - 146° M

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	OCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	300.0	2609.6
13	52°50'35.11"N	008°32'22.47"W	483.4	300.0	2570.2
8	52°50'27.49"N	008°33'22.06"W	482.2	300.0	2566.5
14	52°50'54.44"N	008°32'34.41"W	480.2	300.0	2559.6
12	52°50'38.35"N	008°32'49.28"W	479.9	300.0	2558.7
3	52°49'57.62"N	008°35'11.15"W	469.1	300.0	2523.4
15	52°51'01.35"N	008°32'58.49"W	447.5	300.0	2452.3
11	52°50'43.44"N	008°33'21.94"W	446.5	300.0	2449.1
16	52°51'09.17"N	008°33'21.36"W	419.2	300.0	2359.7
6	52°50'14.90"N	008°34'37.98"W	416.3	300.0	2350.1

Table 7: 5614 - MSA - VOR/DME SHA - Checked Obstacles - 146° M - 056° M

As indicated in Table 6 and Table 7 there is no impact to the MSA.

Figure 2: MSA VOR/DME SHA

2.2. IAP – ILS Runway 06

The Turbines fall into the Missed Approach segment Final Phase.

Parameters	
SOC Position	
ID	SOC (197ft)
Latitude	52°41'51.51"N
Longitude	008°56'02.51"W
Altitude	60.05 m (197 ft)
Track	052.17 °
MOC [fin.]	50 m
MACG	2.5 %
Obstacles	
Number of Checked Obstacles	11

Table 8: 5614 - ILS RWY 06 - CAT A-D - Missed Approach - OA - General

Name	Latitude	Longitude	Alt. (m)	Area	Dz (m)	Do (m)	MOC (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl?
4	52°49'57.43"N	008°34'36.26"W	495.4	Pri.	21042.8	7132.6	50.0	2508.0	1789.3	1.8	No
3	52°49'57.62"N	008°35'11.15"W	469.1	Pri.	21042.8	6618.1	50.0	2465.8	1703.1	1.7	No
1	52°49'46.55"N	008°36'09.71"W	414.6	Pri.	21042.8	5540.5	50.0	2377.4	1524.1	1.6	No
2	52°50'01.40"N	008°35'45.07"W	415.7	Pri.	21042.8	6185.6	50.0	2430.3	1528.0	1.5	No
5	52°50'16.56"N	008°35'16.21"W	412.4	Pri.	21042.8	6899.1	50.0	2488.8	1517.2	1.5	No
6	52°50'14.90"N	008°34'37.98"W	416.3	Pri.	21042.8	7435.4	50.0	2532.8	1529.9	1.5	No
7	52°50'21.96"N	008°33'56.83"W	413.8	Pri.	21042.8	8179.2	50.0	2593.8	1521.5	1.4	No
10	52°50'37.01"N	008°34'01.35"W	406.9	Pri.	21042.8	8395.2	50.0	2611.5	1499.1	1.4	No
9	52°50'30.78"N	008°34'38.78"W	394.5	Pri.	21042.8	7722.3	50.0	2556.3	1458.3	1.4	No
18	52°50'48.42"N	008°34'31.75"W	364.0	Pri.	21042.8	8158.4	50.0	2592.1	1358.2	1.3	No

Table 9: 5614 - ILS RWY 06 - CAT A-D - Missed Approach - OA - Final Phase - Checked Obstacles

As indicated in Table 9, there is no impact to the procedure.

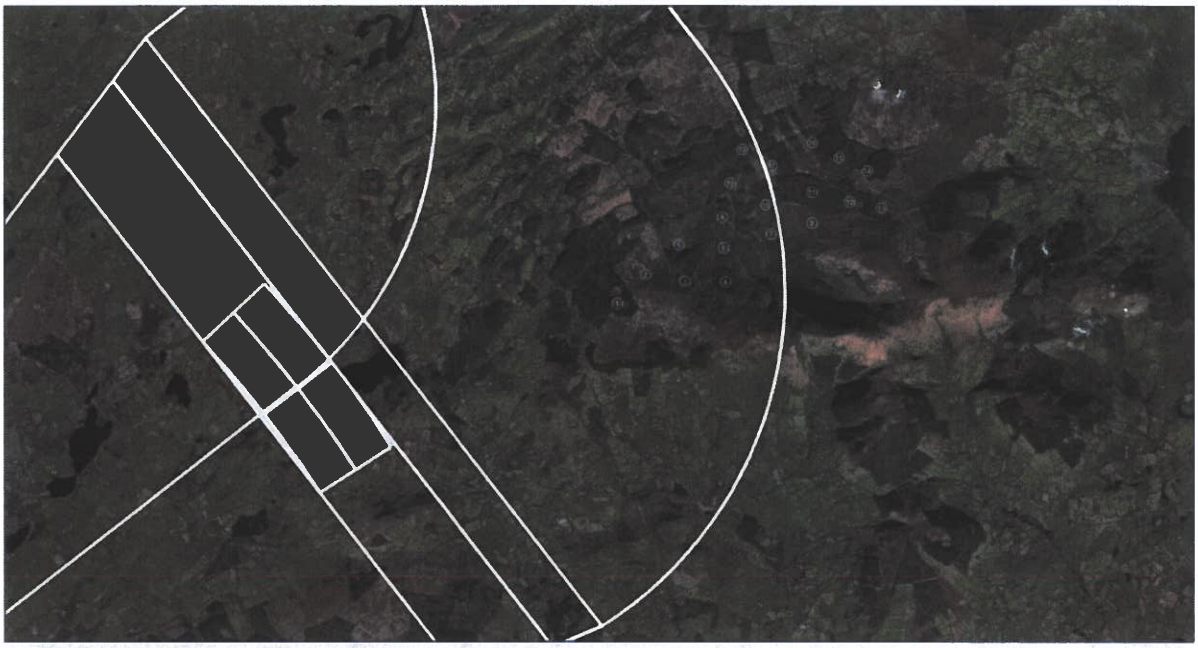

Figure 3: ILS RWY 06 - Final Missed Approach – Windfarm Location

2.3. IAP – LOC Runway 06

The Turbines fall into Missed Approach segment Final Phase for the procedure.

Parameters	
SOC Position	
ID	SOC (350ft)
Latitude	52°41'45.31"N
Longitude	008°56'15.65"W
Altitude	106.68 m (350 ft)
Track	052.09 °
MOC [fin.]	50 m
MACG	2.5 %
Obstacles	
Number of Checked Obstacles	12

Table 10: 5614 - LOC RWY 06 - Missed Approach - General

Name	Latitude	Longitude	Alt. (m)	Area	Dz (m)	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl?
4	52°49'57.43"N	008°34'36.26"W	495.4	Pri.	21354.9	7128.9	50.0	2686.3	1789.3	1.6	No
3	52°49'57.62"N	008°35'11.15"W	469.1	Pri.	21354.9	6615.0	50.0	2644.1	1703.1	1.5	No
1	52°49'46.55"N	008°36'09.71"W	414.6	Pri.	21354.9	5537.9	50.0	2555.8	1524.1	1.4	No
2	52°50'01.40"N	008°35'45.07"W	415.7	Pri.	21354.9	6183.1	50.0	2608.7	1528.0	1.4	No
5	52°50'16.56"N	008°35'16.21"W	412.4	Pri.	21354.9	6896.7	50.0	2667.2	1517.2	1.3	No
6	52°50'14.90"N	008°34'37.98"W	416.3	Pri.	21354.9	7432.4	50.0	2711.2	1529.9	1.3	No
7	52°50'21.96"N	008°33'56.83"W	413.8	Pri.	21354.9	8175.8	50.0	2772.1	1521.5	1.3	No
10	52°50'37.01"N	008°34'01.35"W	406.9	Pri.	21354.9	8392.3	50.0	2789.9	1499.1	1.2	No

9	52°50'30.78"N	008°34'38.78"W	394.5	Pri.	21354.9	7719.8	50.0	2734.7	1458.3	1.2	No
17	52°50'57.29"N	008°33'56.11"W	389.6	Pri.	21354.9	8852.0	50.0	2827.6	1442.2	1.2	No
18	52°50'48.42"N	008°34'31.75"W	364.0	Pri.	21354.9	8156.4	50.0	2770.5	1358.2	1.1	No
19	52°51'05.91"N	008°34'21.24"W	357.9	Pri.	21354.9	8641.8	50.0	2810.4	1338.4	1.1	No

Table 11: 5614 - LOC RWY 06 - Missed Approach - Final Phase - Checked Obstacles

As indicated in Table 11, the LOC procedure is not impacted.

Figure 4: 5614 - LOC RWY 06 - Missed Approach – Windfarm Location

2.4. IAP – VOR Runway 06

The turbines fall in the missed approach segment of the procedure.

Parameters	
SOC Position	
ID	SOC (360ft)
Latitude	52°41'47.52"N
Longitude	008°56'13.04"W
Altitude	109.73 m (360 ft)
Track	052.02 °
MOC [fin.]	50 m
MACG	2.5 %
Obstacles	
Number of Checked Obstacles	6

Table 12: 5614 - VOR RWY 06 - CAT A-D - Missed Approach - OA – General

Name	Latitude	Longitude	Alt. (m)	Area	Dz (m)	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	MACG (%)	Ctrl
4	52°49'57.43"N	008°34'36.26"W	495.4	Pri	21274.3	7125.5	50	2689.4	1789.3	1.6	No
3	52°49'57.62"N	008°35'11.15"W	469.1	Pri	21274.3	6612	50	2647.3	1703.1	1.5	No
1	52°49'46.55"N	008°36'09.71"W	414.6	Pri	21274.3	5535.4	50	2559	1524.1	1.4	No
2	52°50'01.40"N	008°35'45.07"W	415.7	Pri	21274.3	6180.7	50	2611.9	1528	1.3	No
5	52°50'16.56"N	008°35'16.21"W	412.4	Pri	21274.3	6894.3	50	2670.4	1517.2	1.3	No
6	52°50'14.90"N	008°34'37.98"W	416.3	Pri	21274.3	7429.4	50	2714.3	1529.9	1.3	No
9	52°50'30.78"N	008°34'38.78"W	394.5	Pri	21274.3	7717.3	50	2737.9	1458.3	1.2	No

Table 13: 5614 - VOR RWY 06 - CAT A-D - Missed Approach - OA - Final Phase - Checked Obstacles

As indicated in Table 13, there is no impact to the procedure.

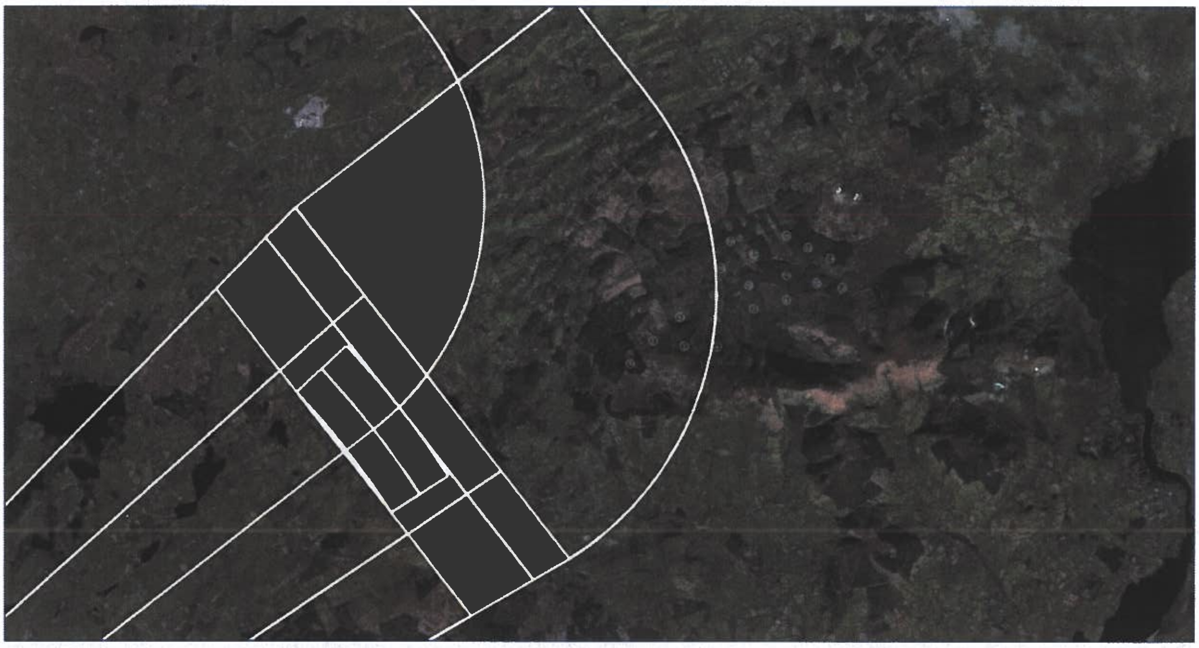

Figure 5: VOR RWY 06 – Final Missed Approach – Windfarm Location

2.5. RNAV SID (DIGAN 3A)

DER	
Latitude	52°42'37.24"N
Longitude	008°54'25.30"W
Altitude	4.57 m (14.99 ft)
Parameters	
Track	052.13 °
MOC	0.8 %
Minimum MOC	75 m
PDG	3.3 %
Turning Altitude	600 ft
Distance DER->TP [Dr]	5251.82 m

Table 14: 5614 - SID - RWY 06 - DIGA3A - Turn Area - Obstacle Assessment

19 obstacles and terrain points were checked.

Name	Latitude	Longitude	Alt. (m)	Area	Do (m)	MOC req. (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?	Close-in
4	52°49'57.43"N	008°34'36.26"W	495.4	Pri.	20653.9	207.2	2836.1	2305.2	2.6	No	No
3	52°49'57.62"N	008°35'11.15"W	469.1	Pri.	20119.0	203.0	2778.2	2205.0	2.5	No	No
8	52°50'27.49"N	008°33'22.06"W	482.2	Pri.	22324.3	220.6	3017.0	2305.9	2.4	No	No
12	52°50'38.35"N	008°32'49.28"W	479.9	Pri.	23020.6	226.2	3092.4	2316.5	2.3	No	No
13	52°50'35.11"N	008°32'22.47"W	483.4	Pri.	23384.7	229.1	3131.8	2337.5	2.3	No	No
14	52°50'54.44"N	008°32'34.41"W	480.2	Pri.	23529.5	230.3	3147.5	2330.7	2.3	No	No
1	52°49'46.55"N	008°36'09.71"W	414.6	Pri.	19028.5	194.2	2660.2	1997.4	2.3	No	No
2	52°50'01.40"N	008°35'45.07"W	415.7	Pri.	19671.6	199.4	2729.8	2018.1	2.2	No	No
11	52°50'43.44"N	008°33'21.94"W	446.5	Pri.	22605.0	222.9	3047.4	2196.0	2.2	No	No
5	52°50'16.56"N	008°35'16.21"W	412.4	Pri.	20384.2	205.1	2807.0	2026.0	2.2	No	No
15	52°51'01.35"N	008°32'58.49"W	447.5	Pri.	23282.4	228.3	3120.7	2216.9	2.2	No	No
6	52°50'14.90"N	008°34'37.98"W	416.3	Pri.	20933.8	209.5	2866.5	2053.1	2.2	No	No
7	52°50'21.96"N	008°33'56.83"W	413.8	Pri.	21690.2	215.5	2948.4	2064.6	2.1	No	No
10	52°50'37.01"N	008°34'01.35"W	406.9	Pri.	21888.5	217.1	2969.8	2047.4	2.1	No	No
16	52°51'09.17"N	008°33'21.36"W	419.2	Pri.	23078.5	226.6	3098.7	2119.0	2.1	No	No
9	52°50'30.78"N	008°34'38.78"W	394.5	Pri.	21208.7	211.7	2896.2	1988.8	2.0	No	No
17	52°50'57.29"N	008°33'56.11"W	389.6	Pri.	22338.0	220.7	3018.5	2002.3	2.0	No	No
18	52°50'48.42"N	008°34'31.75"W	364.0	Pri.	21640.7	215.1	2943.0	1900.0	1.9	No	No
19	52°51'05.91"N	008°34'21.24"W	357.9	Pri.	22125.7	219.0	2995.5	1892.9	1.8	No	No

Table 15: 5614 - SID - RWY 06 - DIGA3A - Turn Area - Obstacle Assessment - Checked Obstacles

As indicated in Table 15, no turbines impact the procedure.

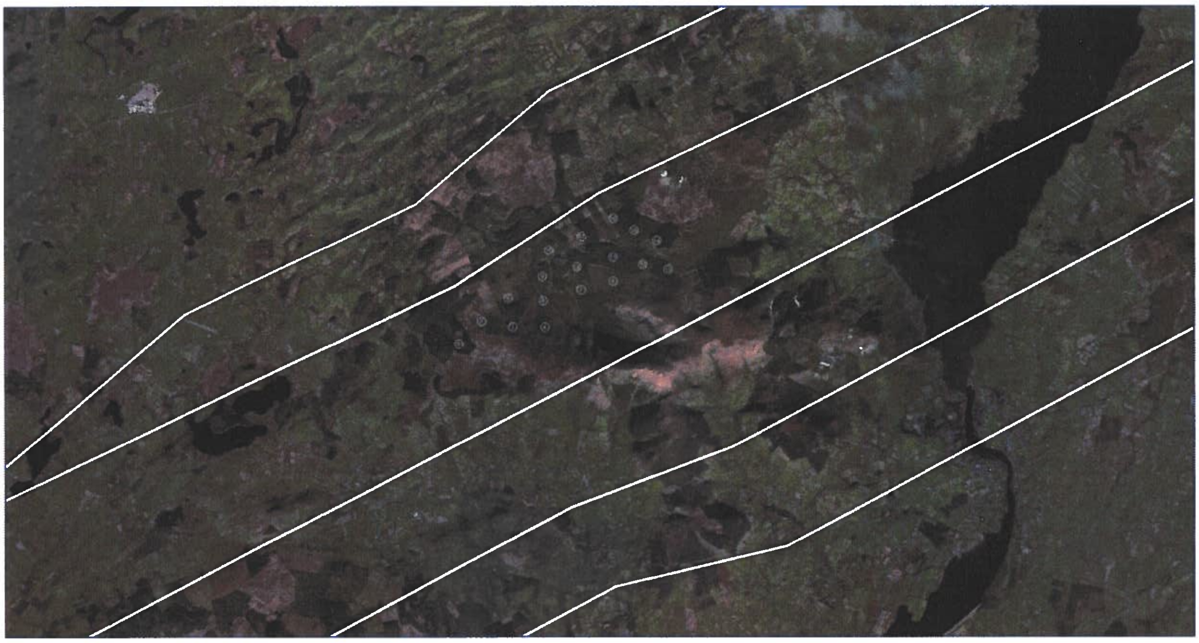

Figure 6: 5614 - SID - DIGAN3A - Obstacle Location

2.6. RNAV SID (TOMTO 3A)

Starting Position	
ID	600 ft
Latitude	52°44'21.36"N
Longitude	008°50'44.03"W

Altitude	4.57 m (14.99 ft)
Finishing Position	
ID	TOMTO
Latitude	52°52'24.80"N
Longitude	008°09'05.20"W
Parameters	
Calculation Type	Ellipsoid
Result	
Forward True Bearing	072.02 °
Distance Between Positions	26.53 nm / 49.14 km

Table 16: SID - RWY 06 - TOMTO3A - Turn Area - Basic Description - Turn #1

Waypoint	
ID	600 ft
Latitude	52°44'21.36"N
Longitude	008°50'44.03"W
Altitude	4.57 m (14.99 ft)
Track TO	052.2 °
Track FROM	072.02 °
Course Change	019.77 °
Turn Direction	Right
Tolerances	
ATT	0.8 nm
XTT	1 nm
Area Semi Width	2 nm
Nominal Turn	
IAS	275 kts
Altitude	10000 ft
ISA	15 °C
Bank Angle	15 °
TAS	328.8 kts
r	10891.61 m
Turn Protection Area	
IAS	275 kts
Altitude	10000 ft
ISA	15 °C
Bank Angle	15 °
Wind	66.7 kts
TAS	328.8 kts
r	10891.61 m
E	3471.59 m
sqrt(r^2 + E^2)	11431.49 m
r + E	14363.2 m
r + 2E	17834.78 m

Table 17: SID - RWY 06 - TOMTO3A - Turn Area - Protection Areas - Turn #1

DER	
Latitude	52°42'37.24"N

Longitude	008°54'25.30"W
Altitude	4.57 m (14.99 ft)
Parameters	
Track	052.13 °
MOC	0.8 %
Minimum MOC	75 m
PDG	3.3 %
Turning Altitude	600 ft
Distance DER->TP [Dr]	5251.82 m

Table 18: SID - RWY 06 - TOMTO3A - Turn Area - Obstacle Assessment

19 obstacles and terrain points were checked. The 0 most controlling obstacles are listed in the following table.

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	Do (m)	MOC (m)	Ac. alt. (ft)	Alt. req. (ft)	PDG (%)	Ctrl?	Close-in
4	52°49'57.43"N	008°34'36.26"W	495.4	Pri.	N/A	20653.9	207.2	2836.1	2305.2	2.6	No	No
3	52°49'57.62"N	008°35'11.15"W	469.1	Sec.	12.4	20119.0	201.6	2778.2	2200.4	2.5	No	No
13	52°50'35.11"N	008°32'22.47"W	483.4	Pri.	N/A	23384.7	229.1	3131.8	2337.5	2.3	No	No
8	52°50'27.49"N	008°33'22.06"W	482.2	Sec.	165.3	22324.3	203.1	3017.0	2248.4	2.3	No	No
1	52°49'46.55"N	008°36'09.71"W	414.6	Pri.	N/A	19028.5	194.2	2660.2	1997.4	2.3	No	No
12	52°50'38.35"N	008°32'49.28"W	479.9	Sec.	266.0	23020.6	198.5	3092.4	2225.5	2.2	No	No
2	52°50'01.40"N	008°35'45.07"W	415.7	Sec.	286.7	19671.6	165.8	2729.8	1907.7	2.1	No	No
14	52°50'54.44"N	008°32'34.41"W	480.2	Sec.	635.4	23529.5	164.8	3147.5	2116.0	2.0	No	No
6	52°50'14.90"N	008°34'37.98"W	416.3	Sec.	296.2	20933.8	176.7	2866.5	1945.5	2.0	No	No
7	52°50'21.96"N	008°33'56.83"W	413.8	Sec.	231.9	21690.2	190.5	2948.4	1982.4	2.0	No	No
11	52°50'43.44"N	008°33'21.94"W	446.5	Sec.	626.5	22605.0	156.5	3047.4	1978.2	1.9	No	No
5	52°50'16.56"N	008°35'16.21"W	412.4	Sec.	593.8	20384.2	137.7	2807.0	1804.9	1.9	No	No
15	52°51'01.35"N	008°32'58.49"W	447.5	Sec.	992.1	23282.4	124.5	3120.7	1876.3	1.7	No	No
10	52°50'37.01"N	008°34'01.35"W	406.9	Sec.	697.4	21888.5	141.6	2969.8	1799.6	1.7	No	No
9	52°50'30.78"N	008°34'38.78"W	394.5	Sec.	761.3	21208.7	127.4	2896.2	1712.1	1.6	No	No
16	52°51'09.17"N	008°33'21.36"W	419.2	Sec.	1367.7	23078.5	81.8	3098.7	1643.8	1.4	No	No
17	52°50'57.29"N	008°33'56.11"W	389.6	Sec.	1250.5	22338.0	85.8	3018.5	1559.5	1.4	No	No
18	52°50'48.42"N	008°34'31.75"W	364.0	Sec.	1226.1	21640.7	80.0	2943.0	1456.6	1.3	No	No
19	52°51'05.91"N	008°34'21.24"W	357.9	Sec.	1664.0	22125.7	36.8	2995.5	1295.1	1.0	No	No

Table 19: SID - RWY 06 - TOMTO3A - Turn Area - Obstacle Assessment - Checked Obstacles

As indicated in Table 19, no turbines have an impact on the procedure.

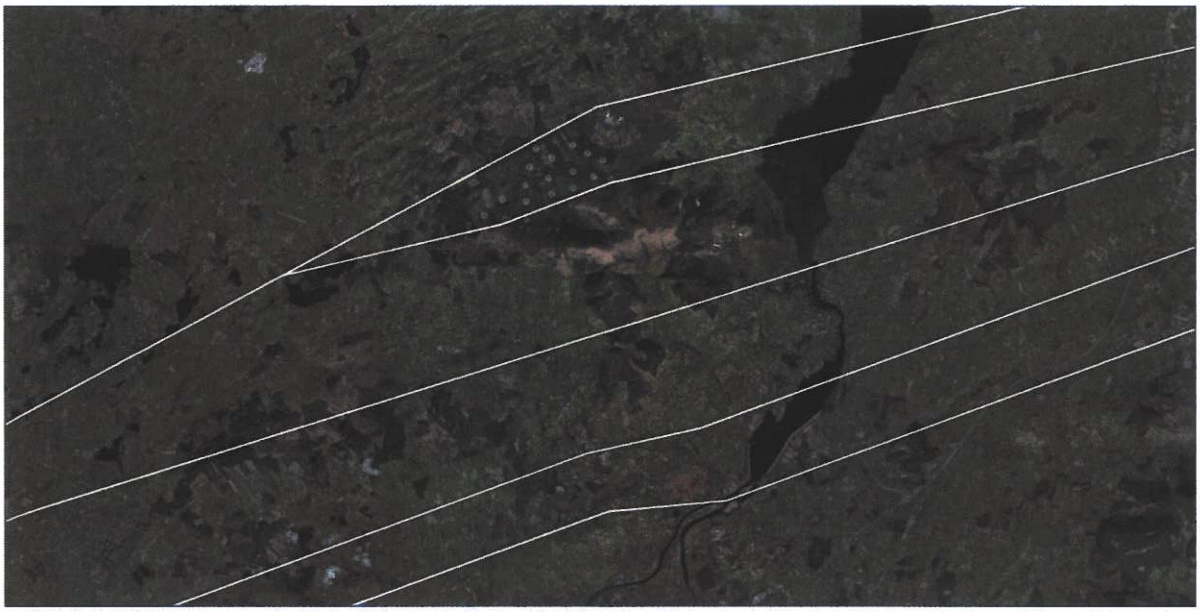

Figure 7: SID TOMTO3A

2.7. IAP – ILS Runway 24

The turbines fall within the Initial and Intermediate approach.

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	19

Table 20: ILS CAT I & II RWY 24 - Base Turn CAT A/B - General

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC applied (m)	MOCA (ft)
3	52°49'57.62"N	008°35'11.15"W	469.1	Sec.	589.5	261.8	2398.1
4	52°49'57.43"N	008°34'36.26"W	495.4	Sec.	1213.0	221.4	2351.7
2	52°50'01.40"N	008°35'45.07"W	415.7	Sec.	15.5	299.0	2344.9
1	52°49'46.55"N	008°36'09.71"W	414.6	Pri.	N/A	300.0	2344.4
5	52°50'16.56"N	008°35'16.21"W	412.4	Sec.	667.8	256.7	2195.5
6	52°50'14.90"N	008°34'37.98"W	416.3	Sec.	1337.8	213.3	2065.8
8	52°50'27.49"N	008°33'22.06"W	482.2	Sec.	2810.3	117.9	1969.0
9	52°50'30.78"N	008°34'38.78"W	394.5	Sec.	1465.2	205.1	1967.1
7	52°50'21.96"N	008°33'56.83"W	413.8	Sec.	2138.1	161.5	1887.2
10	52°50'37.01"N	008°34'01.35"W	406.9	Sec.	2191.3	158.0	1853.5
11	52°50'43.44"N	008°33'21.94"W	446.5	Sec.	2954.6	108.6	1821.0
12	52°50'38.35"N	008°32'49.28"W	479.9	Sec.	3494.4	73.6	1815.9
18	52°50'48.42"N	008°34'31.75"W	364.0	Sec.	1748.5	186.7	1806.7
17	52°50'57.29"N	008°33'56.11"W	389.6	Sec.	2466.0	140.2	1738.2
13	52°50'35.11"N	008°32'22.47"W	483.4	Sec.	3945.8	44.3	1731.4
14	52°50'54.44"N	008°32'34.41"W	480.2	Sec.	3904.0	47.0	1729.7
19	52°51'05.91"N	008°34'21.24"W	357.9	Sec.	2092.8	164.4	1713.7
15	52°51'01.35"N	008°32'58.49"W	447.5	Sec.	3534.2	71.0	1701.0
16	52°51'09.17"N	008°33'21.36"W	419.2	Sec.	3194.3	93.0	1680.7

Table 21: ILS CAT I & II RWY 24 - Base Turn CAT A/B - Checked Obstacles

As indicated in Table 21, there is no impact to the CAT A/B Base Turn.

Figure 8: 5614 - RWY 24 - Base Turn CAT AB – Windfarm Location

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	19

Table 22: 5614 - ILS CAT I & II RWY 24 - Base Turn CAT CD - General

Name	Latitude	Longitude	Alt. (m)	Trees (m)	Area	MOC (m)	MOCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	0.0	Primary	300.0	2609.6
13	52°50'35.11"N	008°32'22.47"W	483.4	0.0	Primary	300.0	2570.2
8	52°50'27.49"N	008°33'22.06"W	482.2	0.0	Primary	300.0	2566.5
14	52°50'54.44"N	008°32'34.41"W	480.2	0.0	Primary	300.0	2559.6
12	52°50'38.35"N	008°32'49.28"W	479.9	0.0	Primary	300.0	2558.7
3	52°49'57.62"N	008°35'11.15"W	469.1	0.0	Primary	300.0	2523.4
15	52°51'01.35"N	008°32'58.49"W	447.5	0.0	Primary	300.0	2452.3
11	52°50'43.44"N	008°33'21.94"W	446.5	0.0	Primary	300.0	2449.1
16	52°51'09.17"N	008°33'21.36"W	419.2	0.0	Primary	300.0	2359.7
6	52°50'14.90"N	008°34'37.98"W	416.3	0.0	Primary	300.0	2350.1
2	52°50'01.40"N	008°35'45.07"W	415.7	0.0	Primary	300.0	2348.2
1	52°49'46.55"N	008°36'09.71"W	414.6	0.0	Primary	300.0	2344.4
7	52°50'21.96"N	008°33'56.83"W	413.8	0.0	Primary	300.0	2341.7
5	52°50'16.56"N	008°35'16.21"W	412.4	0.0	Primary	300.0	2337.5
10	52°50'37.01"N	008°34'01.35"W	406.9	0.0	Primary	300.0	2319.4
9	52°50'30.78"N	008°34'38.78"W	394.5	0.0	Primary	300.0	2278.6
17	52°50'57.29"N	008°33'56.11"W	389.6	0.0	Primary	300.0	2262.5
18	52°50'48.42"N	008°34'31.75"W	364.0	0.0	Primary	300.0	2178.4
19	52°51'05.91"N	008°34'21.24"W	357.9	0.0	Primary	300.0	2158.6

Table 23: 5614 - ILS CAT I & II RWY 24 - Base Turn CAT CD - Checked Obstacles

In indicated in Table 23 there is no impact to the procedure.

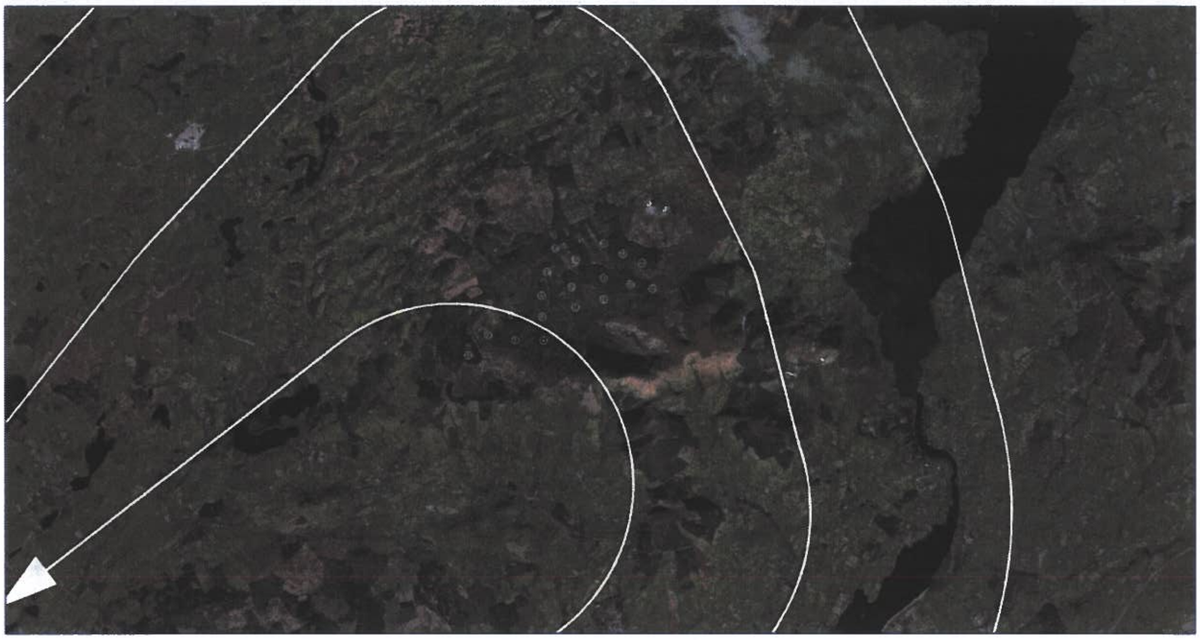

Figure 9: 5614 - RWY 24 - Base Turn CAT CD - OA

General	
Primary MOC	150 m
Obstacles	
Number of Checked Obstacles	15

Table 24: 5614 - ILS RWY 24 - Intermediate Approach - General

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	Primary	150.0	2117.5
8	52°50'27.49"N	008°33'22.06"W	482.2	Primary	150.0	2074.3
3	52°49'57.62"N	008°35'11.15"W	469.1	Primary	150.0	2031.3
15	52°51'01.35"N	008°32'58.49"W	447.5	Primary	150.0	1960.2
16	52°51'09.17"N	008°33'21.36"W	419.2	Primary	150.0	1867.6
6	52°50'14.90"N	008°34'37.98"W	416.3	Primary	150.0	1858.0
2	52°50'01.40"N	008°35'45.07"W	415.7	Primary	150.0	1856.1
1	52°49'46.55"N	008°36'09.71"W	414.6	Primary	150.0	1852.3
7	52°50'21.96"N	008°33'56.83"W	413.8	Primary	150.0	1849.6
5	52°50'16.56"N	008°35'16.21"W	412.4	Primary	150.0	1845.3
10	52°50'37.01"N	008°34'01.35"W	406.9	Primary	150.0	1827.2
9	52°50'30.78"N	008°34'38.78"W	394.5	Primary	150.0	1786.4
17	52°50'57.29"N	008°33'56.11"W	389.6	Primary	150.0	1770.3
18	52°50'48.42"N	008°34'31.75"W	364.0	Primary	150.0	1686.3
19	52°51'05.91"N	008°34'21.24"W	357.9	Primary	150.0	1666.5

Table 25: 5614 – ILS RWY 24 - Intermediate Approach - Checked Obstacles

As indicated in Table 25, no turbines impact the Intermediate Approach segments.

Figure 10: 5614 - ILS CAT I & II RWY 24 - Intermediate Approach – Windfarm Location

2.8. IAP – LOC Runway 24

The turbines fall within the initial and intermediate approach for the procedure, The initial approach via base turn is common to the ILS RWY 25 procedures and is included in section 2.7, turbines 3,4,8,11,12,13,14 and 15 impact the CAT C/D base turn initial approach procedure.

General	
Primary MOC	150 m
Obstacles	
Number of Checked Obstacles	15

Table 26: 5614 - LOC RWY 24 - Intermediate Approach - General

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	Primary	150.0	2117.5
8	52°50'27.49"N	008°33'22.06"W	482.2	Primary	150.0	2074.3
3	52°49'57.62"N	008°35'11.15"W	469.1	Primary	150.0	2031.3
15	52°51'01.35"N	008°32'58.49"W	447.5	Primary	150.0	1960.2
16	52°51'09.17"N	008°33'21.36"W	419.2	Primary	150.0	1867.6
6	52°50'14.90"N	008°34'37.98"W	416.3	Primary	150.0	1858.0
2	52°50'01.40"N	008°35'45.07"W	415.7	Primary	150.0	1856.1
1	52°49'46.55"N	008°36'09.71"W	414.6	Primary	150.0	1852.3
7	52°50'21.96"N	008°33'56.83"W	413.8	Primary	150.0	1849.6
5	52°50'16.56"N	008°35'16.21"W	412.4	Primary	150.0	1845.3
10	52°50'37.01"N	008°34'01.35"W	406.9	Primary	150.0	1827.2
9	52°50'30.78"N	008°34'38.78"W	394.5	Primary	150.0	1786.4
17	52°50'57.29"N	008°33'56.11"W	389.6	Primary	150.0	1770.3
18	52°50'48.42"N	008°34'31.75"W	364.0	Primary	150.0	1686.3
19	52°51'05.91"N	008°34'21.24"W	357.9	Primary	150.0	1666.5

Table 27: 5614 – LOC RWY 24 - Intermediate Approach - Checked Obstacles

As indicated in Table 27, no turbines Impact the Intermediate Approach segment.

Figure 11: 5614 - LOC RWY 24 - Intermediate Approach - Obstacle Location

2.9. IAP – VOR Runway 24

The Turbines fall within the initial approach, base turns for CAT A/B and C/D and intermediate approaches for the procedure.

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	19

Table 28: 5614 - VOR RWY 24 - Base Turn CAT AB - General

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC applied (m)	MOCA (ft)
3	52°49'57.62"N	008°35'11.15"W	469.1	Secondary	589.5	261.8	2398.1
4	52°49'57.43"N	008°34'36.26"W	495.4	Secondary	1213.0	221.4	2351.7
2	52°50'01.40"N	008°35'45.07"W	415.7	Secondary	15.5	299.0	2344.9
1	52°49'46.55"N	008°36'09.71"W	414.6	Primary	N/A	300.0	2344.4
5	52°50'16.56"N	008°35'16.21"W	412.4	Secondary	667.8	256.7	2195.5
6	52°50'14.90"N	008°34'37.98"W	416.3	Secondary	1337.8	213.3	2065.8
8	52°50'27.49"N	008°33'22.06"W	482.2	Secondary	2810.3	117.9	1969.0
9	52°50'30.78"N	008°34'38.78"W	394.5	Secondary	1465.2	205.1	1967.1
7	52°50'21.96"N	008°33'56.83"W	413.8	Secondary	2138.1	161.5	1887.2
10	52°50'37.01"N	008°34'01.35"W	406.9	Secondary	2191.3	158.0	1853.5
11	52°50'43.44"N	008°33'21.94"W	446.5	Secondary	2954.6	108.6	1821.0
12	52°50'38.35"N	008°32'49.28"W	479.9	Secondary	3494.4	73.6	1815.9

18	52°50'48.42"N	008°34'31.75"W	364.0	Secondary	1748.5	186.7	1806.7
17	52°50'57.29"N	008°33'56.11"W	389.6	Secondary	2466.0	140.2	1738.2
13	52°50'35.11"N	008°32'22.47"W	483.4	Secondary	3945.8	44.3	1731.4
14	52°50'54.44"N	008°32'34.41"W	480.2	Secondary	3904.0	47.0	1729.7
19	52°51'05.91"N	008°34'21.24"W	357.9	Secondary	2092.8	164.4	1713.7
15	52°51'01.35"N	008°32'58.49"W	447.5	Secondary	3534.2	71.0	1701.0
16	52°51'09.17"N	008°33'21.36"W	419.2	Secondary	3194.3	93.0	1680.7

Table 29: 5614 - VOR RWY 24 - Base Turn CAT AB - Checked Obstacles

As indicated in Table 29, there is no impact to the initial approach via base turn for CAT A/B aircraft.

Figure 12: 5614 - RWY 24 - Base Turn CAT AB

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	19

Table 30: 5614 - VOR RWY 24 - Base Turn CAT CD - General

Name	Latitude	Longitude	Alt. (m)	Trees (m)	Area	MOC applied (m)	OCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	0.0	Primary	300.0	2609.6
13	52°50'35.11"N	008°32'22.47"W	483.4	0.0	Primary	300.0	2570.2
8	52°50'27.49"N	008°33'22.06"W	482.2	0.0	Primary	300.0	2566.5
14	52°50'54.44"N	008°32'34.41"W	480.2	0.0	Primary	300.0	2559.6
12	52°50'38.35"N	008°32'49.28"W	479.9	0.0	Primary	300.0	2558.7
3	52°49'57.62"N	008°35'11.15"W	469.1	0.0	Primary	300.0	2523.4
15	52°51'01.35"N	008°32'58.49"W	447.5	0.0	Primary	300.0	2452.3
11	52°50'43.44"N	008°33'21.94"W	446.5	0.0	Primary	300.0	2449.1
16	52°51'09.17"N	008°33'21.36"W	419.2	0.0	Primary	300.0	2359.7
6	52°50'14.90"N	008°34'37.98"W	416.3	0.0	Primary	300.0	2350.1

2	52°50'01.40"N	008°35'45.07"W	415.7	0.0	Primary	300.0	2348.2
1	52°49'46.55"N	008°36'09.71"W	414.6	0.0	Primary	300.0	2344.4
7	52°50'21.96"N	008°33'56.83"W	413.8	0.0	Primary	300.0	2341.7
5	52°50'16.56"N	008°35'16.21"W	412.4	0.0	Primary	300.0	2337.5
10	52°50'37.01"N	008°34'01.35"W	406.9	0.0	Primary	300.0	2319.4
9	52°50'30.78"N	008°34'38.78"W	394.5	0.0	Primary	300.0	2278.6
17	52°50'57.29"N	008°33'56.11"W	389.6	0.0	Primary	300.0	2262.5
18	52°50'48.42"N	008°34'31.75"W	364.0	0.0	Primary	300.0	2178.4
19	52°51'05.91"N	008°34'21.24"W	357.9	0.0	Primary	300.0	2158.6

Table 31: 5614 – VOR RWY 24 - Base Turn CAT CD - Checked Obstacles

As indicated in Table 31, There is no impact to the procedure.

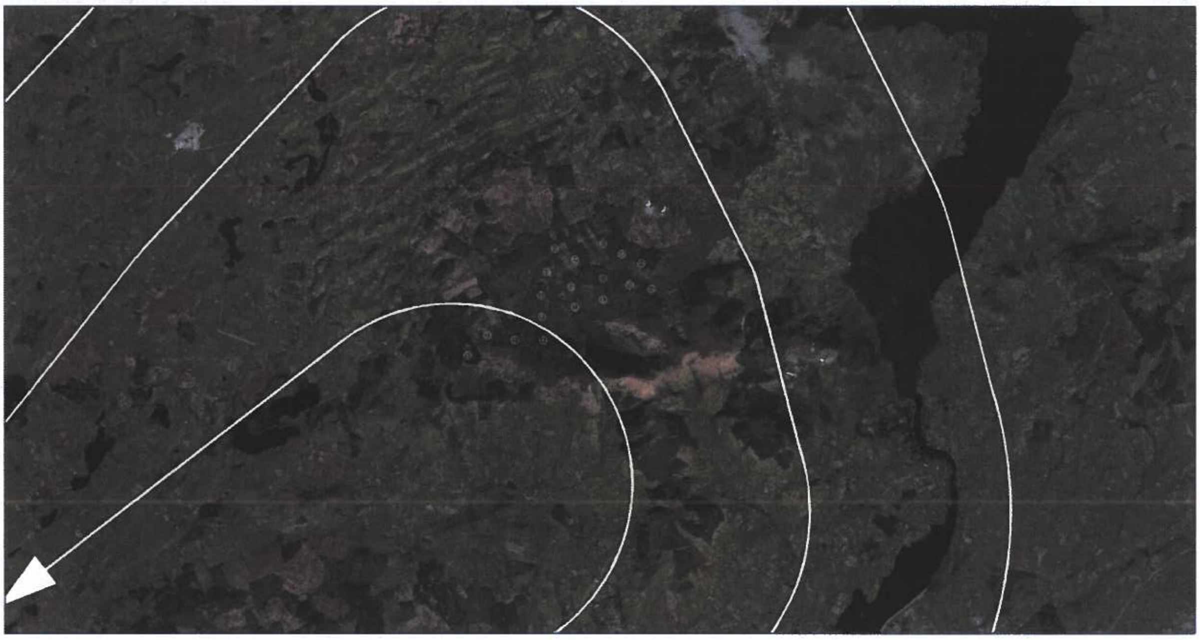

Figure 13: 5614 - RWY 24 - Base Turn CAT CD – Windfarm Location

General	
Primary MOC	150 m
Obstacles	
Number of Checked Obstacles	15

Table 32: 5614 - VOR RWY 24 - Intermediate Approach - General

Name	Latitude	Longitude	Alt. (m)	Area	MOC applied (m)	MOCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	Primary	150.0	2117.5
8	52°50'27.49"N	008°33'22.06"W	482.2	Primary	150.0	2074.3
3	52°49'57.62"N	008°35'11.15"W	469.1	Primary	150.0	2031.3
15	52°51'01.35"N	008°32'58.49"W	447.5	Primary	150.0	1960.2
16	52°51'09.17"N	008°33'21.36"W	419.2	Primary	150.0	1867.6
6	52°50'14.90"N	008°34'37.98"W	416.3	Primary	150.0	1858.0
2	52°50'01.40"N	008°35'45.07"W	415.7	Primary	150.0	1856.1
1	52°49'46.55"N	008°36'09.71"W	414.6	Primary	150.0	1852.3

7	52°50'21.96"N	008°33'56.83"W	413.8	Primary	150.0	1849.6
5	52°50'16.56"N	008°35'16.21"W	412.4	Primary	150.0	1845.3
10	52°50'37.01"N	008°34'01.35"W	406.9	Primary	150.0	1827.2
9	52°50'30.78"N	008°34'38.78"W	394.5	Primary	150.0	1786.4
17	52°50'57.29"N	008°33'56.11"W	389.6	Primary	150.0	1770.3
18	52°50'48.42"N	008°34'31.75"W	364.0	Primary	150.0	1686.3
19	52°51'05.91"N	008°34'21.24"W	357.9	Primary	150.0	1666.5

Table 33: 5614 - VOR RWY 24 - Intermediate Approach - Checked Obstacles

As indicated in Table 33 there is no impact to the Intermediate Approach.

Figure 14: 5614 - VOR RWY 24 - Intermediate Approach - OA

2.10. Common VOR/DME Holding Procedure (DERAG)

The windfarm falls into the protection areas for the hold.

VOR/DME Position	
ID	DVOR SHA
Latitude	52°43'15.60"N
Longitude	008°53'06.80"W
Altitude	60.96 m (200 ft)
Parameters	
Used For	Holding
Type	Towards the Station
IAS	220 kts
TAS	280.6 kts
Altitude	14000 ft

ISA	15 °C
Wind	74.6 kts (ICAO)
Holding DME	14 nm
Limiting DME	20 nm
MOC	300 m
Reciprocal Entry Radial	038.3 °
Entry Areas	
Sector 1	Yes
Sector 2	Yes
Reciprocal Entry	Yes
Orientation	
In-bound Track	232.26 °
Turns	Right
Obstacles	
Number of Checked Obstacles	19

Table 34: VOR DME HOLD DERAG - General

Name	Latitude	Longitude	Alt. (m)	Surface	MOC applied (m)	MOCA (ft)	Ctrl?
4	52°49'57.43"N	008°34'36.26"W	495.4	Primary Area	300.0	2609.6	No
13	52°50'35.11"N	008°32'22.47"W	483.4	Primary Area	300.0	2570.2	No
8	52°50'27.49"N	008°33'22.06"W	482.2	Primary Area	300.0	2566.5	No
14	52°50'54.44"N	008°32'34.41"W	480.2	Primary Area	300.0	2559.6	No
12	52°50'38.35"N	008°32'49.28"W	479.9	Primary Area	300.0	2558.7	No
3	52°49'57.62"N	008°35'11.15"W	469.1	Primary Area	300.0	2523.4	No
15	52°51'01.35"N	008°32'58.49"W	447.5	Primary Area	300.0	2452.3	No
11	52°50'43.44"N	008°33'21.94"W	446.5	Primary Area	300.0	2449.1	No
16	52°51'09.17"N	008°33'21.36"W	419.2	Primary Area	300.0	2359.7	No
6	52°50'14.90"N	008°34'37.98"W	416.3	Primary Area	300.0	2350.1	No
2	52°50'01.40"N	008°35'45.07"W	415.7	Primary Area	300.0	2348.2	No
1	52°49'46.55"N	008°36'09.71"W	414.6	Primary Area	300.0	2344.4	No
7	52°50'21.96"N	008°33'56.83"W	413.8	Primary Area	300.0	2341.7	No
5	52°50'16.56"N	008°35'16.21"W	412.4	Primary Area	300.0	2337.5	No
10	52°50'37.01"N	008°34'01.35"W	406.9	Primary Area	300.0	2319.4	No
9	52°50'30.78"N	008°34'38.78"W	394.5	Primary Area	300.0	2278.6	No
17	52°50'57.29"N	008°33'56.11"W	389.6	Primary Area	300.0	2262.5	No
18	52°50'48.42"N	008°34'31.75"W	364.0	Primary Area	300.0	2178.4	No
19	52°51'05.91"N	008°34'21.24"W	357.9	Primary Area	300.0	2158.6	No

Table 35: VOR DME HOLD DERAG - Checked Obstacles - All

Name	Latitude	Longitude	Alt. (m)	MOC applied (m)	MOCA (ft)	Ctrl?
4	52°49'57.43"N	008°34'36.26"W	495.4	300.0	2609.6	No
13	52°50'35.11"N	008°32'22.47"W	483.4	300.0	2570.2	No
8	52°50'27.49"N	008°33'22.06"W	482.2	300.0	2566.5	No
14	52°50'54.44"N	008°32'34.41"W	480.2	300.0	2559.6	No
12	52°50'38.35"N	008°32'49.28"W	479.9	300.0	2558.7	No
3	52°49'57.62"N	008°35'11.15"W	469.1	300.0	2523.4	No
15	52°51'01.35"N	008°32'58.49"W	447.5	300.0	2452.3	No
11	52°50'43.44"N	008°33'21.94"W	446.5	300.0	2449.1	No
16	52°51'09.17"N	008°33'21.36"W	419.2	300.0	2359.7	No
6	52°50'14.90"N	008°34'37.98"W	416.3	300.0	2350.1	No
2	52°50'01.40"N	008°35'45.07"W	415.7	300.0	2348.2	No
1	52°49'46.55"N	008°36'09.71"W	414.6	300.0	2344.4	No
7	52°50'21.96"N	008°33'56.83"W	413.8	300.0	2341.7	No
5	52°50'16.56"N	008°35'16.21"W	412.4	300.0	2337.5	No
10	52°50'37.01"N	008°34'01.35"W	406.9	300.0	2319.4	No
9	52°50'30.78"N	008°34'38.78"W	394.5	300.0	2278.6	No
17	52°50'57.29"N	008°33'56.11"W	389.6	300.0	2262.5	No
18	52°50'48.42"N	008°34'31.75"W	364.0	300.0	2178.4	No
19	52°51'05.91"N	008°34'21.24"W	357.9	300.0	2158.6	No

Table 36: VOR DME HOLD DERAG - Checked Obstacles - Primary Area

There is no impact to the holding procedure.

Figure 15: 5614 - Hold (Conv) - DERAG

2.11. RNAV 1 STARs Runway 24

The windfarm falls into the protection areas for the TIRPUR 2D and KURUM 2D STARs, including the holding procedure at the waypoint DERAG the end of the STAR.

2.11.1. Arrivals TIRPUR 2D and KURUM 2D

General	
Primary MOC	300 m
Obstacles	
Number of Checked Obstacles	19

Table 37: 5614 - STARs 2D - OA - General

Name	Latitude	Longitude	Alt. (m)	Area	Dist. in (m)	MOC applied (m)	OCA (ft)
4	52°49'57.43"N	008°34'36.26"W	495.4	Primary	N/A	300.0	2609.6
13	52°50'35.11"N	008°32'22.47"W	483.4	Primary	N/A	300.0	2570.2
8	52°50'27.49"N	008°33'22.06"W	482.2	Primary	N/A	300.0	2566.5
14	52°50'54.44"N	008°32'34.41"W	480.2	Primary	N/A	300.0	2559.6
12	52°50'38.35"N	008°32'49.28"W	479.9	Primary	N/A	300.0	2558.7
15	52°51'01.35"N	008°32'58.49"W	447.5	Primary	N/A	300.0	2452.3
11	52°50'43.44"N	008°33'21.94"W	446.5	Primary	N/A	300.0	2449.1
3	52°49'57.62"N	008°35'11.15"W	469.1	Secondary	285.9	263.0	2401.9
16	52°51'09.17"N	008°33'21.36"W	419.2	Primary	N/A	300.0	2359.7
6	52°50'14.90"N	008°34'37.98"W	416.3	Primary	N/A	300.0	2350.1
7	52°50'21.96"N	008°33'56.83"W	413.8	Primary	N/A	300.0	2341.7
5	52°50'16.56"N	008°35'16.21"W	412.4	Primary	N/A	300.0	2337.5
10	52°50'37.01"N	008°34'01.35"W	406.9	Primary	N/A	300.0	2319.4
9	52°50'30.78"N	008°34'38.78"W	394.5	Primary	N/A	300.0	2278.6
17	52°50'57.29"N	008°33'56.11"W	389.6	Primary	N/A	300.0	2262.5
18	52°50'48.42"N	008°34'31.75"W	364.0	Primary	N/A	300.0	2178.4
19	52°51'05.91"N	008°34'21.24"W	357.9	Primary	N/A	300.0	2158.6
2	52°50'01.40"N	008°35'45.07"W	415.7	Secondary	647.9	216.0	2072.7
1	52°49'46.55"N	008°36'09.71"W	414.6	Secondary	1298.3	131.8	1792.4

Table 38: 5614 - STARs 2D - OA - Checked Obstacles

As indicated in Table 38, there is no impact to the arrival procedures.

Figure 16: STAR - TIPUR 2D / KURUM 2D

2.11.2. RNAV Hold DERAG

Waypoint	
ID	DERAG
Latitude	52°51'46.60"N
Longitude	008°34'49.40"W
ATT	0.8 nm
XTT	1 nm
Parameters	
Holding Functionality Required	No
Out-bound Leg Limitation	Distance from Waypoint
IAS	220 kts
TAS	280.6 kts
Altitude	14000 ft
ISA	15 °C
Distance	8.5 nm
Wind	74.6 kts (ICAO)
MOC	300 m
Cat. H (linear MOC reduction up to 2 NM)	No
Entry Areas	
Sector 1	Yes
Sector 2	Yes
Sector 3	Yes
Orientation	
In-bound Track	232.35 °
Turns	Right
Obstacles	
Number of Checked Obstacles	19

Table 39: 5614 - RNAV Hold - DERAG - General

Name	Latitude	Longitude	Alt. (m)	Surface	MOC (m)	MOCA (ft)	Ctrl?
4	52°49'57.43"N	008°34'36.26"W	495.4	Primary Area	300.0	2609.6	No
13	52°50'35.11"N	008°32'22.47"W	483.4	Primary Area	300.0	2570.2	No
8	52°50'27.49"N	008°33'22.06"W	482.2	Primary Area	300.0	2566.5	No
14	52°50'54.44"N	008°32'34.41"W	480.2	Primary Area	300.0	2559.6	No
12	52°50'38.35"N	008°32'49.28"W	479.9	Primary Area	300.0	2558.7	No
3	52°49'57.62"N	008°35'11.15"W	469.1	Primary Area	300.0	2523.4	No
15	52°51'01.35"N	008°32'58.49"W	447.5	Primary Area	300.0	2452.3	No
11	52°50'43.44"N	008°33'21.94"W	446.5	Primary Area	300.0	2449.1	No
16	52°51'09.17"N	008°33'21.36"W	419.2	Primary Area	300.0	2359.7	No
6	52°50'14.90"N	008°34'37.98"W	416.3	Primary Area	300.0	2350.1	No
2	52°50'01.40"N	008°35'45.07"W	415.7	Primary Area	300.0	2348.2	No
1	52°49'46.55"N	008°36'09.71"W	414.6	Primary Area	300.0	2344.4	No
7	52°50'21.96"N	008°33'56.83"W	413.8	Primary Area	300.0	2341.7	No
5	52°50'16.56"N	008°35'16.21"W	412.4	Primary Area	300.0	2337.5	No
10	52°50'37.01"N	008°34'01.35"W	406.9	Primary Area	300.0	2319.4	No
9	52°50'30.78"N	008°34'38.78"W	394.5	Primary Area	300.0	2278.6	No
17	52°50'57.29"N	008°33'56.11"W	389.6	Primary Area	300.0	2262.5	No
18	52°50'48.42"N	008°34'31.75"W	364.0	Primary Area	300.0	2178.4	No
19	52°51'05.91"N	008°34'21.24"W	357.9	Primary Area	300.0	2158.6	No

Table 40: 5614 - RNAV Hold - DERAG - Checked Obstacles – All

As indicated in Table 40, there is no impact to the holding procedure.

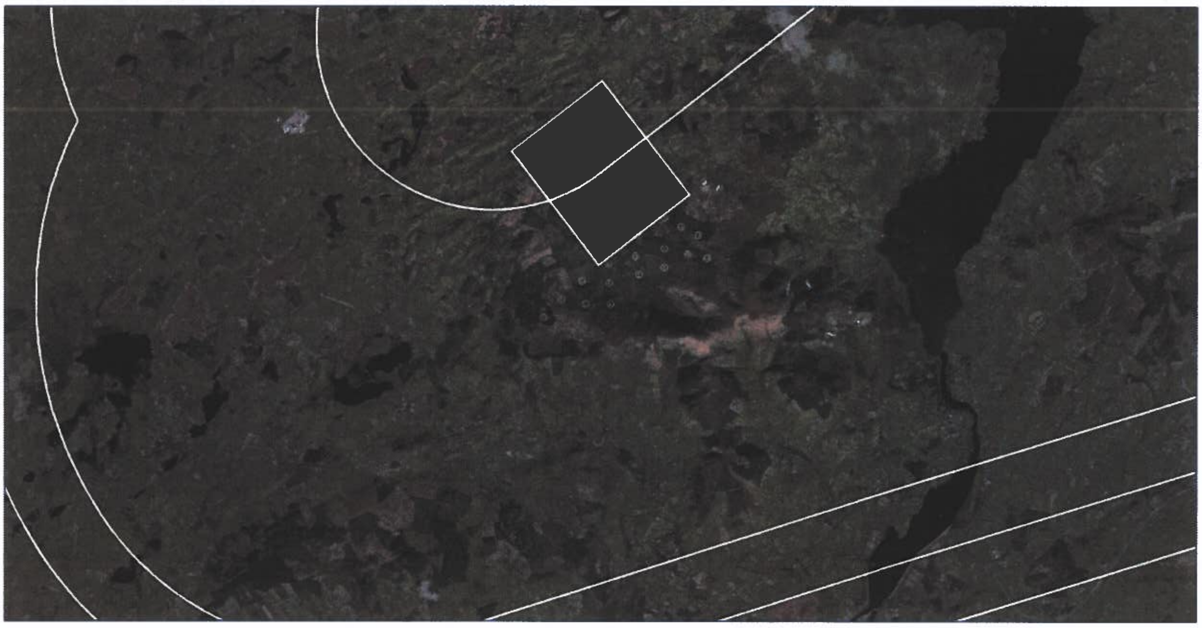

Figure 17: 5614 - RNAV Hold - DERAG

2.12. Unassessed Procedures

The Crane lies out with the protection areas of the following procedures;

- RNAV STARs RWY 06
- RNAV SIDs RWY 24

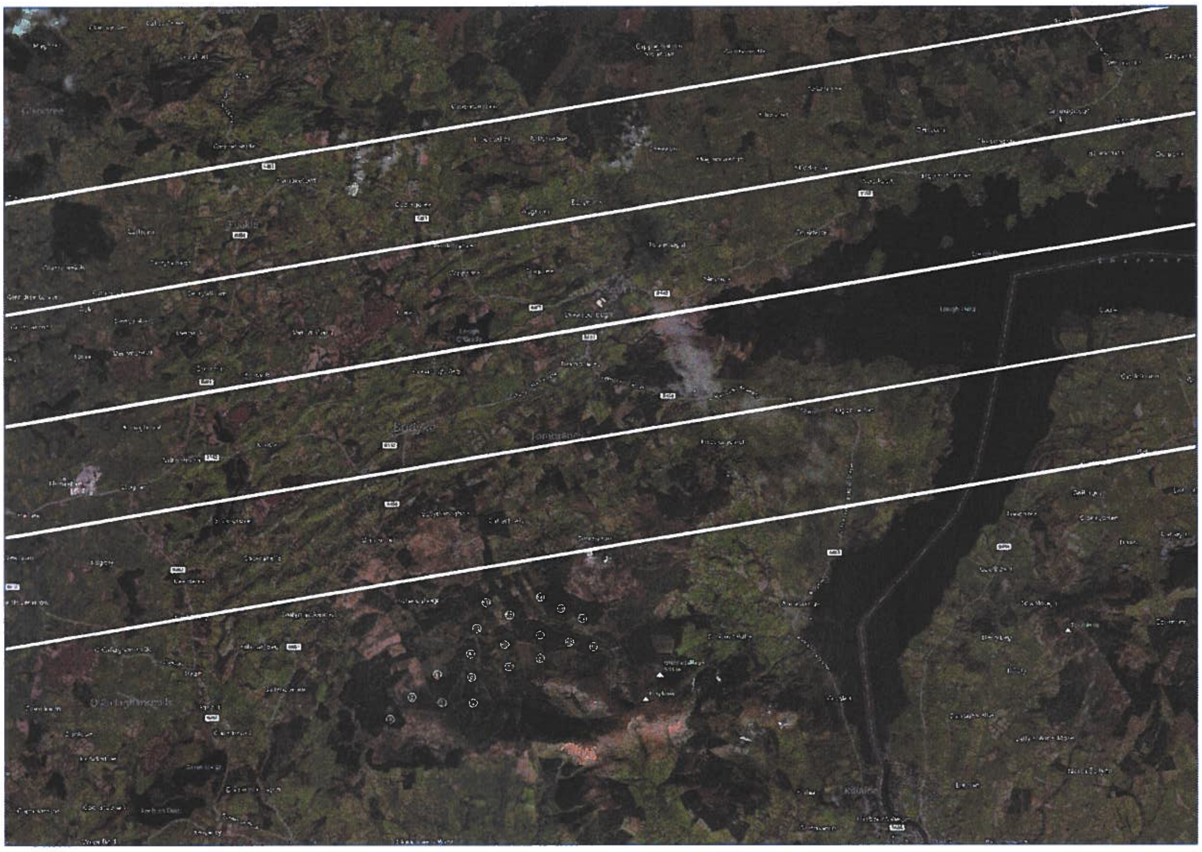

Figure 18: STAR RWY 06 - DIGAN2E

APD Validation Report

We hereby declare that the procedure(s) as detailed COMPLY / ~~DO NOT COMPLY~~ with the design process requirements.

Designation	Name	Signature and Date
Approved Procedure Designer	Mitchell Nunes	Dated: 28 April 2021
Independent Approved Procedure Designer	Ondrej Fischer	Digitally signed by Ondrej. Fischer DN: cn=Ondrej. Fischer, o=ASAP s.r.o., ou, email=ondrej.fischer@asap.sk, c=SK Date: 2021.05.08 12:45:39 +02'00'

IAPD - comment:

Note that all of the current procedures may shortly become obsolete as new SIDs, ILS, VOR & RNP procedures have been submitted to the IAA for both runways. These new procedures could be a safety concern if this structure is not taken into account prior to publication.

The new submitted procedures should be available from the IAA upon request.

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Appendix 4

Letter from the Irish Aviation Authority

Irish Aviation Authority
The Times Building
11–12 D'Olier Street
Dublin 2, D02 T449
Ireland

Údarás Eitlíochta na hÉireann
Foirgneamh na hAmanna
11–12 Sráid D'Olier
Baile Átha Cliath 2, D02 T449,
Éire

T: +353 1 671 8655
F: +353 1 679 2934
www.iaa.ie

Operations
Directorate

An Stiúrthóireacht
Oibríochtaí

Malachy Walsh and Partners
Reen Point
Blennerville
Tralee
Co.Kerry

Ref. Pre-planning of Carrownagowan/Moylussa Clare East Wind Farm
(Updated correspondence following Meeting with Stakeholders 19th May 2021)

Dear Helen and to whom it may concern,

For the purposes of the referenced planning application process and in my capacity as IAA Air Navigation Service Provider (ANSP) Manager Airspace and Navigation, I am happy to revisit our position regarding this process, following our stakeholder meeting of 19th May 2021.

In my previous correspondence, I indicated that there were potential issues to be considered that might in turn impact on the acceptable turbine elevations as proposed in this application.

Following our meeting, I am satisfied that the issues highlighted can be appropriately managed, if and when planning permission is granted.

Specifically, to update my previously supplied comments:

1. '*The proposed Carrownagowan Wind Farm will therefore have no adverse effect on flight inspection procedures and profiles associated with the Runway 24 ILS*', but in 6.1.1 Horizontal Obstacle Clearances '*For a centreline approach profile, the flight inspection aircraft will be approximately 0.7 NM laterally from the nearest wind turbine (T19) at a point on the extended runway centreline closest to the wind farm.* ***This distance is less than the minimum clearance required from any object, as defined in FIP 23'***

   ANSP Comment Updated 19th May 2021: Flight Calibration Services Ltd (FCSL) confirmation, as an approved flight calibration service provider for Ireland, that they do not have a concern over this issue, is accepted by the IAA ANSP.
   Proposal: If and when planning permission is granted, I propose a re-engagement with stakeholders to review the timetable of construction, in order to ensure that this issue is considered in the context of planned calibration flight activity (for Shannon Airport).

2. **ANSP Comment Updated 19th May 2021:** The findings of the Technical Safeguarding Assessment are accepted as being that the proposal does not impact Surveillance (Radar) services provided by the ANSP. ***No further action required***.

3. **ANSP Comment Updated 19th May 2021:** The findings of the interim Instrument Flight Procedures (IFP) Safeguarding Report are accepted.
   Proposal: If and when planning permission is granted, I propose a re-engagement with Cyrrus and other affected stakeholders to consider the following:
   - An update to this IFP assessment to include an assessment of the Shannon Surveillance Minimum Altitude Chart and the non-standard (omni-directional) departures procedures
   - Assessment of any newly developed IFPs, currently in planning, to take account of the planned location of wind turbines associated with this proposal

On the basis of my updated comments and proposals, I wish to confirm that the IAA ANSP has no objections in regard to the planning process for the proposed Carrownagowan/ Moylussa Clare East Wind Farm.

I may be contacted for any queries or clarifications required as follows:

Email: cathal.maccriostail@iaa.ie

Mobile: +353 86 0527130

Yours Sincerely,

____

Cathal Mac Criostail
IAA Manager Airspace & Navigation

19th May 2021

Appendix F – Radar Technical Assessment Requirements & Mitigation Measures

Oatfield Wind Farm

Radar Technical Assessment Requirements & Mitigation Measures

Document Number: 001/VH202104

Author: DMG\PT

Approved for Release: Rev 1.0 DMG\PT **Date:** 14/11/23

APPENDIX E - EuroControl Guidelines – Assessment for PSR and SSR

E1. Introduction - Radar Surveillance Systems Safeguarding

When safeguarding aviation surveillance systems from the possible impacts of wind farms, the Irish Aviation Authority (IAA) utilizes guidance material prepared by the European Organization for the Safety of Air Navigation (EUROCONTROL), *'How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors'.* In the EUROCONTROL document the following four zones are defined:

Zone 1: Safeguarding Zone (PSR and SSR).

An initial restrictive or safeguarding region that surrounds the surveillance sensor. No developments shall be agreed to within this area (500metres).

Zone 2: Detailed Assessment Zone (PSR and SSR).

Following the safeguarded region is an area where surveillance data providers would reject planning applications unless they were supported by a detailed technical assessment provided by the applicant and the results of which are found to be acceptable to the surveillance provider.

Zone 3: Simple Assessment Zone (PSR only).

Beyond the detailed assessment zone is a region within which a simple assessment of PSR performance should be sufficient to enable the surveillance data provider to assess the application.

Zone 4: Accepted Zone (PSR 15km and SSR 16km).

Beyond the simple assessment zone are areas within which no assessments may be required and within which air navigation service providers would be unlikely to raise objections to wind farms on the basis of impact on surveillance services.

The findings made from the field and desktop surveys have found that the proposed development is situated in Assessment Zone 2 of the SSR at Woodcock Hill, which requires a detailed engineering assessment to be carried out.

When assessing the possible impact of wind farms, the IAA refer to the EUROCONTROL document *"Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors*", specifically Section 4.4 of the guidelines. A summary of this section of the Eurocontrol guidelines is provided below.

1.1.1 Radar Surveillance Assessment Methodology

The Irish Aviation Authority provides guidelines on the assessment process under the document " *Irish Aviation Authority Air Navigation Services Policy on consultation by Planning*

Authorities In relation to protection of ATM Systems & Facilities from Buildings and Windfarms in or close to Restricted Area "

The assessment approach recommended by the IAA consists of a two-step approach as shown in Figure 1, as follows

> *The IAA applies a two-step approach for the consideration of proposed developments that may adversely affect Communication, Navigation and Surveillance facilities. The approach is based upon the application of the International Civil Aviation authority (ICAO) document ICAO Eur Doc 015: European Guidance Material on Managing Building Restricted Areas (BRAs).*
>
> *Where the IAA considers that a planning proposal/planning query does not infringe the BRA surfaces as described in ICAO EUR DOC 015 then the Planning Authority is advised that the IAA has no objections to the proposal. Where the IAA considers that BRA surfaces are infringed then the IAA will advise that further expert engineering analysis is required. This analysis is the responsibility of the planning applicant or developer.*

The initial step, Step 1, is to assess whether there is an infringement in the Building Restricted Area surfaces and this assessment is conducted based on the EuroControl Guidelines using the SSR Zones Assessment process. In the event that there is no infringement on the BRA surfaces, as described ICAO EUR DOC 015 then Step 2 is skipped and the IAA would have no objections to the proposed wind turbine development.

Where an infringement has been identified in Step 1 then this would be referred to the IAA and the assessment and analysis of Step 1 are provided for further review by IAA. The IAA guidelines on Step 2 are as follows …

> *If the appropriate engineering experts consider that BRA surfaces are infringed then the appropriate engineering expert's within the IAA will advise the Corporate Affairs Department that further expert engineering analysis is required. This analysis is the responsibility of the developer.*
>
> *If it is shown from expert analysis that the interference effects are within acceptable limits as decided by the appropriate engineering experts within the IAA (following review of evidence provided) then the planning authority is advised that the IAA has no objection to the application.*
>
> *If the analysis shows that the interference affects are outside acceptable limits then the planning authority is advised that the IAA will object and outline the basis for the objection.*
>
> *Following rejection of the building proposal it may be possible to modify and re-submit the planning proposal. A modified proposal will be subjected to the full review processes as described above.*

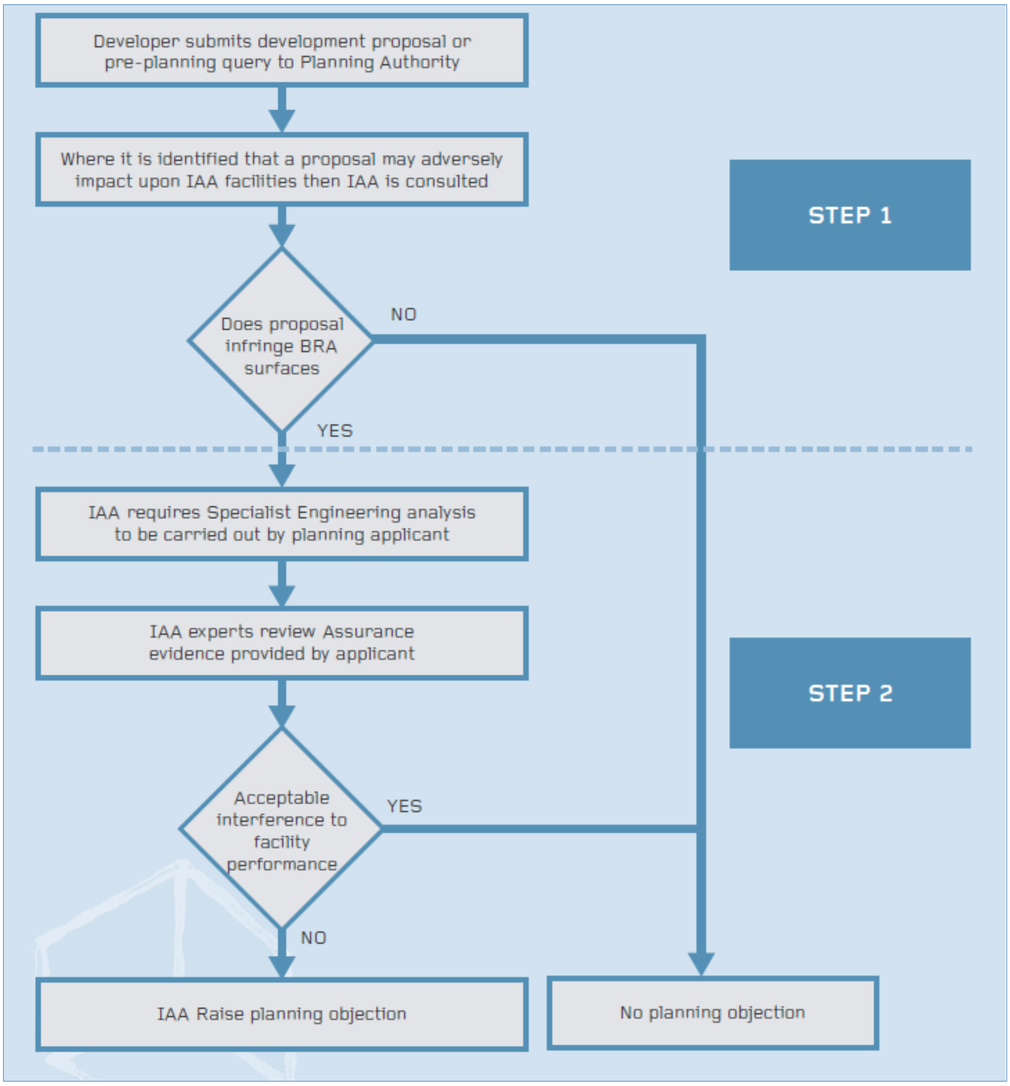


Figure 1. IAA Two-Step Process.

E1.1 EuroControl Guidelines – Assessment for PSR and SSR

The Eurocontrol guidelines state that in the case of a wind farm a detailed impact assessment should be made for each induvial turbine and for the cumulative impact of all of the wind farm turbines. The assessment is described as a complex process as it requires identifying a large number of cases corresponding to different parameter values each of them corresponding to different external conditions including:

- Wind Speed
- Wind Direction
- Topography
- Morphology

E1.1.1 Eurocontrol Guidelines – SSR Assessment

In this section of the Eurocontrol Guidelines, SSR Probability of detection and probability of Mode A and Mode C code detection is described.

Wind turbines in close proximity to an SSR system have the potential to impact the SSR's ability to detect aircraft close to the wind farm. This can occur when an aircraft is located in the shadow region behind a wind turbine (relative to the SSR). Uplink and downlink transmissions between the aircraft and the SSR can be impacted. The detailed engineering assessment must address this topic and must predict possible impacts in 3 dimensions (3D).

The figure below illustrates an aircraft in the shadow zone of a wind turbine. The turbine has the potential to obstruct and therefore impact the radar signals to and from the SSR radar system. When this occurs, the SSR may not be able to accurately detect the aircraft in the shadow zone, causing a serious safety risk.

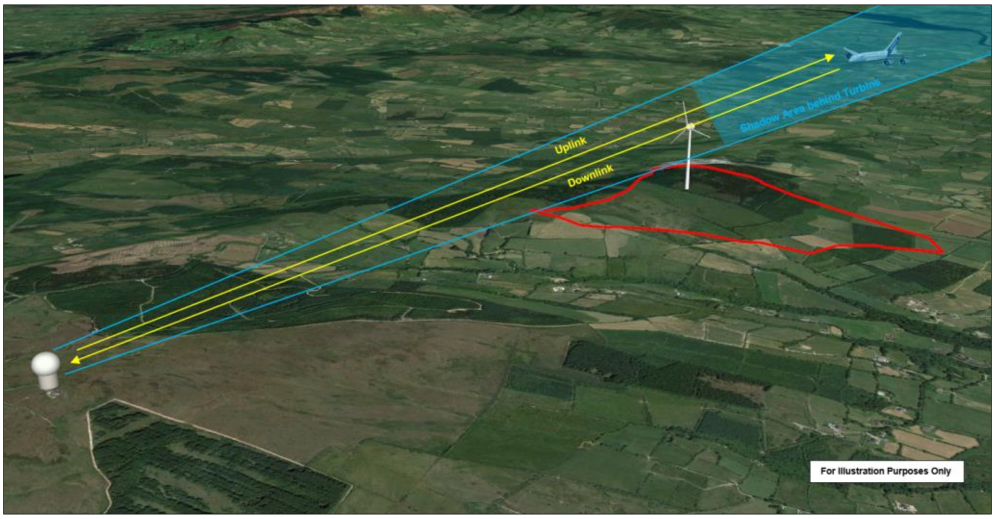


Figure 2. Shadow Area behind Wind Turbine

E1.1.2 Eurocontrol Guidelines – SSR Assessment

In this section of the Eurocontrol Guidelines, SSR false target reporting is described.

SSR Systems map their surroundings and identify static reflectors, such as buildings, towers; however, as wind turbines are not static, SSR systems cannot effectively map wind turbines. As a result, the SSR can report false targets due to reflections caused by wind turbines on the uplink signal, or the downlink signal and/or of both. The detailed engineering assessment must address this topic and must predict where false targets may occur.

The figure below illustrates how a turbine could cause false target reporting. As the proposed turbines are relatively near the SSR at Woodcock Hill, the impact of false targeting must be assessed in detail.

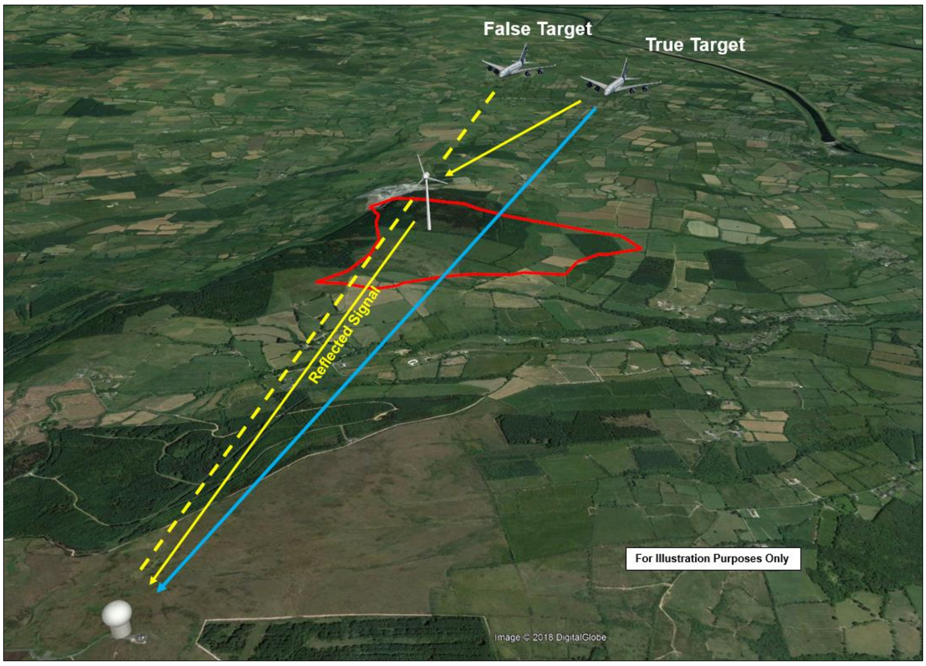


Figure 3. Illustration of SSR False Targeting

E1.1.3 Eurocontrol Guidelines – SSR Assessment

In this section of the Eurocontrol Guidelines, SSR 2D position accuracy is described.

As previously described, reflections due to wind turbines can cause false target reporting, but they can also impact the wave-front of a transmitted signal to/from an SSR. This can lead to the bearing of an aircraft being calculated erroneously. The detailed assessment must address this topic and must predict (in 3D) the impact on the SSR position accuracy performance.

When an aircraft is located behind a wind turbine 2D azimuth errors can occur when there is a small path difference (less than 0.25 μs = 75 m) between the direct and the reflected signal (see Figure 4).

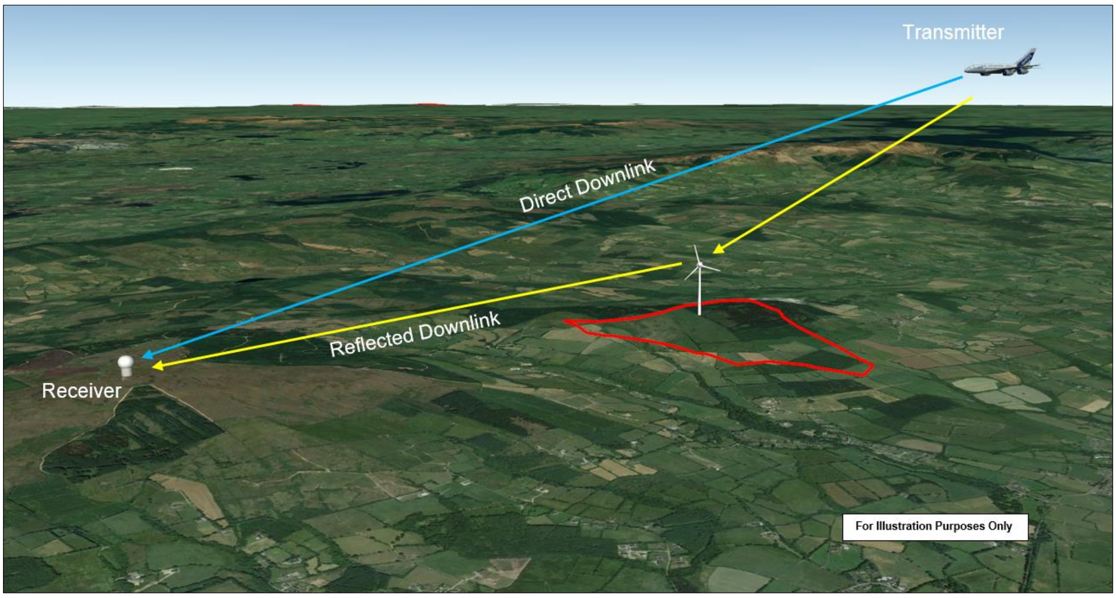


Figure 4. Reflection on Downlink Signal from Aircraft

These errors occur because the receiver can detect two signals from the aircraft transmitter. As the signals are received within a very short time difference of each other, it is difficult for the receiver to distinguish the reflected signal. This can cause erroneous calculations which can impact the azimuth accuracy.

It should be noted that when there are multiple wind turbines located in a radar beam-width, SSR azimuth errors could be significant. The figure above illustrates how a turbine could impact the down signal from an aircraft which could in turn lead to erroneous azimuth calculations.

E2. PSR\SSR Radar Surveillance Mitigation Measures

From the desktop assessments turbines at the proposed wind farm are visible to the Woodcock Hill SSR and are highly likely to be detected. A detailed assessment will be required and based on the outcome, a series of mitigation options would have to be proposed and those mitigations are listed with guidelines taken from the document *UK Civil Aviation Authority (CAA): CAP 764 CAA Policy and Guidelines on Wind Turbines.* Within this document the introduction to suggested mitigations the following is included

> *some of the mitigation methods that are available to help counter the effects of wind turbines, primarily on PSR and SSR related issues. Not all the mitigation methods will be suitable in all circumstances and more than one method may be required to mitigate risks to an acceptable level. The definition of 'acceptable' will have to be made on a case by case basis dependent upon many factors such as the nature of the ATS being provided and the type and density of the airspace affected.*

An overview of some of the mitigation measures are also provided in these guidelines with a reference to possible "work-arounds" in section 4.7 to 4.8

> *4.7 Work-rounds are interim measures which are easy to implement solutions adopted by an ANSP which would enable the ANSP to continue providing a service using surveillance radar, under reduced operational efficiency or an increased level of risk, which may be deemed acceptable whilst a long-term full mitigation solution is being progressed. Such measures inherit limitations which makes it only suitable for a limited period or a limited set of circumstances and are likely to avoid such effects rather than addressing the effects experienced by radar.*
>
> *4.8 Work-rounds include moving the locations of the wind turbines (where this is feasible and in planning stage), introducing sector blanking, rerouting traffic such that all aircraft fly around the wind farm rather than over it, moving any other operational areas of the airfield, or remove PSR and use SSR only etc. These measures may not be sufficient in the long term as the number of wind turbines is likely to increase over time and are therefore temporary measures rather than a permanent fix to the problem*

A further mitigation measure is suggested such as "Multilateration or SSR only operation" which would be applicable as the radar at Woodcosk Hill is a SSR and this technology is being considered by IAA.

> *4.23 Co-operative only surveillance may be viable in areas where full or majority of the airspace comprises co-operative targets. However the current CAA policy has to be reviewed in order to permit SSR only or co-operative only surveillance in circumstances other than in situations where PSR is temporarily unavailable due to failures. Multilateration, SSR or ADS-B are some of the co-operative techniques that can detect co-operative targets despite the presence of wind farms*

A mitigation solution of using radar absorbing materials is suggested and known as a "stealth solution" are also presented.

> *4.24 These techniques try to develop radar absorbing materials (RAM) as well as to design new wind turbines with reduced radar cross section, preserving the efficiency of turbines in terms of electricity production and construction costs. RAM may consist of ferrite paints or polymer layers incorporating crystalline graphite which are coated onto the wind turbines to reduce the RCS*

The mitigation solution suggested under "Changing the wind farm location or its characteristics" is one of the first mitigations to be considered following a requirement for a detailed assessment resulting in a wind farm interference condition on radar would be to look at wind farm design changes and these would include reducing the overall surface area of the turbines RCS while also re-considering a layout where the turbine locations are re-aligned where turbines would be located behind each other to minimize reflections. This would reduce clutter effects on the radar display to the air traffic controllers.

> *4.47 Some ANSPs in collaboration with the operators of a planned wind turbine installation may find through careful planning and pre-modelling that adjustment to the wind farm is possible in order to minimize the predicted effects of a wind farm on a ATC surveillance radar. For example careful spacing between the turbines and the shape of a wind farm can significantly reduce its RCS as seen by the radar hence causing minimal effects on a surveillance system. This option is obviously possible only prior to the implementation of a planned wind farm.*
>
> *4.48 Also, clutter suppression techniques and advanced digital tracking described in this document may reduce the effects of wind turbines on radars that use Doppler processing. However, not all radar systems have advanced signal processing algorithms. Hence where it is possible, the RCS of turbines should be reduced.*

There is a reference to "physical or terrain masking and clutter suppression fence" form of mitigation in sections 4.49 to 4.50

> *4.49 In certain circumstances, and where low level radar coverage in the area of wind turbine development is not required, it may be possible to use either existing terrain or a man-made object to prevent a radar from seeing the wind turbines.*
>
> *4.50 Reflections from nearby mountains and other large clutter can sometimes be of such magnitude that it is not practical to completely suppress their undesirable effects by either MTI or range gating. One technique for reducing the magnitude of such large clutter seen by a fixed radar is to erect an electromagnetically opaque*

> *fence around the radar or between the radar and the clutter source to prevent the radar CAP 764 Chapter 4: Potential mitigation measures from viewing the clutter directly. The two way isolation provided by a typical fence with a straight edge might be about 40dB, where the isolation is given by the ratio of the clutter signal in the absence of a fence to that in the presence of the fence. The isolation is limited by the diffraction of the electromagnetic energy behind the fence. Greater isolation than that provided by a straight-edge fence can be had by incorporating two continuous slots near to, and parallel with, the upper edge of the fence to cancel a portion of the energy diffracted by the fence.*

A mitigation solution reference to co-operative only operation which is applicable only SSR and which refers to en-route airspace

> *4.53 Currently co-operative/SSR only operation is allowed within certain part of the en-route airspace as specified in CAP 670 SUR 01. SSR only service may also be permitted on a temporary basis in the event of failure of a primary radar. However it may be justifiable to use SSR only to maintain detection of aircraft within a limited part of a surveillance display that is affected by wind turbines.*

Appendix G – Radar LOS Plots

Oatfield Wind Farm

Radar LOS Plots

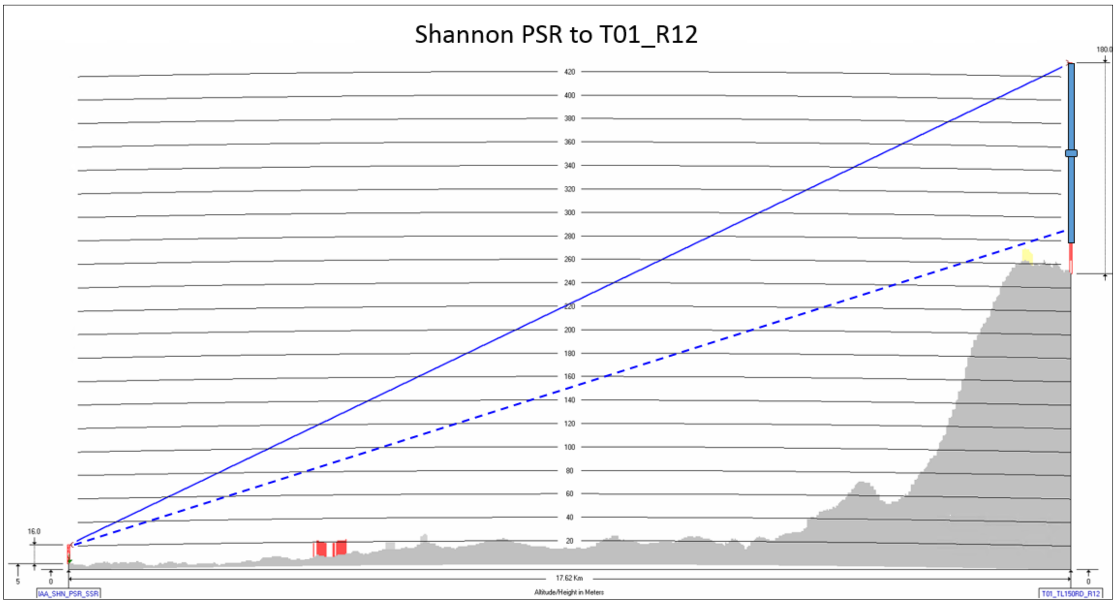
Document Number:	001/VH202104			
Author:	DMG\PT			
Approved for Release:	Rev 2.0	DMG\PT	**Date:**	07/12/23

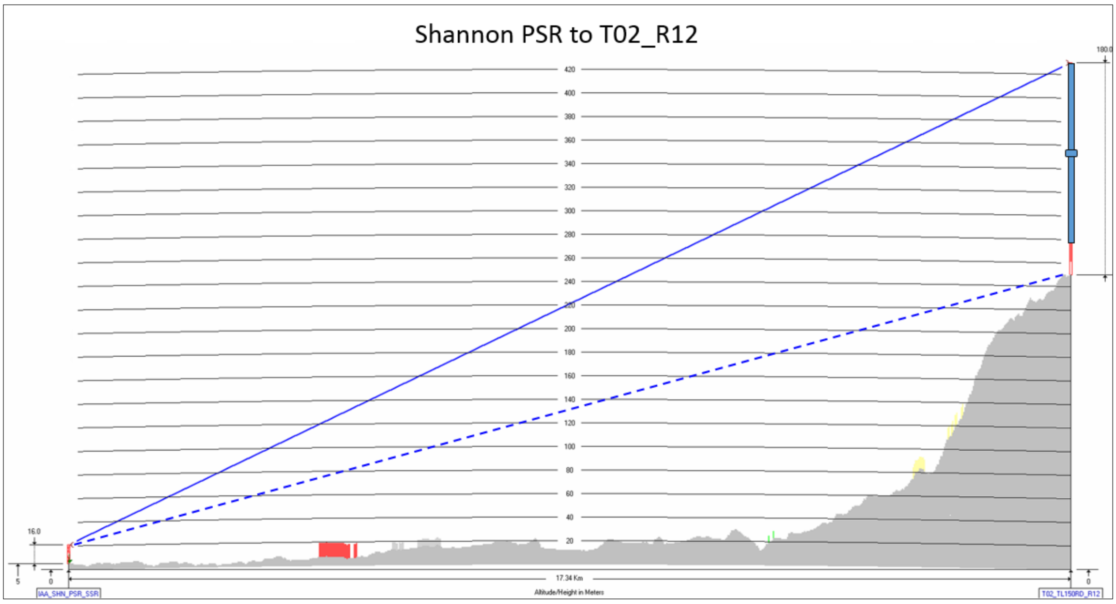
APPENDIX G – Radar Line-of-Sight (RLOS) Plots

Radar line-of-sight (RLOS) plots for the PSR at Shannon Airport and the MSSR at Woodcock Hill have been generated and are shown below in Sections G1 nnd G2.

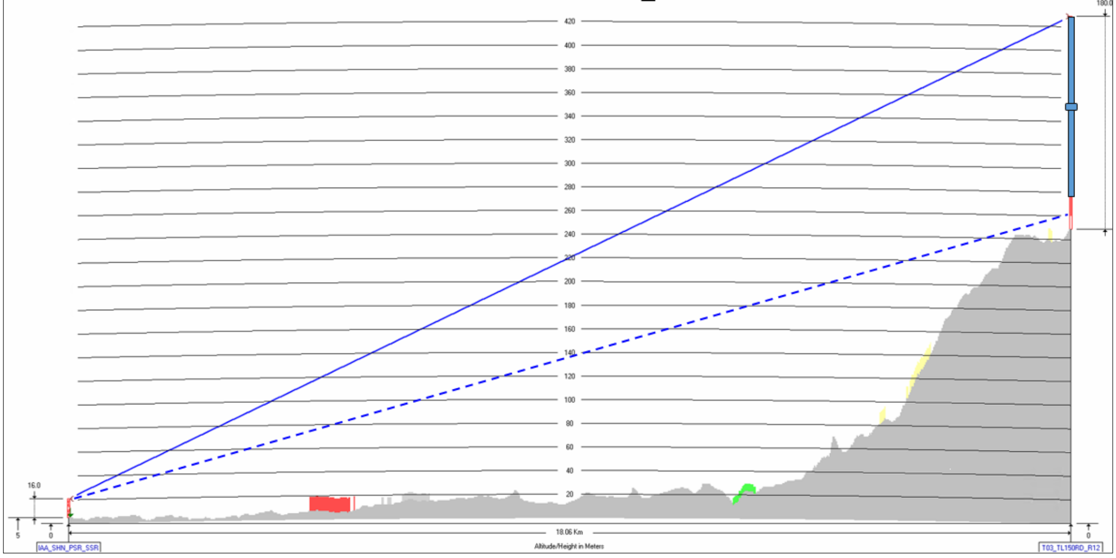
G1. Radar LOS – Shannon PSR

For the PSR at Shannon, RLoS plots have been calculated using the max turbine tip height (180m AGL) as the principal sources of adverse wind farm effects on PSR systems are from turbine blades.

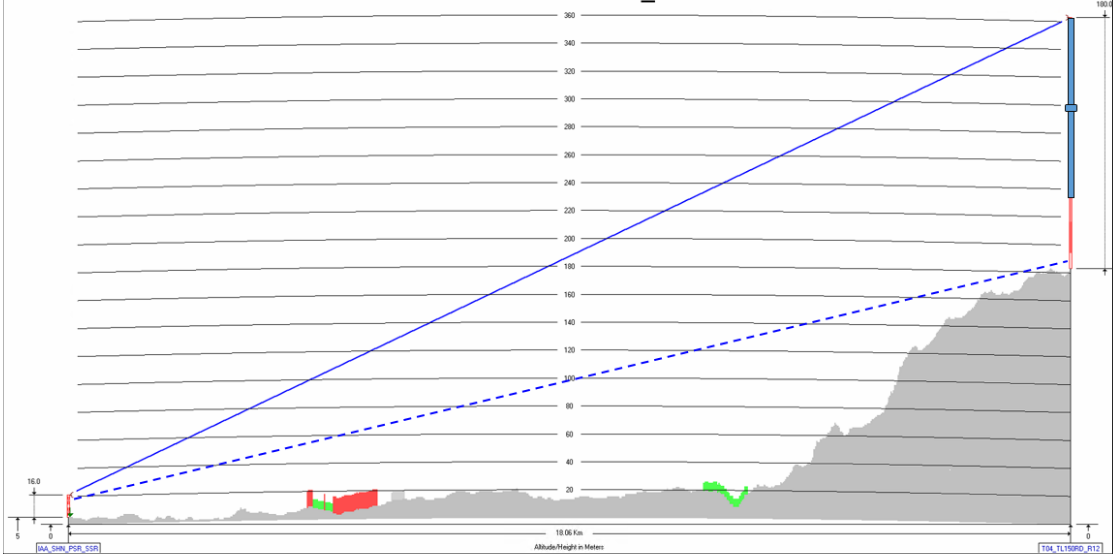




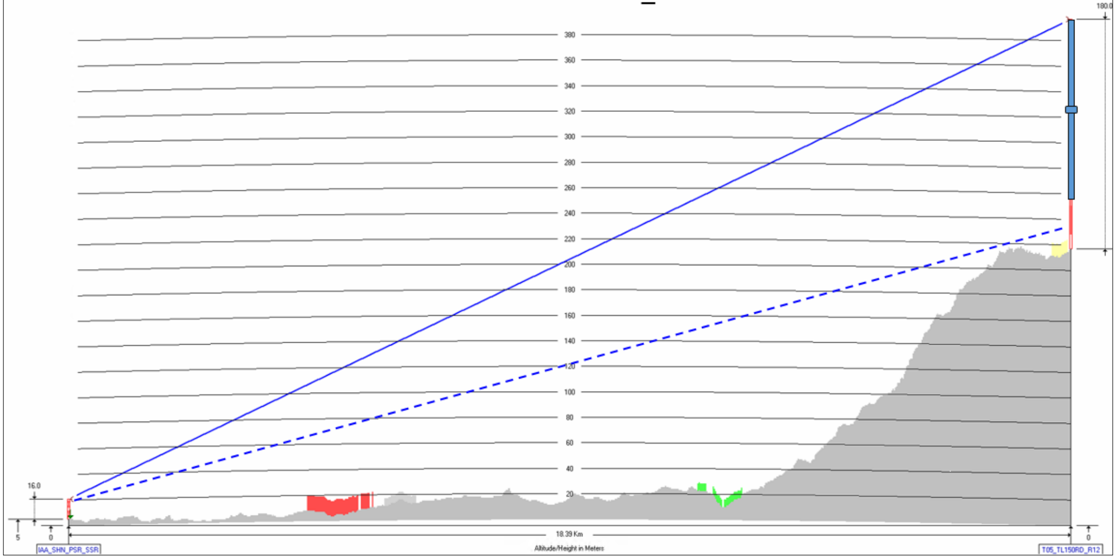
Shannon PSR to T03_R12



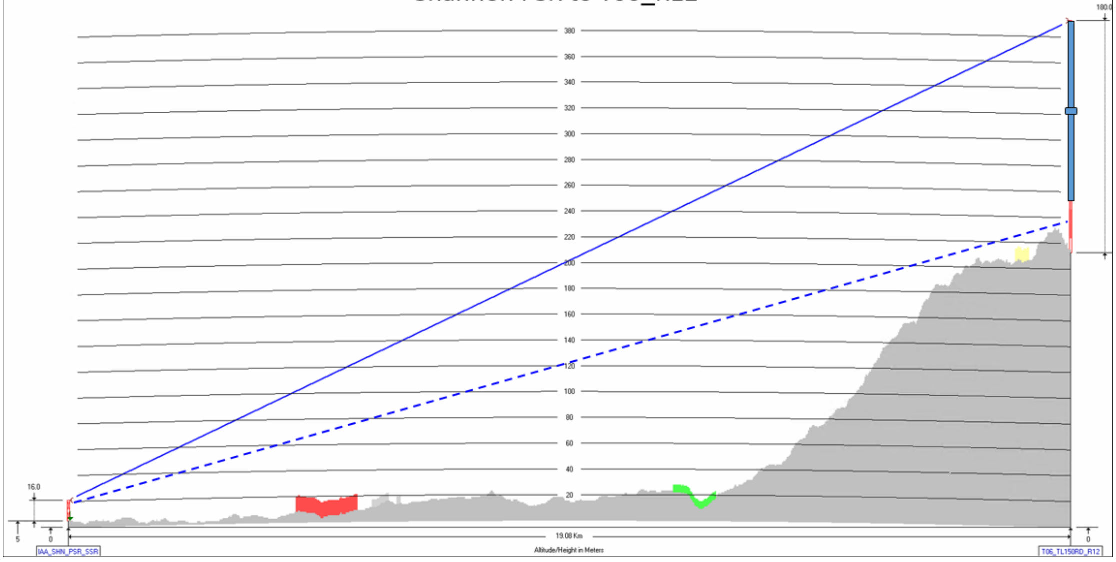
Shannon PSR to T04_R12

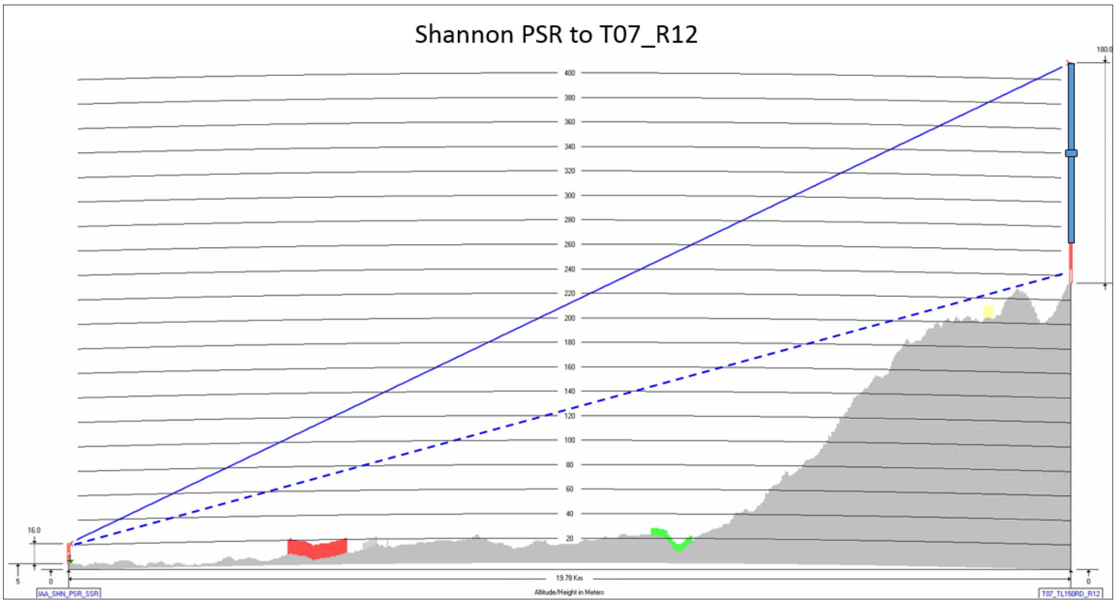


Shannon PSR to T05_R12

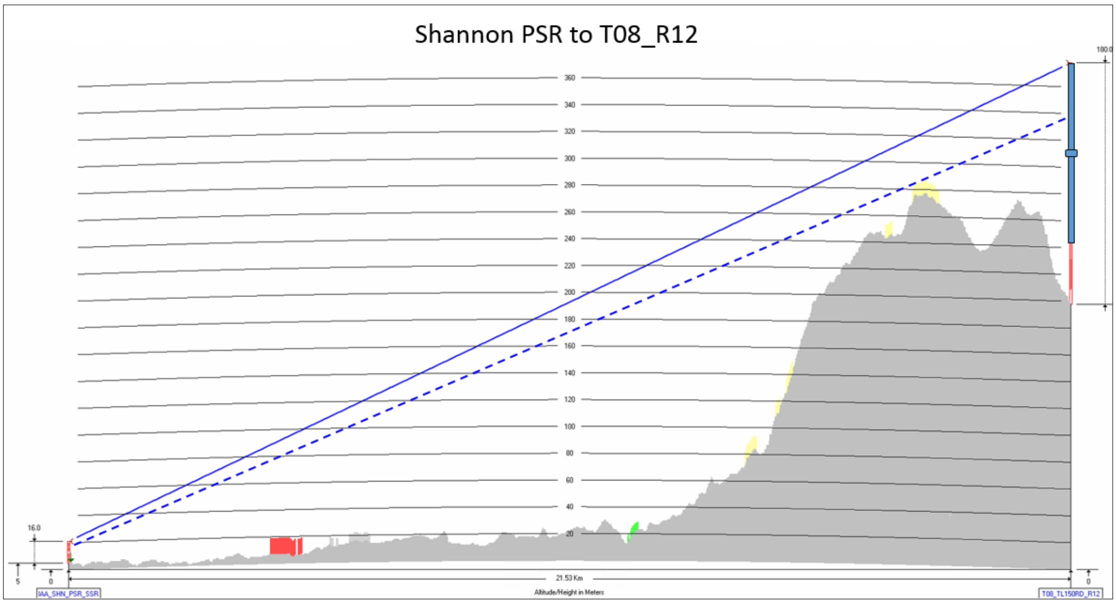


Shannon PSR to T06_R12



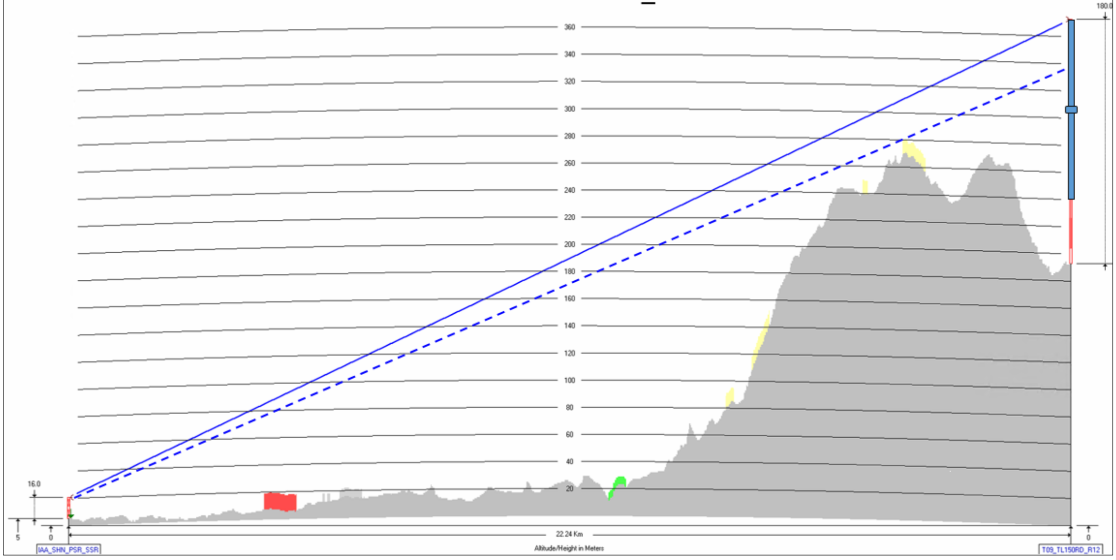


Shannon PSR to T07_R12
19.78 Km
Altitude/Height in Meters
IAA_SHN_PSR_SSR
T07_TL150RD_R12

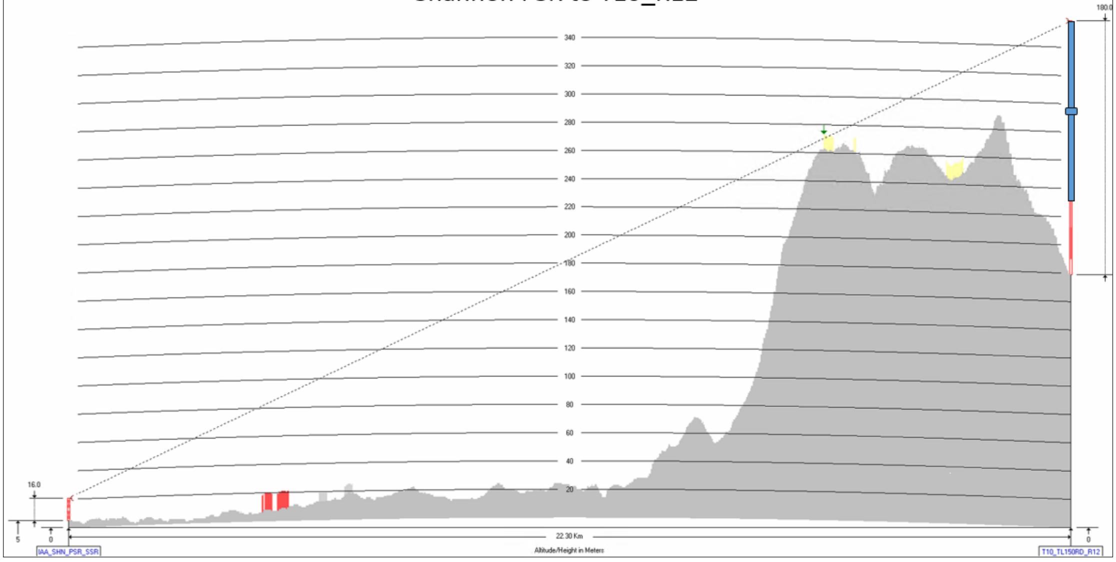


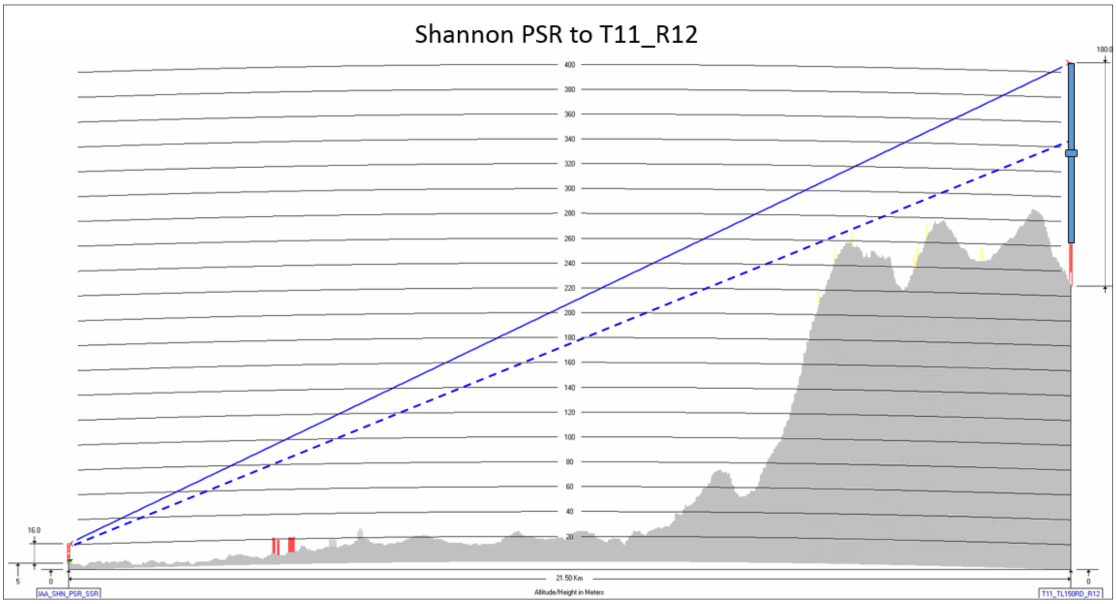
Shannon PSR to T08_R12
21.53 Km
Altitude/Height in Meters
IAA_SHN_PSR_SSR
T08_TL150RD_R12

Shannon PSR to T09_R12



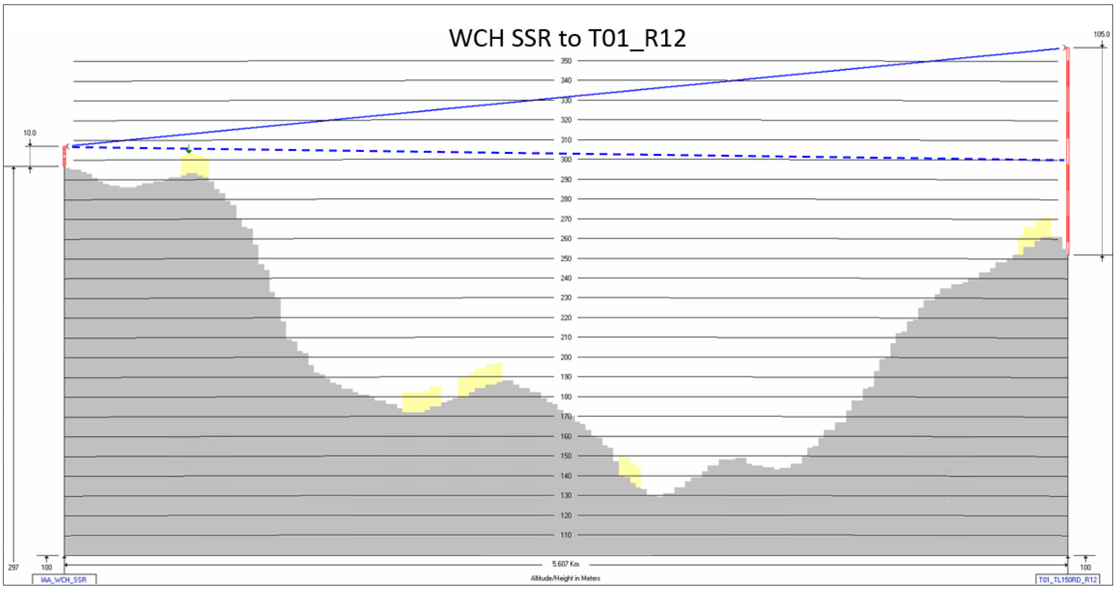
Shannon PSR to T10_R12

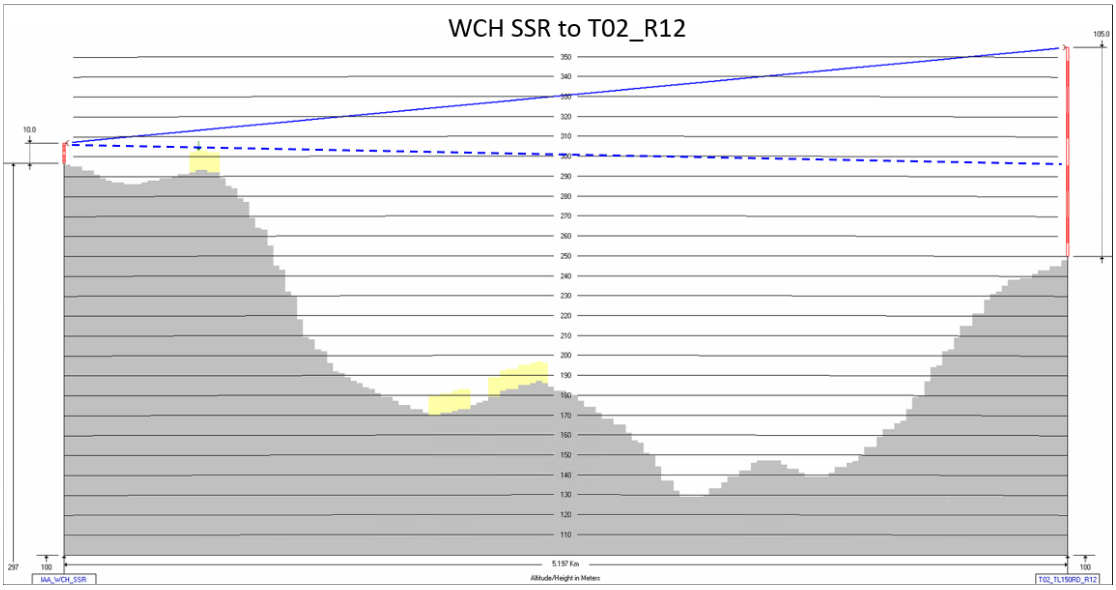


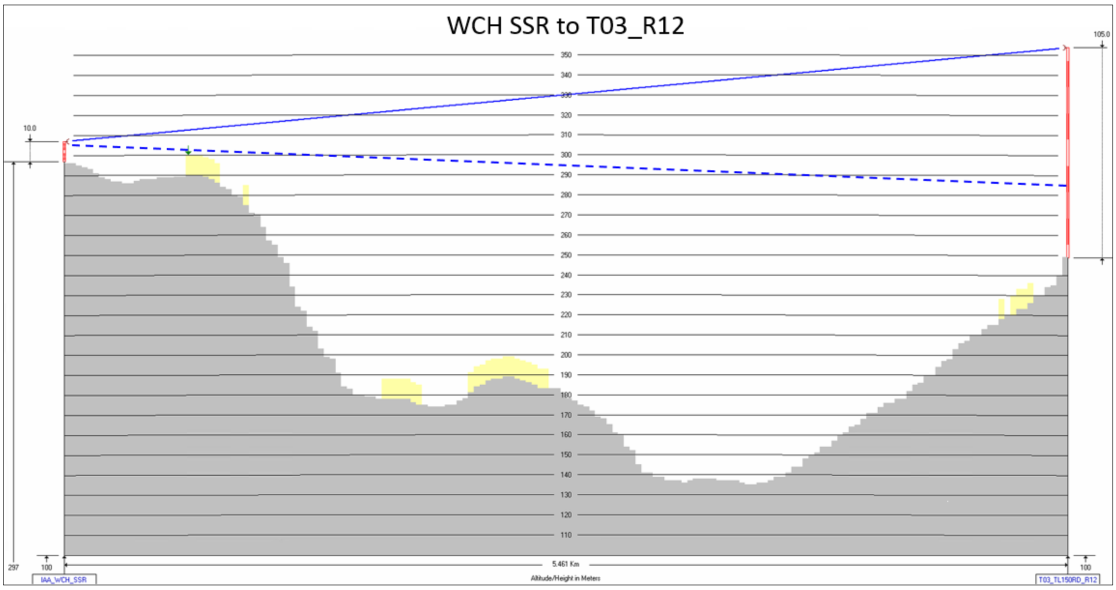

Shannon PSR to T11_R12
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
180.0
16.0
5
0
0
21.50 Km
Altitude/Height in Meters
IAA_SHN_PSR_SSR
T11_TL150RD_R12

G2. Radar LOS Plots – Woodcock Hill MSSR

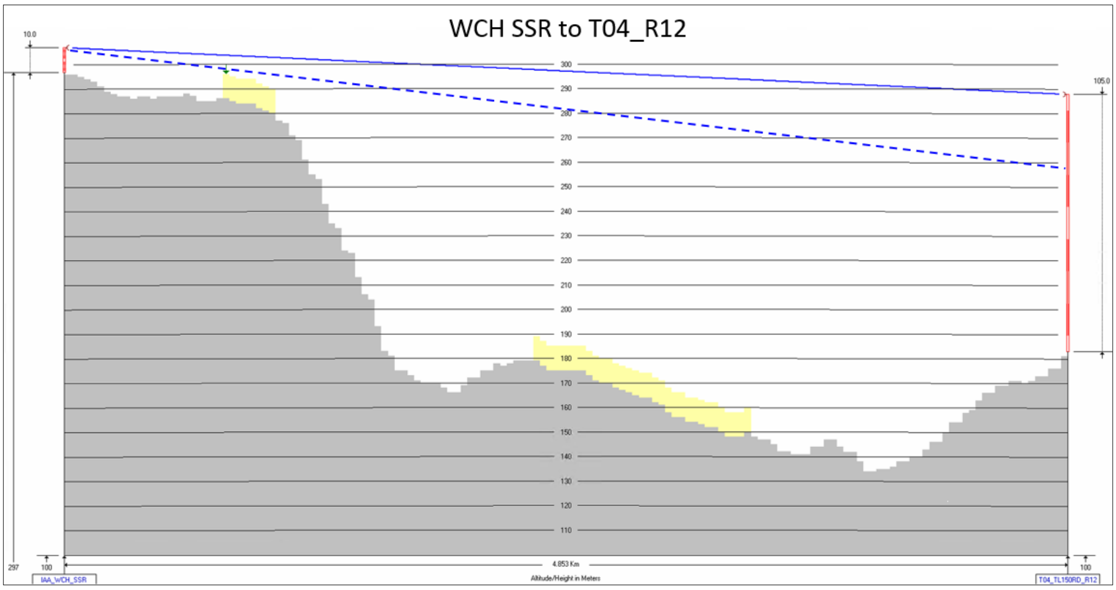
For the MSSR at Woodcock Hill, RLoS plots have been calculated using the max hub height (105m AGL) as the principal sources of adverse wind farm effects on MSSR systems are from turbine towers.



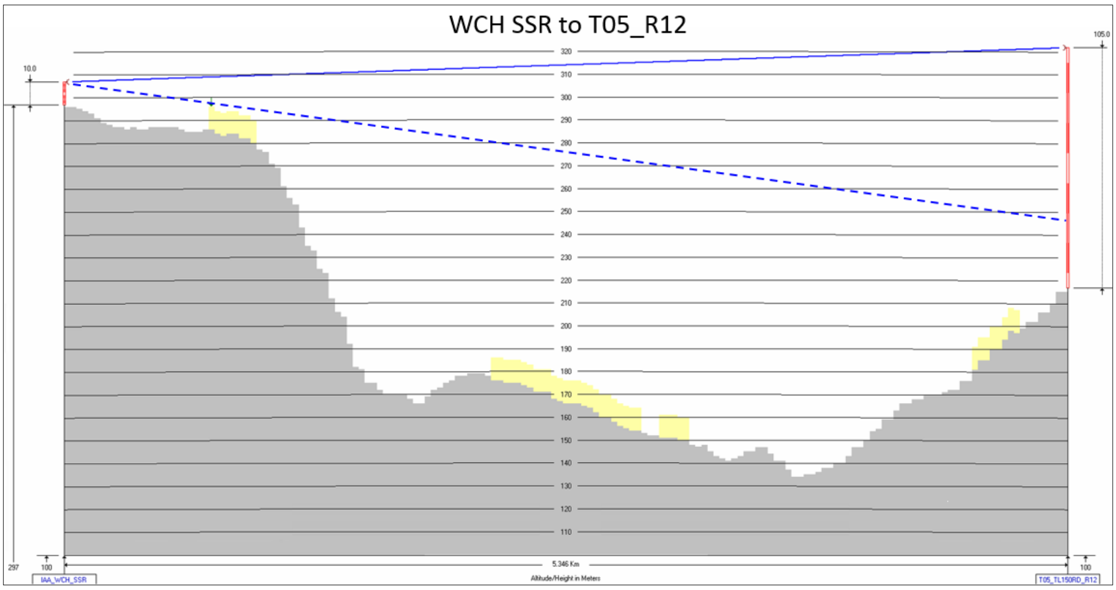




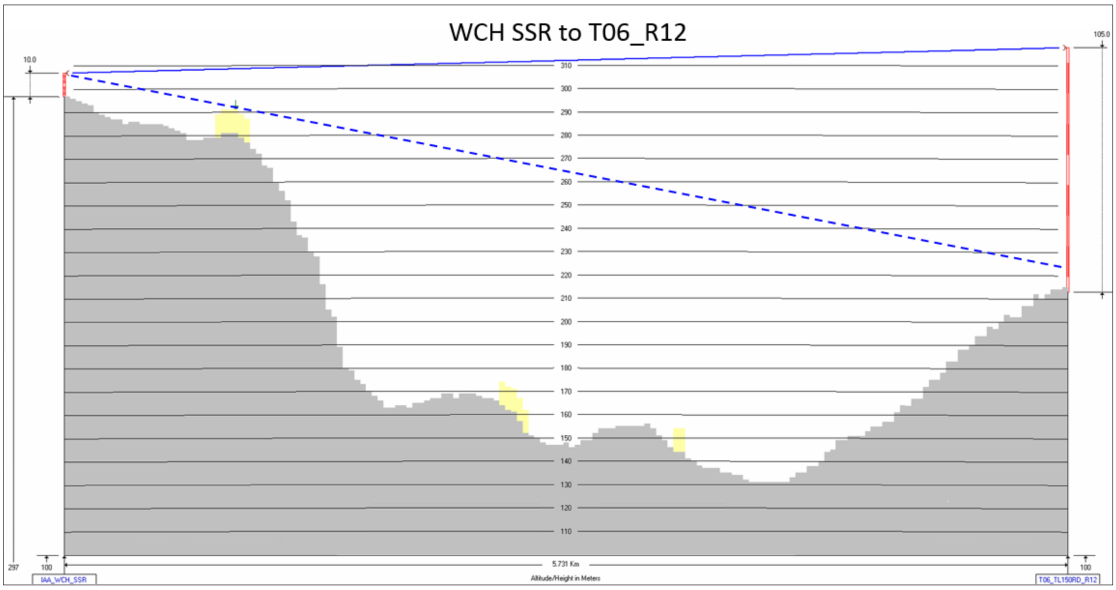
WCH SSR to T03_R12
5.461 Km
Altitude/Height in Meters
IAA_WCH_SSR
T03_TL150RD_R12



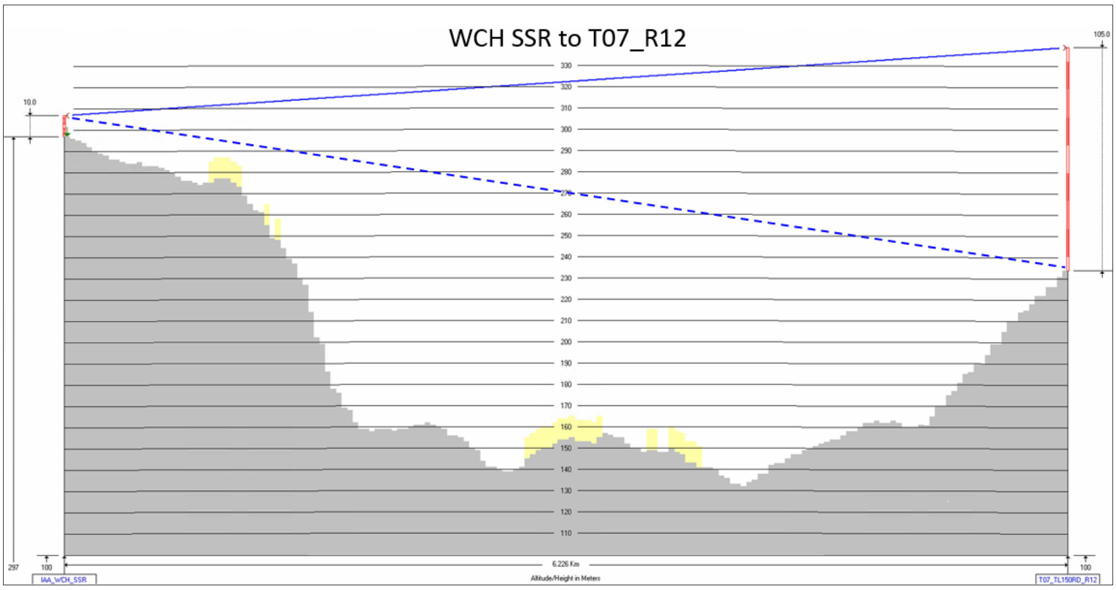
WCH SSR to T04_R12
4.853 Km
Altitude/Height in Meters
IAA_WCH_SSR
T04_TL150RD_R12

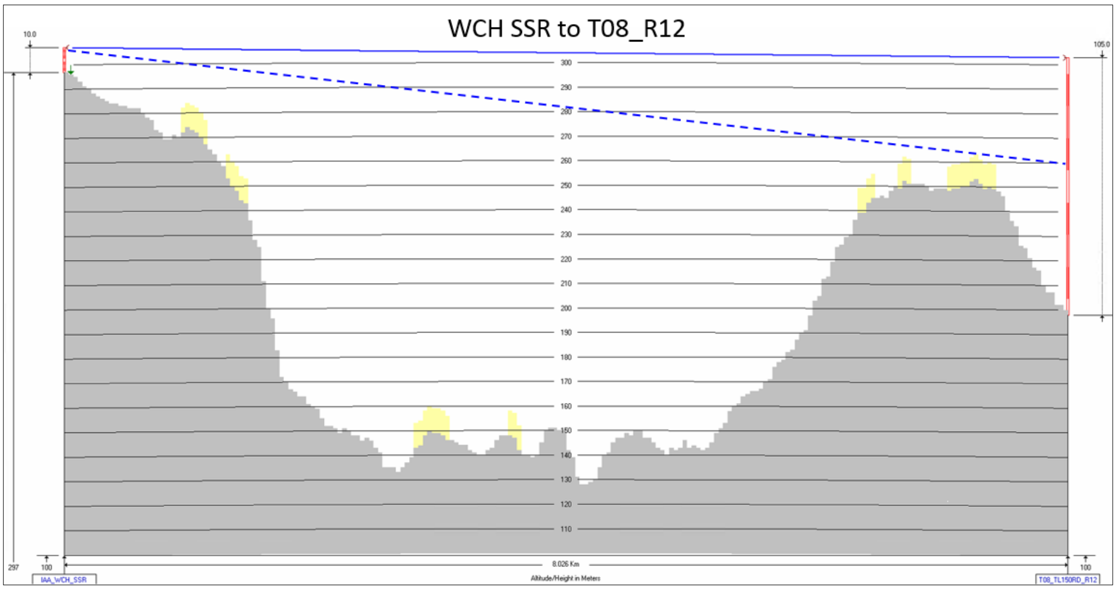


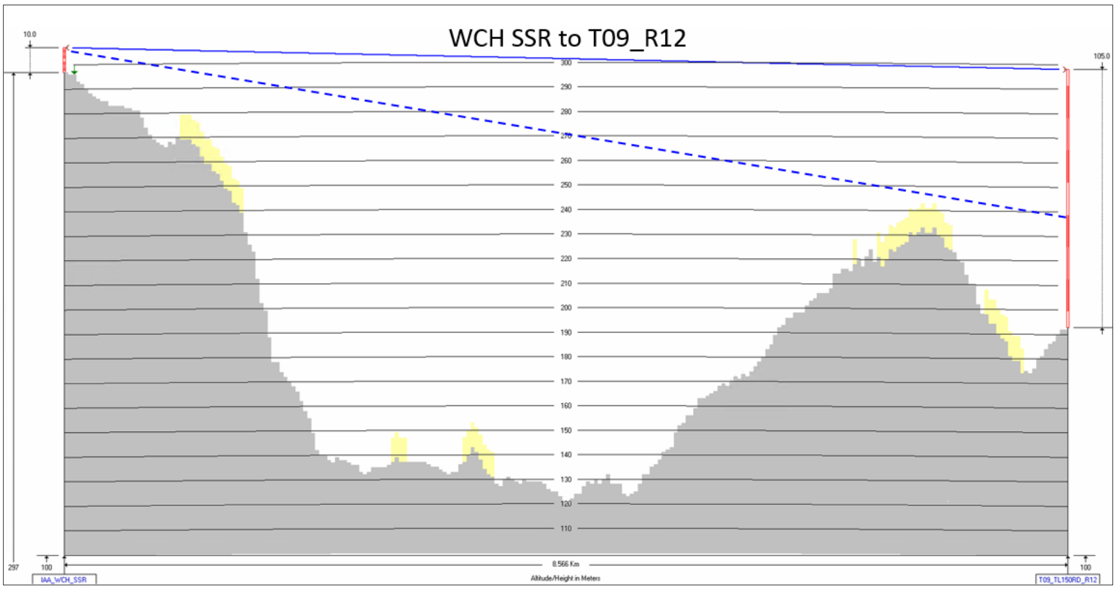
WCH SSR to T05_R12
5.346 Km
Altitude/Height in Meters



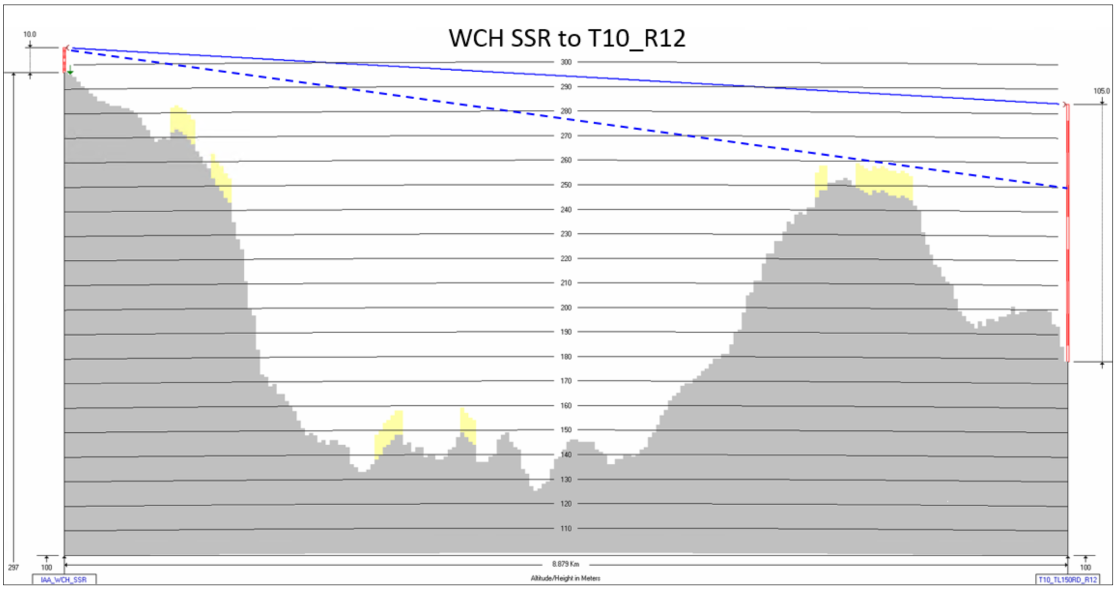
WCH SSR to T06_R12
5.731 Km
Altitude/Height in Meters


WCH SSR to T07_R12
10.0
105.0
297
100
100
6.226 Km
Altitude/Height in Meters
IAA_WCH_SSR
T07_TL150RD_R12

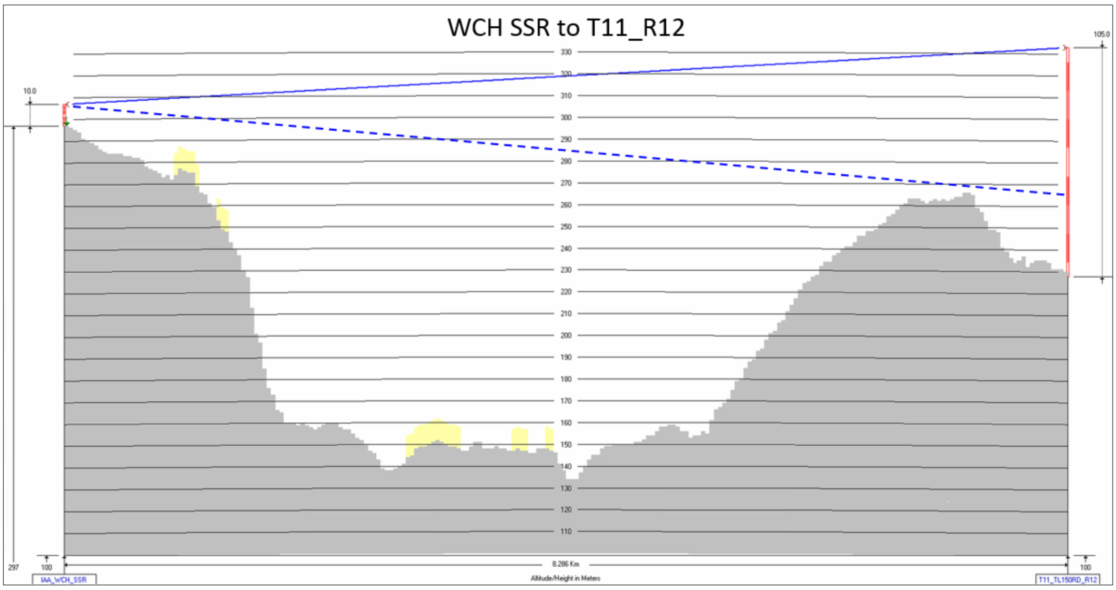

WCH SSR to T08_R12
10.0
105.0
297
100
100
8.026 Km
Altitude/Height in Meters
IAA_WCH_SSR
T08_TL150RD_R12



WCH SSR to T09_R12
8.566 Km
Altitude/Height in Meters
IAA_WCH_SSR
T09_TL150RD_R12



WCH SSR to T10_R12
8.879 Km
Altitude/Height in Meters
IAA_WCH_SSR
T10_TL150RD_R12



WCH SSR to T11_R12
10.0
105.0
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
297
100
8.286 Km
100
IAA_WCH_SSR
Altitude/Height in Meters
T11_TL150RD_R12